

**MDS - MADE EASY**  
**PROSTHODONTICS**  
**PAPER I-APPLIED BASIC SCIENCES**

## **ANATOMY**

1. Give a short account of the applied anatomy of temporomandibular joint. Discuss the degenerative changes that occur in the joint due to ageing. (KUHS, Jan 2020, 20M). Discuss the functional anatomy and biomechanics of temporomandibular joint. (NTR Univ, May 2018, 20M), (SRM, June 2019, 10M). Describe the anatomy of the Temporomandibular joint and mention its prosthetic considerations. (MGR, Oct 2017, 15M). Describe anatomy of Temporomandibular joint. (RGUHS, Nov 2016, 20M).
2. Trigeminal nerve and its course. (MGR, Oct 2019, 10M)
3. Major salivary glands. (MGR, Oct 2019, 10M)
4. Discuss the various mandibular movements and their regulations by muscles and ligaments. (MGR, Oct 2019, 10M)
5. Discuss in detail - Muscles of facial expression and how these are linked to various prosthetic treatment. (NTR Univ, Oct 2019, 20M)
6. Discuss in detail neuromuscular coordination of stomatognathic system and discuss the associated disorders. (NTR Univ, May 2019, 20M)
7. Discuss in detail the anatomy of the muscles of mastication and their applied anatomy/ prosthetic considerations. (RGUHS, June 2018, 20M), (SRM, June 2019, 10M), (KUHS, June 2020, 7M)
8. Trigeminal nerve. (NTR Univ, May 2019, 7M)
9. Muscles of tongue and its applied aspect. (NTR Univ, May 2019, 10M), (MGR, May 2018, 6M). Anatomy of tongue. (MGR, Oct 2018, 6M). Discuss the anatomy of the tongue and its role in prosthetic rehabilitation. (RGUHS, June 2018, 20M). Discuss development, muscular, neuro-vascular and lymphatic drainage of the tongue. (NTR Univ, Nov 2017, 20M)
10. Extra cranial course of Facial Nerve and its clinical significance. (MGR, May 2019, 6M). Applied anatomy of facial nerve. (NTR Univ, Apr 2015, 7M)
11. Movements of mandible. (NTR Univ, Nov 2017, 7M)
12. Discuss the role of facial muscles and muscles of mastication with reference to retention and stability of complete denture. (NTR Univ, June 2017, 20M)
13. Discuss in detail the anatomy, applied anatomy and physiology of oral musculature. (RGUHS, Jul 2017, 20M)
14. Microanatomy of facial bones. Discuss in detail the materials used in prosthetic rehabilitation of bone defects. (RGUHS, Jul 2017, 20M)
15. Minor salivary glands. (NTR Univ, June 2016, 7M)

16. Write the applied anatomy and development of tongue. (NTR Univ, April 2015, 20M)
17. Masticatory musculature and its role in maintaining condylar position. (RGUHS, May 2015, 20M)

## EMBRYOLOGY / OSTEOLGY

18. Developmental defects of oral cavity. (NTR Univ, May 2019, 7M)
19. Alveolar bone (NTR Univ, May 2019, 10M)
20. Development of mandible. (RGUHS, June 2018, 7M)
21. Write in detail about the growth and development of the mandible. (RGUHS, Nov 2017, 20M), (SRM, June 2018, 10M)
22. Development of palate and its applied anatomy. (RGUHS, Jul 2017, 7M). Development of palate and its anomalies. (MGR, Oct 2017, 6M). Development of palate and note on cleft palate. (MGR, June 2017, 6M)
23. Development of the face. (RGUHS, Nov 2016, 7M)
24. Microanatomy of bone. (MGR, Oct 2016, 6M)

## PHYSIOLOGY

25. Describe haemostasis. Add a note on local approaches to stop excess bleeding after implant surgical procedures. (RGUHS, May 2019, 20M)
26. Explain saliva and its role in prosthodontics. (RGUHS, May 2019, 7M), (MGR, Oct 2018, 6M), (MGR, May 2018, 6M). Discuss physiology of saliva and its effect on retention of complete dentures. (NTR Univ, June 2016, 20M). Saliva and artificial saliva. (RGUHS, June 2018, 7M), (MGR, June 2016, 6M). Mechanism of salivary secretion (RGUHS, Nov 2017, 7M).
27. Blood groupings. (MGR, Oct 2018, 6M)
28. Deglutition phases. (MGR, Oct 2017, 6M), (MGR, June 2017, 6M)
29. Explain the stage of erythropoiesis with an illustrated diagram. (NTR Univ, April 2015, 20M)

## BIOCHEMISTRY

30. Role of vitamin D in metabolism. (NTR Univ, May 2019, 10M)
31. Calcium and phosphate metabolism. (RGUHS, Jul 2017, 7M)
32. Calcium metabolism and prosthodontic complications. (NTR Univ, Nov 2017, 7M)
33. Calcium metabolism. (RGUHS, Nov 2017, 20M), and role of vitamin D in controlling plasma calcium concentration. (SRM, June 2018, 10M)
34. Vitamin D. (NTR Univ, June 2016, 7M)
35. Vitamin and its functions. (NTR Univ, Apr 2015, 7M)

## MICROBIOLOGY

36. HIV tests. (NTR Univ, June 2016, 7M)

## PATHOLOGY

37. Antigen antibody reaction. (NTR Univ, May 2019, 10M)
38. Define edema. Discuss the pathology of various types of edema. (SRM, June 2019, 10M)
39. Management of bleeding disorders in prosthodontics. (MGR, Oct 2019, 6M)
40. Healing and repair - role of vitamin C. (MGR, May 2018, 6M)
41. Describe the coagulation of blood and enumerate blood investigations to diagnose bleeding and clotting disorders. (SRM, June 2018, 10M)
42. Chemical mediators of inflammation. Deglutition phases. (MGR, Oct 2017, 6M)
43. Healing of Extraction socket. (NTR Univ, June 2016, 7M)
44. Discuss in detail the primary and secondary wound healing and add a note on osseointegration. (RGUHS, Jul 2016, 20M)
45. Hepatitis B virus. (RGUHS, May 2015, 7M). Etiology, pathology and protection of clinical personnel from Hepatitis B. (SRM, June 2018, 10M)
46. Chronic inflammation. (RGUHS, May 2015, 7M)

## PHARMACOLOGY

47. Classify analgesics. Discuss in detail about the action of NSAIDs explaining the mechanism of actions. What are the advantages and disadvantages of using CoX2 selective inhibitors. (SRM, June 2019, 10M), (SRM, June 2018, 10M)
48. Anti inflammatory and analgesic drugs used in prosthodontics. (NTR Univ, May 2018, 7M)

## DENTAL ANATOMY/ORAL HISTOLOGY

49. Oral mucosa. (MGR, Oct 2019, 10M), geriatric changes in oral mucosa. (SRM, June 2019, 10M). Microanatomy of oral mucosa. (RGUHS, Jul 2016, 7M). Histology of oral mucosa. (RGUHS, Nov 2016, 7M), (MGR, Oct 2016, 6M)
50. Discuss self protective features of human dentition. (NTR Univ, May 2018, 20M)
51. Give a short account of degenerative changes that occur in mandible due to ageing. (SRM, June 2018, 10M)

## ORAL PATHOLOGY/ ORAL MEDICINE/ ORAL SURGERY

52. Nerve block anaesthesia. (NTR Univ, May 2019, 10 M)

53. Describe the pathophysiology of pain. Explain the role of opiate system in modulation of pain. (SRM, June 2019, 10M)
54. Enumerate the viral infections affecting the oral cavity. Write in detail the pathogenic clinical features and oral manifestations of Herpes simplex virus. (SRM, June 2019, 10M)
55. Write briefly about the different types of benign tumors of the jaws. (MGR, Oct 2019, 10M)
56. Aphthous stomatitis. (SRM, June 2018, 10M)
57. Congenital and developmental defects of teeth. (MGR, June 2016, 6M)
58. Types and Oro Dental manifestation of Ectodermal dysplasia. (MGR, Oct 2019, 6M)
59. Precancerous conditions and their effects on prosthodontic treatment. (MGR, May 2018, 6M)

## RESEARCH METHODOLOGY / BIOSTATISTICS

60. Sample techniques in research. (KUHS, Jan 2020, 7M)
61. Study designs in research. (NTR Univ, May 2019, 7M)
62. Standard deviation. (NTR Univ, May 2019, 10M)
63. Tests of significance in biostatistics. (KUHS, June 2019, 7M)
64. Define Bias. Enumerate different bias that can occur in any research design. (SRM, June 2018, 10M)
65. Standard deviation and coefficient of variation. (RGUHS, Jul 2016, 7M)
66. Explain Mean, Mode and Median. (RGUHS, Nov 2016, 7M)

## GENERAL MEDICINE

67. Describe the regulations of blood glucose level. Add a note on diabetes mellitus and its prosthodontic significance. (RGUHS, May 2019, 7M)
68. Oral cavity epitomizes the systemic conditions of an individual - Justify (NTR Univ, May 2019, 20M)
69. Write in detail about anaphylactic shock and its management. (NTR Univ, May 2019, 7M)
70. Shock. (NTR Univ, May 2019, 10M)
71. Xerostomia. (NTR Univ, May 2019, 10M)
72. Facial Edema. (MGR, May 2019, 6M)
73. What is osteomyelitis. mention the management of osteomyelitis of body of the mandible. (MGR, Oct 2019, 10M)
74. Regulation of blood pressure. (RGUHS, Nov 2017, 7M)
75. Management of patients with Diabetes Mellitus. (MGR, June 2017, 6M)
76. Endocrine disorders affecting prosthodontic treatment. (NTR Univ, June 2016, 7M)

77. Discuss the effect of diabetes on success of prosthodontic treatment. (NTR Univ, April 2015, 7M)

## RADIOLOGY

78. Role of radiographic investigations in prosthodontics. (NTR Univ, Oct 2019, 7M)

## DENTAL MATERIALS

79. Discuss the evolution of ceramics in prosthodontics with emphasis on latest advances. (KUHS, Jan 2020, 20M)
80. Selection of dental materials used in prosthodontics. (MGR, May 2019, 6M)
81. Write in detail about implant biomaterials used in dentistry. (RGUHS, May 2019, 20M), (KUHS, June 2019, 20M)
82. Write in detail about casting defects. (RGUHS, May 2019, 7M), (KUHS, Jan 2020, 7M)
83. Hardness tests. (NTR Univ, May 2019, 10M)
84. Principles of casting. (NTR Univ, May 2019, 7M)
85. Dentine bonding agents. (NTR Univ, May 2019, 7M)
86. Resilient liners- Types, properties and their applications in prosthodontics. (MGR, May 2019, 15M)
87. Reinforced polymethyl methacrylate Denture base resin. (MGR, May 2019, 6M)
88. Alloys for RPD Framework. (MGR, May 2019, 6M)
89. Denture base porosities. (KUHS, June 2019, 7M)
90. Polyvinyl siloxane impression material. (KUHS, June 2019, 7M)
91. Explain biocompatibility of dental materials. Describe briefly about the adverse effects from dental materials. (SRM, June 2019, 10M). Biocompatibility tests used in dentistry. (SRM, June 2018, 10M)
92. Noble metal alloys. ((MGR, Oct 2019, 10M), (MGR, Oct 2016, 6M)
93. Phosphate bonded investments. (MGR, Oct 2019, 10M), (MGR, Oct 2017, 6M)
94. Zirconia is the new age dental material - Elaborate and give your views (NTR Univ, Oct 2019, 20M), (MGR, Oct 2016, 6M)
95. Colour science for esthetic restorations. (NTR Univ, Oct 2019, 7M)
96. Ideal die materials in prosthodontics. (MGR, Oct 2019, 6M)
97. Porosities in dental casting. (NTR Univ, May 2018, 7M)
98. Elastomeric impression materials. (NTR Univ, May 2018, 7M). Merits and demerits. (SRM, June 2018, 10M)
99. Resin cements. (RGUHS, June 2018, 7M). Resins used in dentistry. (NTR Univ, Nov 2017, 7M). Resin bonded cements. (RGUHS, Nov 2016, 7M)

100. Casting in dentistry - note on casting defects. (MGR, May 2018, 15M).  
Describe various casting defects and describe in detail how to avoid them.  
(NTR Univ, June 2017, 20M)
101. Die materials used in prosthetic dentistry. (RGUHS, June 2018, 7M)
102. Write an essay on dental ceramics. (MGR, Oct 2018, 15M)
103. Tissue conditioners. (NTR Univ, Nov 2017, 7M)
104. Physical properties of dental materials. (NTR Univ, June 2017, 7M)
105. Castable ceramics. (NTR Univ, June 2017, 7M)
106. Recent advances in impression material. (NTR Univ, June 2017, 7M)
107. Titanium. (NTR Univ, June 2017, 7M), (MGR, Oct 2018, 6M), (MGR, Oct 2019, 10M)
108. Denture adhesive components and its effects and ill effects. (MGR, Oct 2019, 6M)
109. Recent advances in denture based materials. (RGUHS, Jul 2017, 7M)
110. Recent advances in luting cements. (RGUHS, Jul 2017, 7M)
111. Compare and contrast the properties of various elastomeric impression materials. (RGUHS, Nov 2017, 7M)
112. Write about the methods of strengthening ceramics. (RGUHS, Nov 2017, 7M)
113. Measurements of colour and clinically used devices. (RGUHS, Nov 2017, 7M), (RGUHS, May 2015, 7M).
114. Abrasives and polishing agents for prosthesis. (MGR, Oct 2017, 6M), (MGR, June 2017, 15M)
115. Alloys for metal ceramic restorations. (MGR, June 2017, 6M)
116. How do you select different luting agents for various direct and indirect restorations in prosthodontics practice. (NTR Univ, June 2016, 20M)
117. Discuss in detail polymers and their applications in prosthetic dentistry. (MGR, June 2016, 15M)
118. Nano ceramics. (MGR, June 2016, 6M)
119. Titanium used in dental implants. (RGUHS, Jul 2016, 7M)
120. Induction casting. (MGR, Oct 2016, 15M)
121. Write in detail about implant biomaterials used in dentistry. (MGR, Oct 2016, 15M)
122. Age hardening of alloys. (NTR Univ, April 2015, 7M)
123. Classify dental waxes and write in detail about Inlay casting wax. (RGUHS, May 2015, 20M)
124. Setting expansion of gypsum products. (RGUHS, May 2015, 7M)

## PROSTHODONTICS

125. Colour and its role in prosthodontics. (KUHS, Jan 2020, 7M)

126. Write briefly about geriatric nutrition. (RGUHS, May 2019, 7M), (SRM, June 2019, 10M)
127. Management of a Xerostomia patient is a challenge to prosthodontist- Discuss. (SRM, June 2019, 10M)
128. Discuss significance of mandibular movements in prosthodontics. (KUHS, June 2019, 20M)
129. Bone density classification in implant dentistry. (KUHS, June 2019, 7M)
130. Discuss the anatomy of Alveolingual sulcus and its clinical significance in prosthodontics. (MGR, Oct 2019, 15M)
131. Role of nutrients in Geriatric Oral health care. (MGR, Oct 2019, 6M)
132. Role of Plasma rich fibrin in Prosthodontics. (MGR, Oct 2019, 6M)
133. Residual ridge resorption. (MGR, Oct 2018, 6M). Classify and discuss residual resorption and its prosthodontic management. (KUHS, June 2019, 7M)
134. Role of adhesives in maxillofacial prosthodontics. (MGR, May 2018, 6M)
135. Diet for new complete denture patient. (NTR Univ, Nov 2017, 7M)
136. Gag Reflex. (NTR Univ, June 2017, 7M)
137. Stents and splints used in prosthetic dentistry. (RGUHS, Jul 2017, 7M)
138. Role of sialagogues and anti sialagogues in Prosthodontics. (MGR, June 2017, 6M)
139. Nutrition in geriatric patients. (RGUHS, Nov 2016, 7M), (MGR, June 2016, 6M)
140. Speech in cleft palate patients. (RGUHS, Jul 2016, 7M)
141. CAD CAM applications in prosthodontics. (RGUHS, Jul 2016, 7M)
142. Role of saliva in prosthesis retention. (RGUHS, May 2015, 7M). (KUHS, June 2019, 7M), (KUHS, Jan 2020, 7M)

## **MISCELLANEOUS**

143. Describe control of cross infections in prosthodontics. (RGUHS, May 2019, 7M), (MGR, May 2018, 6M)
144. Bone grafting in prosthodontics. (NTR Univ, Oct 2019, 7M)
145. Osteoradiationcrosis. (NTR Univ, Oct 2019, 7M)
146. "Communication with the patient - secret to success" - Discuss. (NTR Univ, Oct 2019, 7M)
147. Biomaterials used for alveolar ridge augmentation. (MGR, Oct 2019, 10M)
148. Sterilization method of impression obtained from patient for prosthodontic treatment. (NTR Univ, May 2018, 7M)
149. Discuss cross infection control in prosthodontics. (NTR Univ, Nov 2017, 20M), (SRM, June 2019, 10M)
150. Sterilization. (NTR Univ, May 2019, 10M)

151. Tissue engineering. (RGUHS, June 2018, 20M)
152. Disinfection of impressions. (MGR, June 2017, 6M)
153. Discuss infection control in prosthodontics. (RGUHS, Nov 2016, 20M), (MGR, May 2019, 6M)
154. Discuss in detail sterilization and disinfection techniques used in prosthodontics and add a note on biomedical waste disposal. (RGUHS, Jul 2016, 20M), (MGR, Oct 2018, 6M)
155. Stem cells. (MGR, June 2016, 6M)

**Q. 09: Alveolar bone (10M)****Microanatomy of bone (6M)****CONTENTS/SYNOPSIS**

- Introduction
- Development of alveolar bone
- Structure of the alveolar bone
- Alveolar bone proper
  - Lamellate bone
  - Bundle bone
    - Sharpey's fibres
    - Radiological finding: Lamina dura
    - Significance
- Supporting bone
  - Cortical bone
    - Variations in the cortical bone of maxilla and mandible
  - Spongiosa
    - Types I
    - Type II
- Interdental and interradicular septa
- Periosteum
- Endosteum
- Clinical considerations
  - Fenestrations
  - Dehiscence
- Disease affecting alveolar bone
  - Chronic Periodontitis
  - Aggressive periodontitis
  - Osteomalacia
  - Hyper parathyroidism
  - Paget's disease
  - Thalassemia
  - Acute Leukemia
  - Dysplasias
- Conclusion
- References

## INTRODUCTION

**Synonym:** Alveolar process

- Alveolar bone along with periodontal ligament and cementum represent the tooth supporting structures
- Referred to as tooth dependent structures as it forms when the tooth erupts and disappears once the tooth is lost.

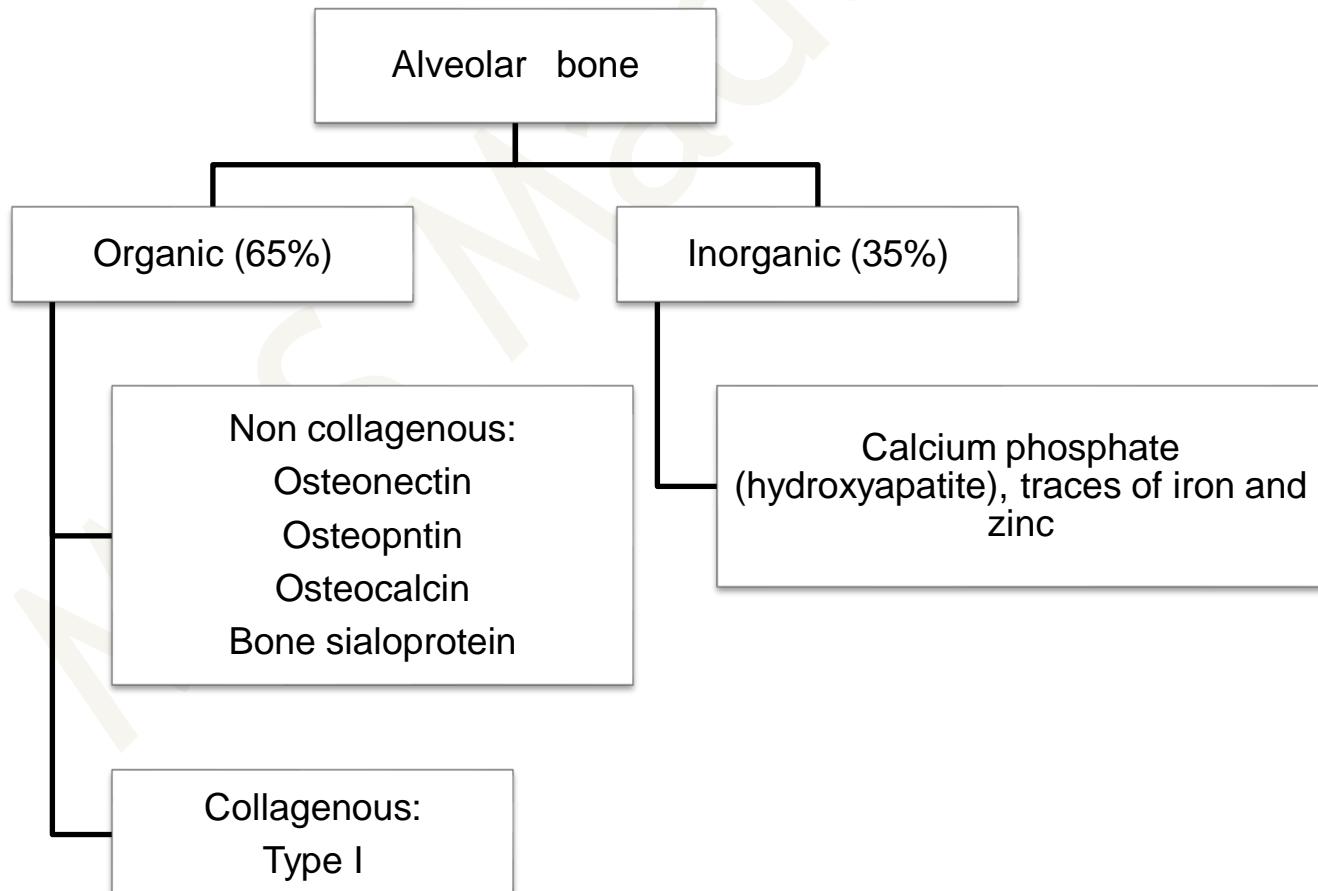
**Definition:** Alveolar process forms the portion of the maxilla and mandible which supports the tooth sockets

## DEVELOPMENT OF ALVEOLAR BONE

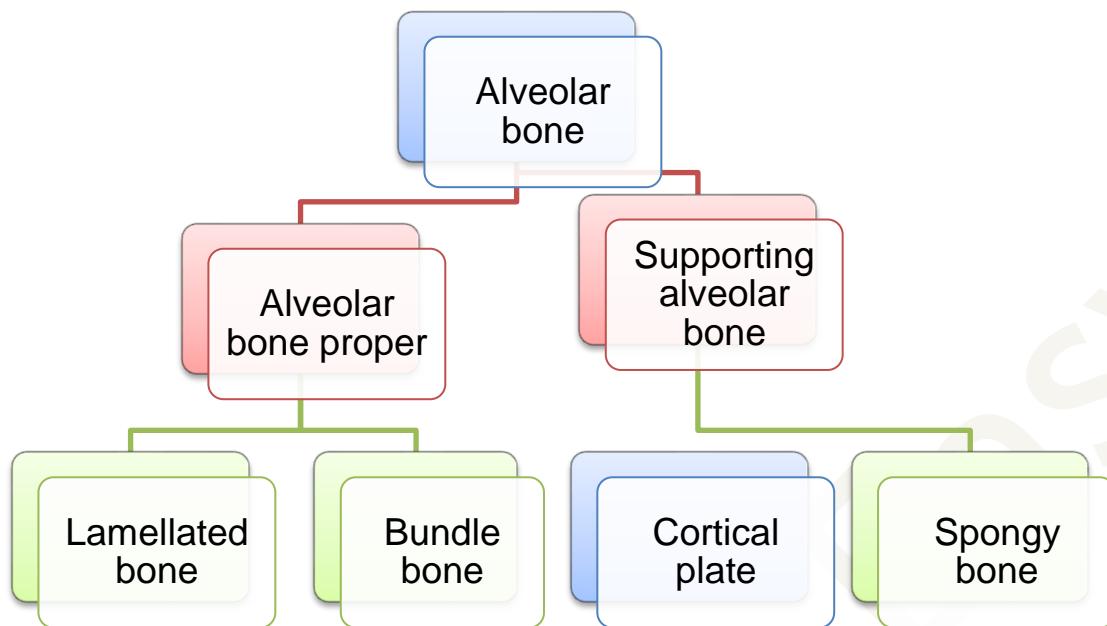
- The formation occurs during eruption of the developing tooth.
- Once root formation begins, complex interaction between the mesenchyme of the dental follicle and the Hertwig root sheath.
  - The dental follicle gives rise to cementoblasts which forms the cementum.
  - Mesenchymal cells in the dental follicle differentiate into fibroblasts, forming the periodontal ligament
  - Some of the mesenchymal cells differentiate into osteoblasts adjacent to the bone which help to form socket within the alveolar process.
  - This relationship between three structure facilitates the embedding of periodontal fibers into the cementum of the tooth and the alveolar bone proper.
    - As the root continues to form, the periodontal fibres increase its length continues to increase in length as the new root portion provides attachment to new fibers of the periodontal ligament.
    - Similarly, the alveolar bone lining the socket continues to be remodelled.
  - Bone deposition occurs in vertical direction, thereby increasing the depth of the socket.
  - The alveolar bone continues to remodel, around the root as it erupts

- Once the tooth emerges into oral cavity and establishes occlusion . The periodontal ligament absorbs and then distributes it to the surrounding alveolar process via the alveolar bone proper.
  - The alveolar bone proper provides the attachment site for sharpey fibers from the periodontal ligament
  - These collagen fibers are organized into bundles provide a strong attachment between tooth and bone. This portion of alveolar bone is sometimes referred to as bundle bone
- Bundle bone, in turn, merges with adjacent lamellar bone that comprises the alveolar process.
- The bone lining the socket is closely contoured with the tooth, and its coronal margin becomes the alveolar crest
- Under functional occlusion, the thickness of the alveolar bone also increases.

## COMPOSITION OF ALVEOLAR BONE



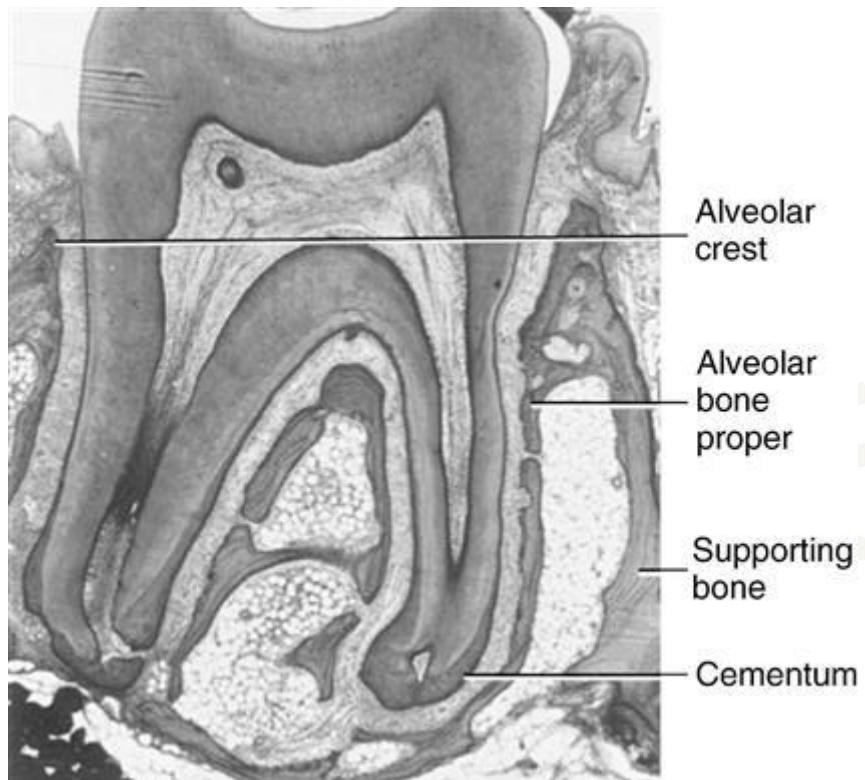
## STRUCTURE OF THE ALVEOLAR BONE



### ALVEOLAR BONE PROPER

- Forms the inner socket wall of the tooth socket, comprising of compact bone
  - Provides attachment to periodontal ligament fibres
  - Radiographically it is referred to as lamina dura
  - Thickness – 0.1 – 0.4 um
- Histologically it comprises of series of perforations Cribiform plates through which Volkmann canals pass from the alveolar bone into the PDL.

1. Lamellate bone	2. Bundle bone
<ul style="list-style-type: none"> <li>• Arranged parallel to the surface of the adjacent marrow spaces and contain haversion system.</li> </ul>	<ul style="list-style-type: none"> <li>• Bone into which the principal fibres of the periodontal ligament are embedded is called bundle bone</li> <li>• Term bundle bone refers to the bundles of the principles fibres which continue as <u>sharpey's fibres</u> insert into this bone</li> <li>• Sharpey's fibres component and perpendicular to bone surface.</li> <li>• Present in the inner wall of alveolar socket</li> <li>• Layer of fibre bundle bone 100-200 mm.</li> </ul>



### 1. Radiological Features

- Radiographically it appears as a thin opaque line called as lamina dura.
- Dense radio-opacity is due to increased amounts of calcium salts per unit area, bone being more densely packed with smaller marrow spaces than adjacent bone

### 2. Significance

- Thickness and density of bone depends on the occlusal forces the tooth is subjected.
  - Wider and dense bone – Heavy occlusal forces
  - Thinner and less bone – Teeth in hypo function.
- Presence of an intact lamina dura around the apex of a tooth suggests of a vital pulp.
- Loss of the alveolar bone suggest onset of periodontitis.

## SUPPORTING BONE

### 1. Cortical bone

- Forms the external plate of alveolar socket
- Continues with the compact layer of the maxillary and mandibular body thinner in maxilla than in the mandible.
- Outer cortical plate is perforated by several small openings, through which blood and lymph vessels pass.

#### *Variations in the cortical bone*

- Mandible: **thick**
- Maxilla: **thin**
- Anterior region of jaws: **thin**
- Premolar and molar regions: **thickest**
- Anterior region: **thin**
- Buccal cortical plate: **thick**
- Lingual cortical plate: **thin**

### 2. Spongiosa



- Present between the cortical plate and alveolar bone proper
- It is continuing with the spongy bone of the body of the jaws.
- Surrounds the lamina dura in apical and interradicular areas.

## Types of spongy bone

i. Types I	ii. Type II
<ul style="list-style-type: none"> <li>The trabeculae horizontal in a ladder-like arrangement</li> <li>It is seen most often in the mandible</li> </ul>	<ul style="list-style-type: none"> <li>irregularly arranged numerous, trabeculae.</li> <li>More common in the maxilla.</li> </ul>

Interdental and Interradicular Septa	Periosteum	Endosteum
<ul style="list-style-type: none"> <li>Contain the perforating canals of <i>Zuckerkandl and Hirschfield</i> (nutrient canals), contain arteries, veins and lymph vessels and nerves.</li> </ul>	<ul style="list-style-type: none"> <li>Is an outer fibrocollagen layer, covering the alveolar process, has two layers <ul style="list-style-type: none"> <li>Outer dense, irregular fibrous layer</li> <li>Inner layer rich in vascular supply</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Comprises of marrow Spaces in adults usually contain red marrow.</li> </ul>

## CLINICAL CONSIDERATIONS

### Fenestrations

- Isolated areas where the root is denuded of bone and root surface is covered only by periosteum and overlying gingiva is called as fenestrations.
- The marginal bone is intact
- Fenestration is more common in maxilla.

### Dehiscences

- When the denuded areas extend through the marginal bone is called as dehiscence.
- Dehiscence is more in mandible.
- Frequently seen bilateral
- More on facial surface than on lingual and more on anterior teeth than on posterior teeth.

**Significance:** Complicate the outcome of periodontal surgery.

## DISEASES AFFECTING ALVEOLAR BONE

### I. Chronic Periodontitis

- The most common immune inflammatory disease which occurs due to presence of plaque
- Untreated or improperly treated gingivitis leads to periodontitis
- Radiographically – The earliest change in the alveolar bone is a blunting of alveolar crest due to beginning bone resorption
- Resorption results in horizontal/ vertical bone loss



### II. Aggressive periodontitis

- Associated with rapid destruction of alveolar bone
- Familial aggregation seen
- Can be localized or generalized
- Vertical bone loss around maxillary molars and central incisors
- Arch shaped bone loss extending from distal of second premolar to the mesial aspect of second molar



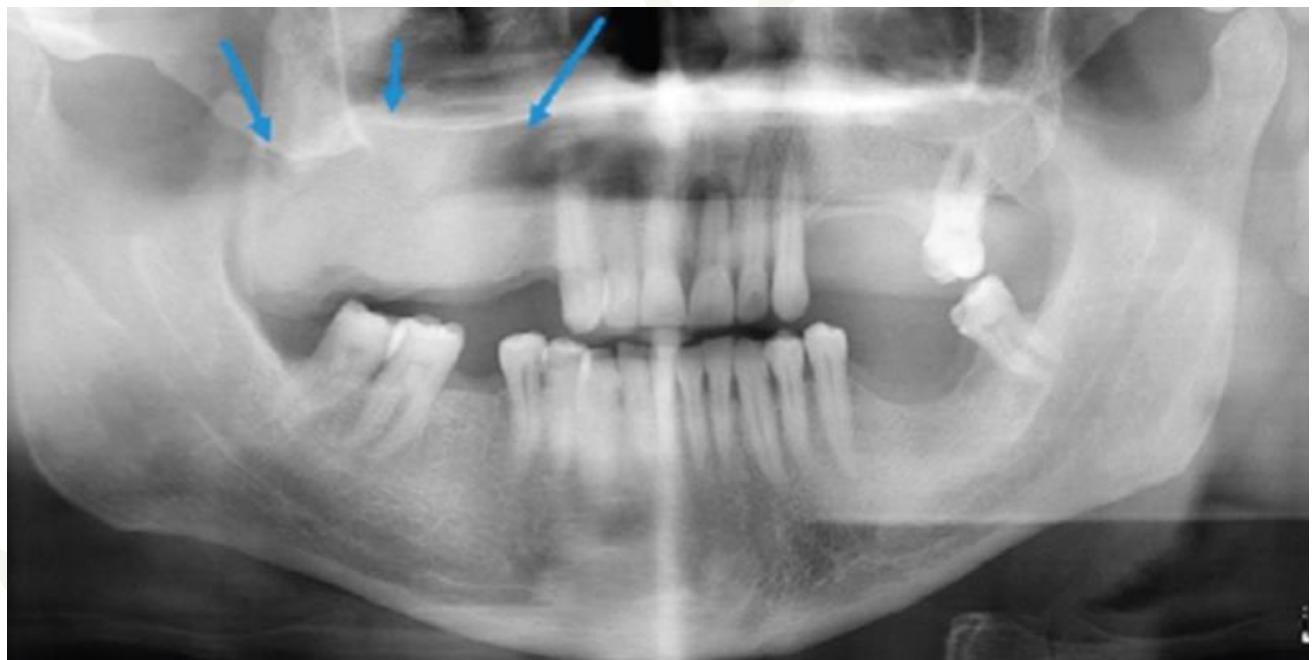
### III. Osteomalacia

- Occurs due to deficiency of Vitamin D3
- Disappearance of lamina dura
- Reduced density of superior bone loss of trabeculae,
- Increase radiolucency of trabeculae interstices and increase prominence of the remaining trabeculae.

### IV. Hyper parathyroidism

- Produces generalized demineralization of the skeleton
- Increase osteoclasia with proliferation of the connective tissue in the enlarged marrow spaces and
- Formation of bone cyst and giant cells tumors.

- Late sign of hyper parathyroidism, shows loss of lamina dura, with closely meshed. trabeculae, (ground glass appearance of bone) and radiolucent cyst like spaces.



### V. Paget's disease

- Alveolar ridge widened, if teeth present become loose and migrate, producing spacing.

- More diagnostic significance is the finding of loss of normal trabeculations and appearance of irregular osteoblasts activity “Cotton wool” appearance (Lazzy diffuse fine trabecular margin)
- Often these is loss of lamina dura, with pronounced of hypercementosis

## VI. Thalassemia

- Finding include thinning of lamina dura and circular radiolucency in the alveolar bone,
- Apparent coarsening of some trabecular and
- Blurring and disappearance of other – (Salt and pepper appearance)

## VII. Acute Leukemia

- Alteration in developing tooth crypts, destruction of lamina dura, displacement of teeth and poor radiographic definition of bone.
- Sometimes extending to the crest of the alveolar bone with destruction of the bone.

## VIII. Dysplasias

- Floridcemento osseous dysplasia
- Confined to alveolar process.
- May associated with bony expansion.

## REFERENCES

1. Schroeder H: Oral structural biology. 1991. New York, TimeMedical Publishers
2. Monje A, Chan HL, Galindo-Moreno P, Elnayef B, Suarez-Lopez del Amo F, Wang F, Wang HL : Alveolar Bone Architecture: A Systematic Review and Meta-analysis . j Periodontol. 2015 Nov;86(11):1231-48
3. Pan, W., Wang, Q. & Chen, Q. The cytokine network involved in the host immune response to periodontitis. Int J Oral Sci 2019;11:30.
4. Nanci A. Ten Cate's Oral histology: Development, structure and function, 9th edition. St Louis, Mo: Mosby/ Elsevier 2017.
5. Rajendran R, Sivapathasundharam B, Shafer WG. Shafer's textbook of oral pathology. New Delhi, Elsevier/ Reed Elsevier 2009.

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**Please Give Your Feedback on this Answer**

**Q. 05: Discuss in detail - Muscles of facial expression and how these are linked to various associated disorders (20M)**

**Discuss in detail the anatomy of the muscles of mastication and their applied anatomy/ prosthodontic considerations (20M) (10M) (7M)**

**Discuss the role of facial muscles and muscles of mastication with reference to retention and stability of complete denture (7M)**

**Discuss in detail the anatomy, applied anatomy and physiology of oral musculature (20M)**

### CONTENTS/SYNOPSIS

- Introduction
- Embryological Development
- Classifications
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    - Temporalis
    - Medial Pterygoid
    - Lateral pterygoid
  - Accessory muscles of mastication
    - Digastric
    - Mylohyoid
    - Geniohyoid
    - Stylohyoid
    - Buccinator
- Role of musculature in various mandibular movements
- Role of masticatory musculature in prosthetic procedures
- Applied Aspects
- Muscles of facial expression
  - Types of facial muscles and their action
  - Innervations
  - Applied aspects
- References

## INTRODUCTION

- Muscle refers to a group of muscle fibres which are bound by connective tissue
- Functions of a muscle:
  - Generates forces and movements used to regulate internal environment
  - Brain controls the activity of these muscles to express
- Muscles of mastication are the group of muscles that help in movement of the mandible during chewing and speech.
- They also play a role in the configuration of face.
- Four pairs of the muscles in the mandible make chewing movement possible. These muscles along with accessory ones together are termed as “*Muscles of Mastication*”

## EMBRYOLOGICAL DEVELOPMENT

- The muscular system develops from intra-embryonic mesoderm called myoblast.
- Derived from first branchial arch (mandibular arch) at 5<sup>th</sup> - 6<sup>th</sup> intrauterine life.
- At 10<sup>th</sup> week muscle mass is well organized, and nerves get incorporated.
- Striated muscles in head and neck region are formed from muscular component of branchial arch
- Muscles of mastication are derived from mandibular arch

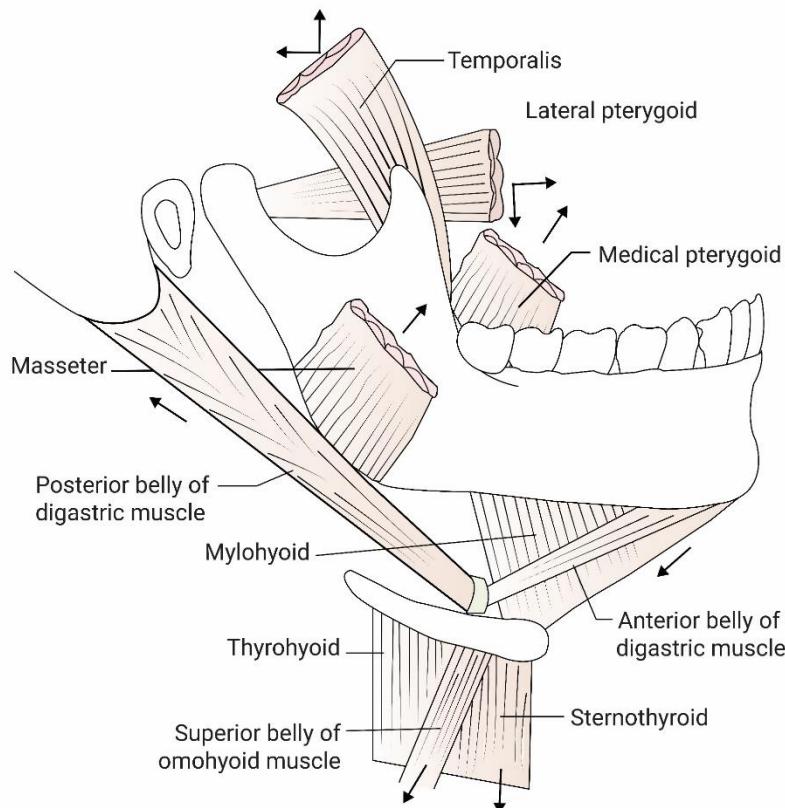
## CLASSIFICATIONS

### I. Based on Role

<i>Chief/ Primary muscles</i>	<i>Accessory or Secondary muscles</i>
<ul style="list-style-type: none"> <li>• Masseter</li> <li>• Temporalis</li> <li>• Lateral pterygoid</li> <li>• Medial Pterygoid</li> </ul>	<ul style="list-style-type: none"> <li>• Digastric</li> <li>• Stylohyoid</li> <li>• Mylohyoid</li> <li>• Geniohyoid</li> </ul>

### II. Based on function

<i>Jaw depressors</i>	<i>Jaw elevators</i>
<ul style="list-style-type: none"> <li>• Lateral pterygoid – lower head</li> <li>• Anterior Digastric</li> <li>• Mylohyoid</li> <li>• Geniohyoid</li> </ul>	<ul style="list-style-type: none"> <li>• Masseter</li> <li>• Temporalis</li> <li>• Medial Pterygoid</li> <li>• Lateral pterygoid – upper head</li> </ul>



## MUSCLES OF MASTICATION

### I. Chief Muscles

#### 1. Masseter

- One of the most powerful muscles involved in the power stroke closure of mandible
- Quadrilateral muscle covering most of the lateral aspect of ramus
- Partly tendinous, partly fleshy
- Consists of 3 layers which blend anteriorly.

i. Origin	ii. Insertion
<ul style="list-style-type: none"> <li>Superficial layer (Largest): Maxillary process of zygomatic bone + Anterior 2/3<sup>rd</sup> of inferior border of zygomatic arch.</li> <li>Middle layer: Medial aspect of ant 2/3<sup>rd</sup> of zygomatic arch + lower border of posterior third of zygomatic arch.</li> <li>Deep Layer: Deep surface of zygomatic arch.</li> </ul>	<ul style="list-style-type: none"> <li><b>Superficial layer:</b> Angle of mandible + Lower posterior half of lateral surface of ramus.</li> <li><b>Middle layer:</b> Middle part of ramus</li> <li><b>Deep Layer:</b> Upper part of ramus + coronoid process</li> </ul>
<i>iii. Direction of muscle</i>	

- Superficial: downward & slightly backward
- Deep: Vertical

*iv. Arterial supply*

- Masseteric branch of maxillary artery

*v. Nerve supply*

- Masseteric branch of anterior division of mandibular nerve

*vi. Venous drainage:* Masseteric vein

*vii. Actions of masseter*

- Active during forceful clenching/ centric occlusion
- Deep head exerts vertical forces on the mandible primarily
- Superficial head exerts vertical and anterior directed forces
- Helps in ipsilateral excursion due to the presence of origin slightly lateral to its insertion, hence contraction of masseter on one side moves the mandible to ipsilateral side

*viii. Prosthodontic significance*

- On activation masseter pushes the buccinator medially against the border of the denture in the retromolar pad area
- It is a dislodging force; hence denture base must be contoured (masseteric groove) to accommodate these actions
- If not contoured at distobuccal flange, denture will displace
- Buccal flange of maxillary buccal vestibule is influenced by buccinator, masseter.

## 2. *Temporalis*

- Fan-shaped muscle
- Largest masticatory muscle

<i>i. Origin</i>	<i>ii. Insertion</i>
<ul style="list-style-type: none"> <li>• Inferior temporal line, floor of the temporal fossa (except zygomatic bone) and overlying temporal fascia</li> </ul>	<ul style="list-style-type: none"> <li>• Coronoid process and anterior border of ascending ramus</li> </ul>

***iii. Direction of fibre***

- Anterior: Vertical
- Middle: Oblique (forward and downward)
- Posterior: Almost horizontal

***v. Arterial supply***

- Superficial temporal branch of maxillary artery.

***iv. Venous drainage***

- Superficial temporal and middle temporal vein

***vi. Nerve supply***

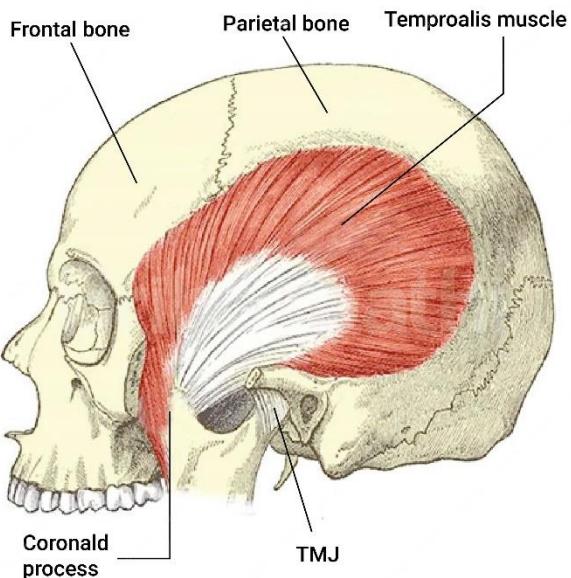
- Deep temporal branch of anterior division of mandibular nerve.

***vii. Actions of temporalis***

- Anterior contraction: elevation of mandible
- Middle contraction: Elevation and retrusion of mandible.
- Posterior: Elevation and slight retrusion of mandible, helps to keep mandible at rest (centric relation) with the patient in upright position as the fibres lie in horizontal
- Contributes to side to side grinding movement
- Helps in ipsilateral excursion

***viii. Prosthodontic significance***

- Stabilizes the TMJ during protrusion as the posterior fibres are very close to the condyle
- Suspends the mandible in centric relation by anterior fibres
- Temporal headaches are seen commonly in TMD's



### 3. *Lateral pterygoid muscle*

- Also called external pterygoid muscle
- Occupies a primarily horizontal position
- Thick short, triangular or conical muscle
- 2 heads – superior and inferior

#### *Lateral pterygoid (Inferior belly)*

<i>i. Origin</i>	<i>ii. Insertion</i>	<i>iii. Direction of fibre</i>
<ul style="list-style-type: none"> <li>• Outer surface of lateral pterygoid plate</li> </ul>	<ul style="list-style-type: none"> <li>• Neck of condyle</li> </ul>	<ul style="list-style-type: none"> <li>• Backward, Upward and Outward.</li> </ul>

#### *Lateral pterygoid (Superior belly)*

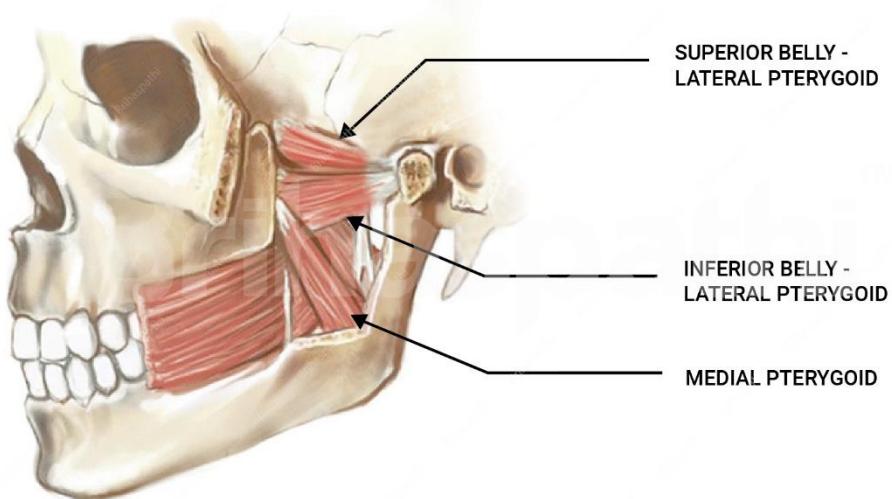
<i>i. Origin</i>	<i>ii. Insertion</i>	<i>iii. Direction of fibre</i>
<ul style="list-style-type: none"> <li>• Infratemporal surface of the greater sphenoid wing</li> </ul>	<ul style="list-style-type: none"> <li>• Articular capsule, (30%-40% fibers) disc and neck of condyle (60%-70%).</li> </ul>	<ul style="list-style-type: none"> <li>• Horizontally, backward and outwards.</li> </ul>

#### *v. Arterial supply*

- Maxillary artery and ascending palatine artery

#### *iv. Nerve supply*

- Lateral pterygoid branch of anterior division of mandibular nerve.



#### vi. Actions of lateral pterygoid

Inferior belly	Superior belly
<ul style="list-style-type: none"> <li>Bilateral contraction: Pulls condyles down the articular eminences &amp; protrudes mandible.</li> <li>Unilateral contraction: Mediotrusive movement of that condyle and lateral movement of condyle to opposite side.</li> </ul>	<ul style="list-style-type: none"> <li>Inactive during opening</li> <li>Active during power stroke (movement of mandible against resistance).</li> <li>Responsible for the medial pull on the articular disc.</li> </ul>

#### vii. Prosthodontic significance

- During closure of mouth, the backward gliding of articular disc and condyle is controlled by lateral pterygoid while masseter and temporalis stabilizes and restores the mandible in occlusal position
- Holds the condyles in centric relation
- Most involved in MPDS
- Unilateral failure to contract results in deviation of mandible towards the affected side on opening
- Bilateral failure causes limited opening, loss of protrusion and loss of full lateral deviation

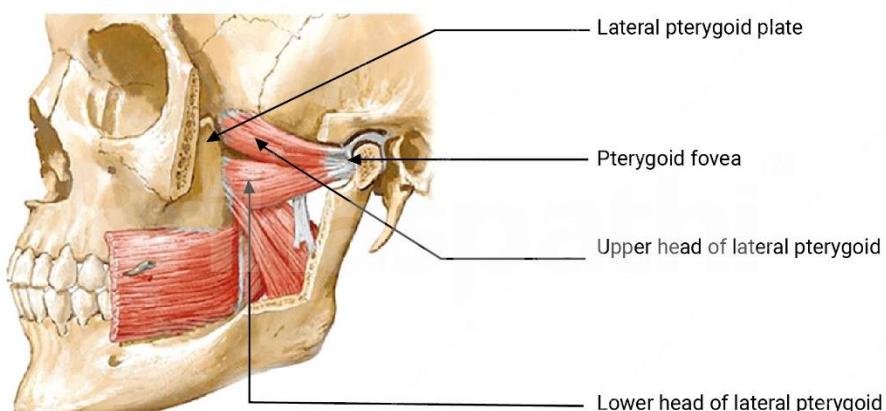
#### 4. Medial pterygoid muscle

- Also called internal pterygoid muscle
- Mirror like image of masseter
- Rhomboidal in shape
- 2 heads (superficial and deep).

<i>i. Origin</i>	<i>ii. Insertion</i>	<i>iii. Direction of fibre</i>	<i>iv. Function</i>
<ul style="list-style-type: none"> <li>Superficial head: Maxillary tuberosity</li> <li>Deep head: Medial surface of lateral pterygoid plate and part of palatine bone</li> </ul>	<ul style="list-style-type: none"> <li>Downward, Backward and Outward.</li> </ul>	<ul style="list-style-type: none"> <li>Medial surface of angle of mandible</li> </ul>	<ul style="list-style-type: none"> <li>Elevation of mandible.</li> <li>Unilateral contraction: Mediotrusive movement of the mandible.</li> </ul>
<i>v. Arterial supply</i>		<i>vi. Nerve supply</i>	
<ul style="list-style-type: none"> <li>Pterygoid branch of maxillary artery</li> </ul>		<ul style="list-style-type: none"> <li>Branch of main trunk of mandibular nerve</li> </ul>	

#### vii. Prosthodontic significance

- Most involved in MPDS
- Involved in trismus following IAN Block



## II. Accessory Muscles of Mastication

### 1. *Digastric muscle*

<i>i. Origin</i>	<i>ii. Insertion</i>	<i>iii. Function</i>	<i>iv. Nerve Supply</i>
<ul style="list-style-type: none"> <li>Anterior belly: digastric fossa of mandible, lateral to mental symphysis.</li> <li>Posterior belly: mastoid notch of temporal bone.</li> </ul>	<ul style="list-style-type: none"> <li>Both meet at the intermediate tendon and held by the fibrous pulley to the hyoid bone.</li> </ul>	<ul style="list-style-type: none"> <li>Depression of jaw, both sides contract simultaneously.</li> <li>Provide antagonism to elevation of mandible.</li> <li>Elevation of hyoid during swallowing.</li> </ul>	<ul style="list-style-type: none"> <li><b>Anterior belly:</b> nerve to Mylohyoid.</li> <li><b>Posterior belly:</b> facial nerve</li> </ul>

### 2. *Mylohyoid muscle*

- Flat, triangular muscle lying deep to the anterior belly of digastric
- It forms the floor of the mouth.

<i>i. Origin</i>	<i>ii. Insertion</i>	<i>iii. Function</i>	<i>iv. Nerve supply</i>
<ul style="list-style-type: none"> <li>Mylohyoid line of mandible</li> </ul>	<ul style="list-style-type: none"> <li><b>Middle and anterior fibers:</b> median raphae.</li> <li><b>Posterior fibers:</b> body of hyoid bone.</li> </ul>	<ul style="list-style-type: none"> <li>Helps in depression of mandible, elevation of hyoid bone. It elevates the floor of mouth to help in deglutition.</li> </ul>	<ul style="list-style-type: none"> <li>Nerve to Mylohyoid</li> </ul>

### 3. *Geniohyoid muscle*

- Short and narrow muscle lies above Mylohyoid

<i>i. Origin</i>	<i>ii. Insertion</i>	<i>iii. Function</i>	<i>iv. Nerve supply</i>
<ul style="list-style-type: none"> <li>Inferior mental spine (genial tubercle)</li> </ul>	<ul style="list-style-type: none"> <li>anterior surface of the body of hyoid bone</li> </ul>	<ul style="list-style-type: none"> <li>Carry hyoid bone and the tongue upward during deglutition</li> </ul>	<ul style="list-style-type: none"> <li>1st Cranial nerve, the fibers pass through hypoglossal nerve</li> </ul>

#### 4. Stylohyoid muscle

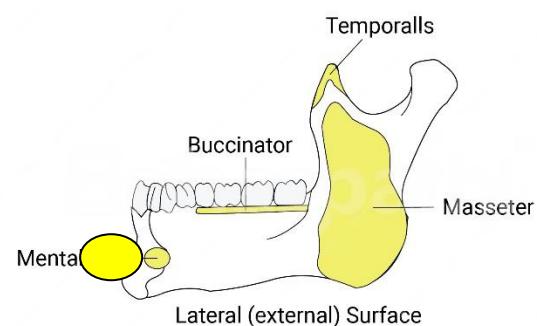
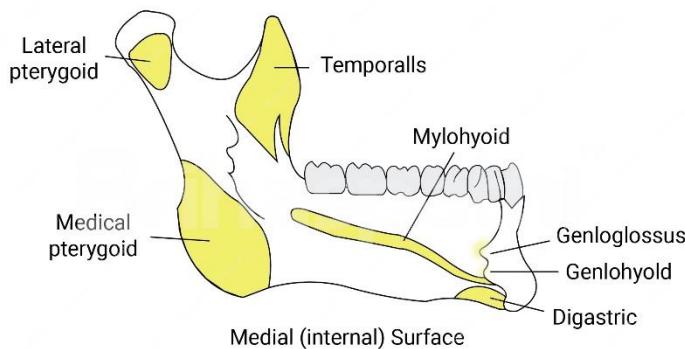
- Small muscle that lies along the upper border of the posterior belly of digastric muscle.

Origin	Insertion	Function	Nerve supply
<ul style="list-style-type: none"> <li>From the lateral &amp; inferior surface of the styloid process of temporal bone</li> </ul>	<ul style="list-style-type: none"> <li>body of the hyoid bone, at its junction with the greater cornu.</li> </ul>	<ul style="list-style-type: none"> <li>Pulls hyoid bone upwards and backwards</li> </ul>	<ul style="list-style-type: none"> <li>Branch from facial nerve</li> </ul>

#### 5. Buccinator muscle

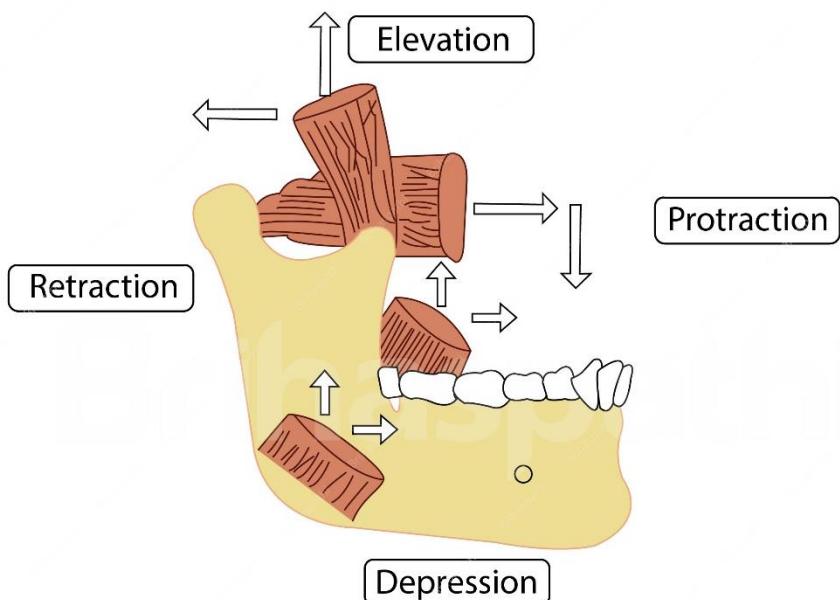
- Occupies the gap between mandible and maxilla forming important part of the cheek.

i. Origin	ii. Insertion	iii. Function	iv. Nerve supply
<ul style="list-style-type: none"> <li><b>Upper fibers:</b> From maxilla opposite molar teeth.</li> <li><b>Middle fibers:</b> From pterygomandibular raphe.</li> <li><b>Lower fibers:</b> From mandible opposite molar</li> </ul>	<ul style="list-style-type: none"> <li><b>Upper fibers:</b> Straight to the upper lip</li> <li><b>Middle fibers:</b> Decussate before passing to the lips</li> <li><b>Lower fibers:</b> Straight to the lower lip</li> </ul>	<ul style="list-style-type: none"> <li>Flatten cheek against gums and teeth, prevent accumulation of food in the vestibule of mouth and to bring the food on to the occlusal table during mastication.</li> </ul>	<ul style="list-style-type: none"> <li>Branch from facial nerve</li> </ul>



## ROLE OF MUSCULATURE IN VARIOUS MANDIBULAR MOVEMENTS

I. Elevation	II. Depression
<ul style="list-style-type: none"> <li>Right &amp; left temporalis muscles (anterior fibres)</li> <li>Right &amp; left masseter muscles</li> <li>Right &amp; left medial pterygoid muscles</li> </ul>	<ul style="list-style-type: none"> <li>Right &amp; left inferior heads of lateral pterygoids</li> <li>Right &amp; left suprathyoid and infrathyoid muscles</li> <li>Anterior belly of digastric &amp; mylohyoid</li> </ul>
III. Protrusion	IV. Retruson
<ul style="list-style-type: none"> <li>Right &amp; left inferior heads of lateral pterygoid</li> <li>Right &amp; left medial pterygoids</li> <li>Right &amp; left superior heads of masseter</li> </ul>	<ul style="list-style-type: none"> <li>Right &amp; left posterior fibres of temporalis</li> <li>Right &amp; left deep heads of masseter</li> </ul>
V. Right lateral excursion	VI. Left lateral excursion
<ul style="list-style-type: none"> <li>Right masseter, right temporalis, left medial pterygoid and left lateral pterygoid</li> </ul>	<ul style="list-style-type: none"> <li>Left masseter, left temporalis, right medial pterygoid and right lateral pterygoid</li> </ul>



## ROLE OF MASTICATORY MUSCLES IN PROSTHETIC PROCEDURES

### I. Border molding

- Tray extensions should be checked to avoid contraction and obliteration of sulcus by buccinator and masseter.
- Periphery should be trimmed to about 2mm short to occupy the buccal vestibule in function

### II. Freeway space

- Freeway space is seen when the mandible is at rest and is supported by elevator muscles which are not completely relaxed but are in a state of tonic contraction partially.
- It is enough to balance the tonicity of depressor muscles and gravity

## APPLIED ASPECTS

### I. Trismus

- Due to prolonged tetanic spasm of the jaw muscles by which normal opening of the mouth is restricted.
- Restricted jaw movements.

### Causes

- Intracapsular: Arthritis Condylar fracture
- Pericapsular: Irradiation Dislocation Infection & inflammation
- Muscular: TMJ dysfunction syndrome Tetanus
- Other: Oral sub mucous fibrosis, Systemic sclerosis, Fractures

1. Problems	2. Treatment
<ul style="list-style-type: none"> <li>• Eating issues</li> <li>• Oral hygiene issues</li> <li>• Swallowing issues</li> <li>• Joint immobilization</li> </ul>	<ul style="list-style-type: none"> <li>• Removal of the cause</li> <li>• Heat therapy</li> <li>• Warm saline rinses</li> <li>• NSAIDs</li> <li>• Passive muscle stretching exercises</li> </ul>

### II. Bruxism

- Bruxism is the clenching or grinding of the teeth when the individual is not chewing or swallowing
- It can occur as a brief rhythmic strong contraction of the jaw muscles during eccentric lateral jaw movements, or in maximum intercuspsation, which is called clenching.

1. Causes	2. Treatment
<ul style="list-style-type: none"> <li>Associated with stressful events</li> <li>Non stress related or hereditary Bruxism</li> <li>May lead to: Tooth wear Fracture of the teeth or restoration Muscle hypertrophy</li> <li>Increased muscle tension is directly related to stress activity during the day.</li> </ul>	<ul style="list-style-type: none"> <li>Coronoplasty</li> <li>Maxillary stabilization appliance</li> </ul>

### III. Tetanus (lock jaw)

- Tetanus is a disease of the nervous system characterized by intense activity of motor neuron and resulting in severe muscle spasm
- Caused by exotoxins of gram-positive bacillus, clostridium tetani.

1. Clinical features	2. Treatment
<ul style="list-style-type: none"> <li>Pain and stiffness in the jaws and neck muscles, with muscle rigidity producing trismus and dysphagia</li> <li>Rigidity of facial muscles</li> <li>Sometimes whole body becomes affected.</li> </ul>	<ul style="list-style-type: none"> <li>All patients should receive antimicrobial drugs</li> <li>Active and passive immunization.</li> <li>Surgical wound care</li> <li>Anticonvulsant if indicated</li> </ul>

### IV. Myofacial pain dysfunction syndrome (MPDS)

- Muscular disorders (myofacial pain disorders) are the most common cause of TMJ pain associated with masticatory muscles.

1. Etiology	2. Treatment
<ul style="list-style-type: none"> <li>High stress level</li> <li>Habits including gum chewing, bruxism, hard candy chewing</li> <li>Poor dentition</li> </ul>	<ul style="list-style-type: none"> <li>Muscle exercises</li> <li>Drugs involving NSAIDs and muscle relaxants.</li> <li>Bite appliance</li> </ul>

## V. Congenital hypoplasia/ hyperplasia

- It occurs very rarely and is more common in masseter and orbicularis oris.

### Symptoms

- Enlargement or decreased size of the affected muscle, which may show an asymmetric facial pattern and stiffness in the temporomandibular joint.
- It may or may not be associated with hypermobility/ hypo mobility of the muscles.

## VI. Muscle hypermobility/ hypomobility

- This disorder involves extreme or diminished activity of the masticatory muscles.

### Etiology

- Decreased/ increased threshold potential of neural activity.
- Parkinsonism
- Facial paralysis
- Nerve decompression
- Secondary involvement of systemic diseases.

## MUSCLES OF FACIAL EXPRESSION

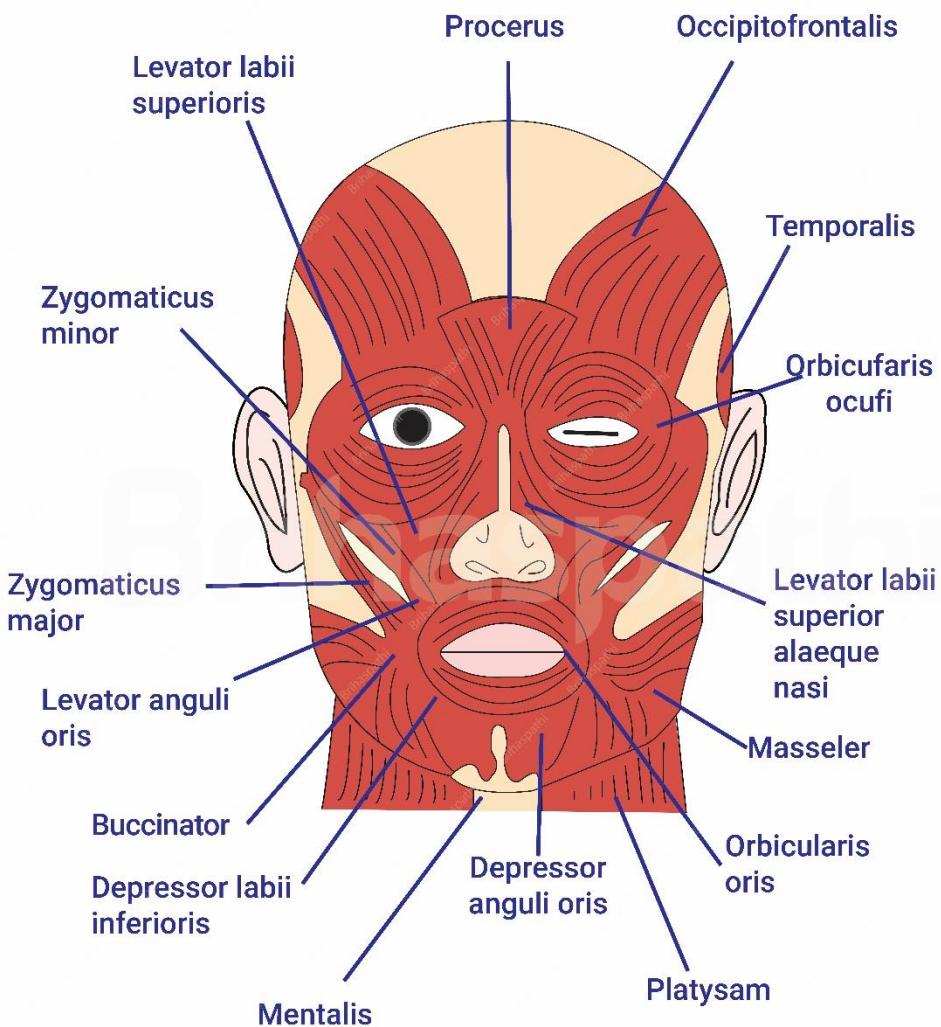
- Facial muscles are striated skeletal muscles, innervated by facial nerve which controls the facial expression
- Also called as mimetic muscles
- Developed from second pharyngeal arch

## I. Types of facial muscles and their action

1. <i>Orbicularis oculi</i>	2. <i>Levator palpebrae superioris</i>
<ul style="list-style-type: none"> <li>Closes and squints the eye</li> <li><u>Wink, perplexion, concern</u></li> </ul>	<ul style="list-style-type: none"> <li>Elevates the upper eyelid</li> <li><u>Surprise and fear</u></li> </ul>
3. <i>Corrugator supercilii</i>	4. <i>Nasalis</i>
<ul style="list-style-type: none"> <li>Draws the eyebrow inferomedially</li> <li>Shows <u>anger and concern</u></li> </ul>	<ul style="list-style-type: none"> <li>Maxilla to the cartilage of the nose and opposite side of nasalis muscle</li> <li><u>Compresses nares</u></li> </ul>
5. <i>Procerus</i>	6. <i>Depressor septi nasi</i>
<ul style="list-style-type: none"> <li>Fascia and skin medial to the</li> </ul>	<ul style="list-style-type: none"> <li>From medial fibre of dilator naris</li> </ul>

<p>eyebrow to the fascia and</p> <ul style="list-style-type: none"> <li>• To the skin over the nasal bone</li> <li>• Gives <u>disdain look</u></li> </ul>	<p>muscle to the mobile part of nasal septum</p> <ul style="list-style-type: none"> <li>• Depresses septum and narrows nostril</li> </ul>
<p><b>7. <i>Levator labii superioris</i></b></p>	<p><b>8. <i>Levator labii superioris alaeque nasi</i></b></p>
<ul style="list-style-type: none"> <li>• Infraorbital head and zygomatic head to upper lip</li> <li>• Raises upper lip</li> <li>• Helps in nasolabial furrow</li> <li>• <u>Disgust, smugness</u></li> </ul>	<ul style="list-style-type: none"> <li>• Frontal nasal process to one to ala and other to orbicularis oris</li> <li>• Raises upper lip and opens nostril</li> <li>• <u>Anger and contempt</u></li> </ul>
<p><b>9. <i>Levator angulii oris</i></b></p>	<p><b>10. <i>Risorius</i></b></p>
<ul style="list-style-type: none"> <li>• Maxilla below infraorbital foramen and canine fossa to the angle of mouth</li> <li>• Elevates the angle of mouth</li> <li>• <u>Smile, sneer, Dracula expression</u></li> </ul>	<ul style="list-style-type: none"> <li>• From superficial fascia over parotid to skin and mucosa on lip angle</li> <li>• Retracts corner of mouth</li> <li>• <u>Grin, smile, laugh</u></li> </ul>
<p><b>11. <i>Zygomaticus major</i></b></p>	<p><b>12. <i>Zygomaticus minor</i></b></p>
<ul style="list-style-type: none"> <li>• From zygomatic bone and arch to angle of mouth</li> <li>• Draws the corner of the mouth upward and laterally</li> <li>• <u>Smile and laugh</u></li> </ul>	<ul style="list-style-type: none"> <li>• From zygomatic bone and medial to zygomatic major to nasolabial groove</li> <li>• Draws the upper lip upward</li> <li>• <u>Smile and smugness</u></li> </ul>
<p><b>13. <i>Depressor anguli oris/ triangularis</i></b></p>	<p><b>14. <i>Depressor labii inferioris</i></b></p>
<ul style="list-style-type: none"> <li>• From oblique line of mandible to angle of mouth</li> <li>• Draws corner of mouth down and lateral</li> </ul>	<ul style="list-style-type: none"> <li>• From base of mandible to skin and mucosa of lower lip</li> <li>• Draws lower lip downward and laterally</li> <li>• <u>Sadness, uncertainty and dislike</u></li> </ul>
<p><b>15. <i>Mentalis</i></b></p>	<p><b>16. <i>Orbicularis oris</i></b></p>
<ul style="list-style-type: none"> <li>• From mandible below lower incisors to skin of chin</li> <li>• Raises and protrudes lower lip as it wrinkles skin and chin</li> </ul>	<ul style="list-style-type: none"> <li>• From buccinator muscle to angle of mouth (upper lip) and mandible (lower lip)</li> <li>• <u>Closes lip, protrudes lips, puckering</u></li> </ul>

• <u>Doubt, pout and disdain</u>	<u>and whistling</u>
<b>17. Buccinator</b>	<b>18. Platysma</b>
<ul style="list-style-type: none"> <li>From alveolar process of maxilla and mandible</li> <li>In areas of molar and pterygomandibular ligament</li> <li>Presses the cheek against teeth</li> <li>Compresses distended cheeks</li> <li><u>Pucker, exertion and sigh</u></li> </ul>	<ul style="list-style-type: none"> <li>From skin and superficial fascia of pectoral and deltoid region to lower border of mandible</li> <li>Draws up the skin of the superior chest and neck</li> <li><u>Black lagoon creature expression</u></li> </ul>
<b>19. Occipitofrontalis (front belly)</b>	<b>20. Occipitofrontalis (Occipital belly)</b>
<ul style="list-style-type: none"> <li>From anterior part of galea aponeurotica to skin on lower part of forehead</li> <li><u>Wrinkles forehead and raises eyebrows</u></li> </ul>	<ul style="list-style-type: none"> <li>From lateral 2/3rd of superior nuchal line to posterior part of galea aponeurotica</li> <li>Draws scalp backward</li> </ul>
<b>21. Anterior auricular</b>	<b>22. Superior auricular</b>
<ul style="list-style-type: none"> <li>Draws ear upward and forward</li> </ul>	<ul style="list-style-type: none"> <li>Elevate ear</li> </ul>
<b>23. Posterior auricular</b>	
<ul style="list-style-type: none"> <li>Draws ear upward and backward</li> </ul>	



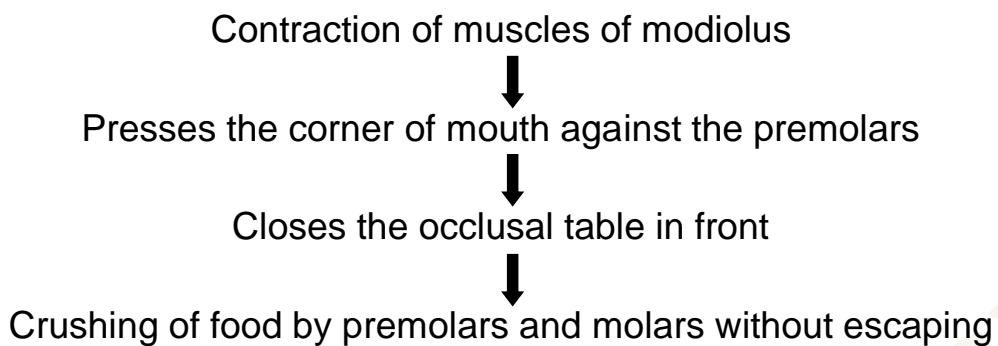
## II. Prosthodontic significance

### 1. Modiolus

- It is a convergence of nine muscles lateral to the buccal angle

- i. **Cruciate modiolar muscles:** Zygomaticus major, depressor anguli oris, platysma pars modiloaris, levator anguli oris
- ii. **Transverse muscles:** Buccinator, risorius, incisive superior and inferior, orbicularis oris

## Action



- Border molding using functional movements by holding the modiolus
- Helps in establishing the occlusal plane height of maxillary rim
- Used as landmarks for the height of premolars

## 2. Neutral zone

- It is a potential denture space at which the forces of tongue pressing outwards is neutralized by forces of cheek muscles and lips pressing inwards.
- A clinically recorded neutral zone and transferred to the dentures gives stability to the dentures

## III. Applied aspects

### 1. Bell's palsy

- Charles Bell described Bell's palsy in the year
- It is common, acute and benign neurological disorder due to sudden isolated peripheral facial nerve paralysis
- Unknown etiology

#### Clinical features

- Complete or partial face involvement
- Loss of facial expressions on one side
- Unable to whistle, blow, smile and grimace
- Increases lacrimation, loss of taste, hypersensitivity to sound, metallic taste
- Facial weakness
- Difficulty in articulation
- Unable to close the eye completely

### Treatment

- Medications prescribed are oral corticosteroids.

### CONCLUSION

- Masticatory system is a complex one with bones, muscles, ligaments and teeth
- Precise movements of musculature of mandible is needed for the teeth to effectively perform functions
- Hence knowledge of anatomy, physiology and mechanisms of these muscles is essential to understand

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Please Give Your Feedback on this Answer

**Q. 11: Development of mandible (7M)****Write in detail about the growth and development of the mandible (20M) (10M)****CONTENTS/SYNOPSIS**

- Introduction
- Development of mandible
  - Meckel's cartilage
  - Development of Body
  - Development of Ramus
  - Fate of Meckel's cartilage
  - Further Development
    - Condylar cartilage
    - Coronoid cartilage
    - Symphyseal cartilage
  - Development of alveolar process
- Growth of mandible
  - Growth by secondary cartilage
  - Development of the alveolar process
  - Subperiosteal bone apposition and bone resorption
- Age Related Changes
- Clinical Considerations
  - Developmental disturbances
  - Abnormalities of dental arch relations
  - Developmental cyst
- References

## INTRODUCTION

- Mandible is the largest and strongest bone of the face, serves for the reception of the lower teeth.
- Parts of mandible: body which meets in midline at symphysis, 2 rami, 2 condylar heads, 2 coronoid processes.

## DEVELOPMENT OF MANDIBLE

- About the fourth week of intrauterine life, the pharyngeal arches are laid down  
→ The first arch is called the mandibular arch.

The first branchial arch



Divides into a maxillary process and a mandibular process

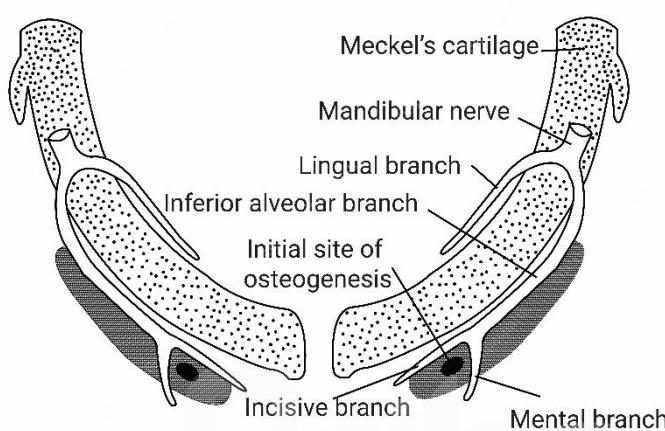


Forms the bones of the lower two-thirds of the face and the jaw.

- The maxillary process becomes the maxilla (or upper jaw), and palate while the mandibular process becomes the lower jaw.
- The first structure to develop in the primordium of the lower jaw is the mandibular division of trigeminal nerve.

### I. Meckel's cartilage

- It has a close, relationship to the mandibular nerve → at the junction between posterior and middle thirds, where the mandibular nerve divides into the lingual and inferior dental nerve.
- The lingual nerve passes forward, on the medial side of the cartilage, while the inferior dental lies lateral to its upper margins & runs forward parallel to it and terminates by dividing into the mental and incisive branches.



## II. Development of Body

- At 6 weeks of development, Meckel's cartilage extends as a solid hyaline cartilaginous rod surrounded by a fibrocellular capsule.
- Their proximal or cranial ends are connected with the ear capsules, and their distal extremities are joined to one another at the symphysis by mesodermal tissue.

### **Ossification:**

- On the lateral aspect of Meckel's cartilage, during the 6th week of embryonic development, a condensation of mesenchyme occurs in the angle formed by the division of inferior alveolar nerve and its incisor and mental branches.
  - 7th week → ossification begins at this site
- 
- From this centre of ossification, bone formation spreads rapidly anteriorly to the midline and posteriorly to the point
    - Where the mandibular nerve divides into lingual and inferior alveolar branch.
  - The new bone forms a trough that consists of medial and lateral plates that unite beneath the nerve.
  - The trough is soon converted into a canal as bone forms over the nerve, joining the lateral and medial plates.

## III. Development of Ramus

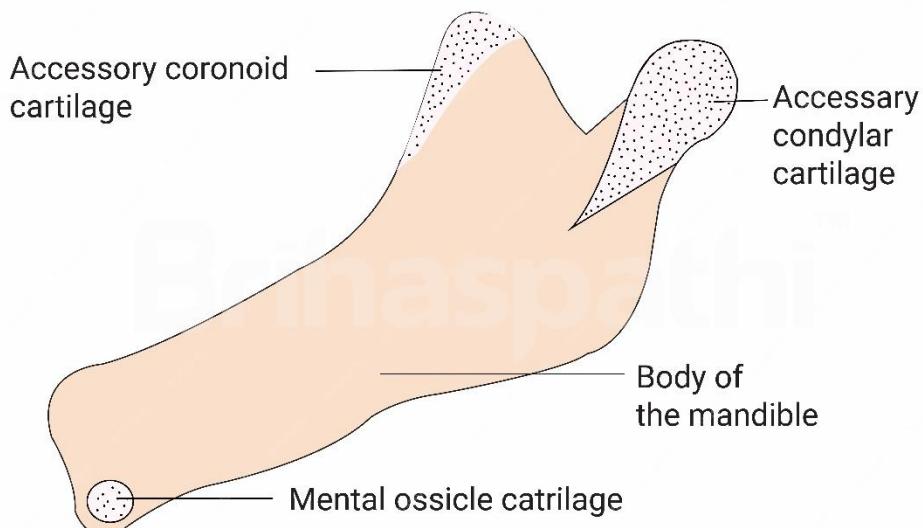
- The ramus of the mandible develops by a rapid spread of ossification backwards into the mesenchyme of the first branchial arch diverging away from Meckel's cartilage.
- This point of divergence is marked by the lingula in adult mandible, where the inferior alveolar nerve enters mandibular foramen.
- By 10 weeks: rudimentary mandible is formed almost entirely by intramembranous ossification.

#### IV. Fate of Meckel's cartilage

- Its posterior end forms the malleus and incus of the inner ear and the sphenomalleolar ligament
- Its fibrocellular capsule persists to form the sphenomandibular ligament
- From the lingula forward to the division of the alveolar nerve into its incisor and mental branches, Meckel's cartilage degenerates.

#### V. Further development

- Influenced by the appearance of 3 secondary cartilages:
  1. Condylar cartilage
  2. Coronoid cartilage
  3. Symphyseal cartilage



##### 1. Condylar cartilage

- Carrot shaped cartilage
- Appears at 12 weeks of development in the region of the condyle and occupies most of the developing ramus.
- Converted to bone by endochondral ossification
- Develops into Condyle head and neck of the mandible.
- The posterior half of the ramus to the level of inferior dental foramen
- At 20 weeks a thin layer of cartilage remains in the condylar head.

**2. Coronoid cartilage**

- It is relatively transient growth cartilage centre
- Appears at 4th month of development
- Develops into Coronoid process and anterior half of the ramus to the level of inferior dental foramen
- Disappears long before birth

**3. Symphyseal cartilage**

- 2 in number, appear in the connective tissue between the 2 end of Meckel's cartilage
- They are obliterated within the 1st year after birth.

**VI. Development of alveolar process**

Starts when the deciduous tooth germs reach the early bell stage



Bone begins to grow on each side of the tooth germ



Tooth germs come to be in a trough or groove of bone, which also includes the alveolar nerves and blood vessels



Septa of bone between the adjacent tooth germs develop



Keep each tooth separate in its bony crypt



The mandibular canal is separated from the bony crypts by a horizontal plate of bone



The alveolar processes grow at a rapid rate during the periods of tooth eruption

**GROWTH OF THE MANDIBLE**

Occurs in following ways

- Growth by secondary cartilage
- Development of the alveolar process
- Subperiosteal bone apposition and bone resorption

## I. Growth by secondary cartilage (mainly condylar cartilage)

- Increase in height of the mandibular ramus
- Increase in the overall length of the mandible
- Increase of the inter condylar distance

## II. Development of the alveolar process

- Due to the increase in the space between the upper and lower jaws a space is created between the opposing teeth to erupt.
- At the same time bone apposition occurs at the crest of the alveolar process and the fundus of the alveolus.
- This means that bone deposition contributes to the growth of the body of the mandible in height.

## III. Subperiosteal bone apposition and bone resorption

<i>Bone deposition</i>	<i>Bone resorption</i>	<i>Result</i>
• External surface of the mandible	• Inner surface of the mandible	• Increase the transverse dimension
• Posterior border of the ramus	• Anterior border of the ramus	• Adjust the thickness of the ramus
• Anterior border of the coronoid process	• Posterior border of the coronoid process	• Displacement of the coronoid process
• Chin region	-	• Modeling of the lower face

## AGE CHANGES IN THE MANDIBLE

	<b>At birth</b>	<b>Adulthood</b>	<b>Old Age</b>
<b>1. Mandibular canal</b>	Above mylohyoid line	Parallel to mylohyoid line	Run closer to upper border
<b>2. Mental foramen</b>	Mental foramen opens beneath the socket of the first deciduous molar tooth. Lies near lower border	Middle of the bone	Near upper border
<b>3. Angle</b>	Angle is obtuse (175°), and the condyloid portion is nearly in line with the	110° – 120°	Obtuse 140°

	body.		
<b>4. Coronoid and condylar process</b>	coronoid process is of comparatively large size, and projects above the level of the condyle.	Condyle is above coronoid	Condyle is above coronoid
<b>5. Symphysis menti</b>	Present and 2 halves are united by fibrous band	Present as a faint ridge only on upper part	Absent or not recognizable

## CLINICAL CONSIDERATIONS

### I. Developmental disturbances

<b>1. Agnathia</b>	<ul style="list-style-type: none"> <li>• Hypoplasia or absence of mandible</li> <li>• The entire mandible or one side may be missing or only the condyle or the entire ramus.</li> </ul>
<b>2. Micrognathia</b>	<ul style="list-style-type: none"> <li>• Means small jaw</li> <li>• Can be due to small jaw or to an abnormal positioning or abnormal relation of one jaw to another.</li> </ul>
<b>3. Macrognathia</b>	<ul style="list-style-type: none"> <li>• Abnormally large jaws</li> </ul>
<b>4. Facial hemihypertrophy</b>	<ul style="list-style-type: none"> <li>• Exhibits an enlargement which is confined to one side of the body, unilateral macroglossia, and premature development, and eruption as well as increased size of dentition.</li> </ul>
<b>5. Facial hemiatrophy</b>	<ul style="list-style-type: none"> <li>• Progressive wasting of subcutaneous fat accompanied by atrophy of skin, cartilage, bone and muscle.</li> </ul>

## II. Abnormalities of dental arch relations



Skeletal Class III  
Facial Profile



Skeletal Class I  
Facial Profile



Skeletal Class II  
Facial Profile

## III. Developmental cyst

### 1. Median mandibular cyst

- Originate from proliferation of epithelial remnants entrapped in the median mandibular fissure during fusion of the bilateral mandibular arches.
- Primordial cyst originating from a supernumerary enamel organ in the anterior mandibular segment.

### 2. Alveolar cyst of newborn

- Arise from epithelial remnants of deeply budding dental lamina during tooth development

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*Please Give Your Feedback on this Answer*

**Q. 13: Development of palate and its applied anatomy (7M)****Development of plate and its anomalies (6M)****Development of palate and note on cleft palate (6M)****CONTENTS/SYNOPSIS**

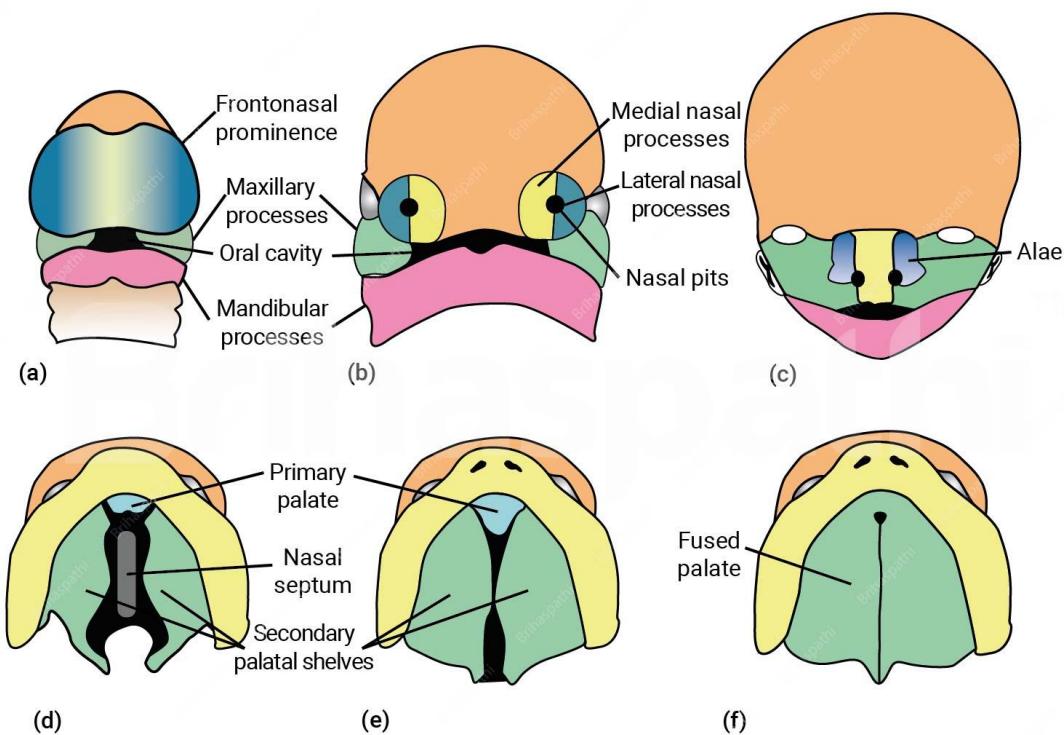
- Introduction
- Development of palate
- Hard palate
  - Anatomic relations
  - Arterial supply
  - Venous drainage
  - Nerve supply
- Soft palate
  - External features
    - Anterior (oral) surface
    - Posterior surface
    - Superior border
    - Inferior border
  - Muscles of the Soft Palate
  - Functions of the Soft Palate
  - Arterial Supply of Soft Palate
  - Venous Drainage of Soft Palate
  - Lymphatic Drainage of Soft Palate
  - Nerve Supply of Soft Palate
    - Motor supply
    - Sensory supply
    - Secretomotor Supply to Palatine Glands
- Applied aspects
  - Cleft palate
  - Muscle paralysis
  - Developmental swellings of palate
- Prosthodontic significance
- Conclusion
- References

## INTRODUCTION

- It is an osteomuscular partition between nasal and oral cavities.
- It also separates nasopharynx from oropharynx.
- The palate consists of two parts:
  - Hard palate: It forms the anterior 2/3rd of the palate.
  - Soft palate: It forms the posterior 1/3rd of the palate.

## DEVELOPMENT OF PALATE

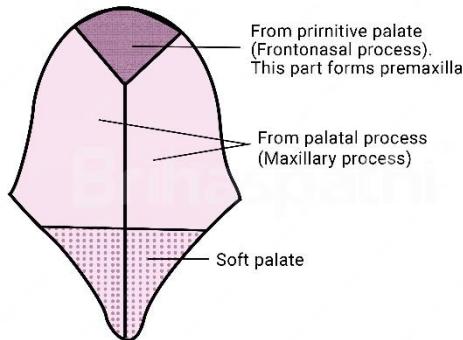
- Fusion of the two medial nasal processes of frontonasal process at a deeper level forms a wedge-shaped mass of mesenchyme opposite upper jaw carrying four incisor teeth.
- The part of the palate derived from the frontonasal process forms the premaxilla or primary palate which carries the incisor teeth.
- The palatine processes of maxilla are hook like projections on either side of tongue. Later they assume horizontal position above the tongue and fuse with each other forming the secondary palate.



- At a later stage, the mesoderm in the palate undergoes intramembranous ossification to form the hard palate.
- However, ossification does not extend into the most posterior portion, which remains as the soft palate.

The definitive/permanent palate is formed by the fusion of these three parts as follows:

- Fusion of palatal processes of maxilla with primitive palate
- Fusion of both palatal processes of maxilla
- Fusion of palatal processes with nasal septum



## HARD PALATE

- The hard palate forms a partition between the nasal and oral cavities.
- The anterior 3/4th is formed by the palatine processes of the maxillae and the posterior 1/4<sup>th</sup> by the horizontal plates of the palatine bones.

### I. Anatomic relations

- The *superior surface* of hard palate forms the floor of nasal cavity and is lined by the ciliated pseudo stratified columnar epithelium.
- The *inferior surface* of hard palate forms the roof of oral cavity and is lined by masticatory mucosa. It presents with a median palatine raphe.
- *Anteriorly and laterally*, the hard palate becomes continuous with the alveolar arches and gums.
- The *posterior margin* of hard palate is free and provides attachment to the soft palate.

- The inferior surface presents with irregular horizontal folds of mucosa with a connective tissue core, running laterally from the median raphe.
- The neurovascular bundle runs anteroposteriorly, along the lateral margins, in the submucosa of the palate.

**III. Arterial supply**

- Greater palatine artery,
- Branch of maxillary artery,
- Ascending palatine branch of facial artery

**II. Nerve supply**

- Greater palatine,
- Nasopalatine branches of maxillary nerve through pterygopalatine ganglion

**IV. Venous supply**

- The veins drain into pterygoid plexus of veins.

**SOFT PALATE**

- The soft palate is a mobile muscular fold suspended from the posterior border of the hard palate like a curtain or velum.
- It is lined by nonkeratinized stratified squamous epithelium which encloses muscles, vessels, nerves, lymphoid tissue and mucous glands.
- It appears red in comparison with the hard palate which is pink.
- It separates the nasopharynx from oropharynx.

**V. External features**

1. Anterior (oral) surface	2. Posterior surface	3. Superior border
<ul style="list-style-type: none"> <li>• It is concave and marked by a median raphe.</li> <li>• The lining epithelium has taste buds on the surface.</li> </ul>	<ul style="list-style-type: none"> <li>• It is convex and continuous with the floor of the nasal cavity.</li> </ul>	<ul style="list-style-type: none"> <li>• It is attached to the posterior border of hard palate.</li> </ul>

**4. Inferior border**

- It is free and forms the anterior boundary of the pharyngeal isthmus.
- A conical, small tongue like projection hangs from its middle and is called the uvula.
- On each side, from the base of uvula, two curved folds of mucous membrane extend laterally and downwards along the lateral wall of oropharynx.

*i. Palatoglossal fold*

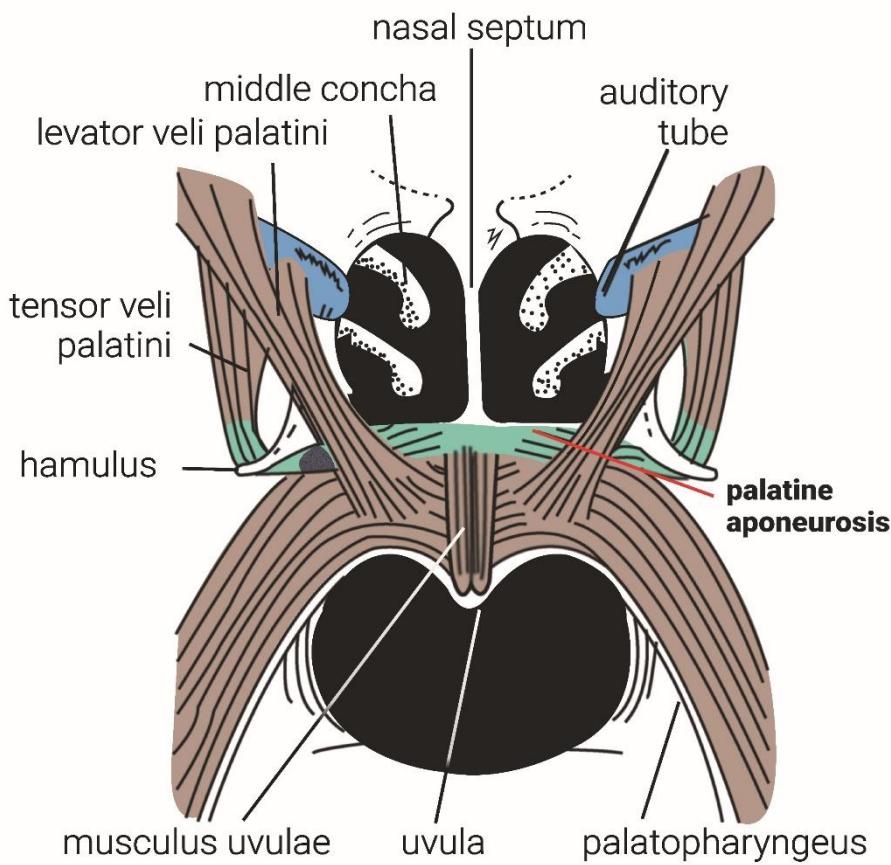
- It is the anterior fold which merges inferiorly with the sides of the tongue at
- the junction of its oral and pharyngeal parts.
- The palatoglossal fold contains the palatoglossal muscle.
- It forms the lateral boundary of the oropharyngeal isthmus and the anterior boundary of tonsillar fossa.

*ii. Palatopharyngeal fold*

- It lies posterior to the palatoglossal fold and merges inferiorly with the lateral wall of the pharynx.
- The palatopharyngeal fold contains the palatopharyngeus muscle and forms the posterior boundary of the tonsillar fossa.

**VI. Muscles of the Soft Palate**

- The soft palate consists of five pairs of muscles.
  1. Tensor palate (Tensor veli palatini)
  2. Levator palate (levator veli palatini)
  3. Musculus uvulae
  4. Platatoglossus
  5. palatopharyngeous



## VII. Functions of the Soft Palate

- Separates the oropharynx from nasopharynx during swallowing so that food does not enter the nose.
- Isolates the oral cavity from oropharynx during chewing so that breathing is unaffected.
- Helps to modify the quality of voice, by varying the degree of closure of the pharyngeal isthmus.

### IV. Arterial Supply

- Ascending palatine artery, branch of facial artery.
- Palatine branch of ascending pharyngeal artery.
- Greater palatine artery, branch of maxillary artery.

### VI. Venous Drainage

- Drain into the pterygoid plexus of veins.

### V. Lymphatic Drainage

- Retropharyngeal nodes.
- Deep cervical lymph nodes.

## VIII. Nerve Supply of Soft Palate

1. Motor supply	2. Secretomotor Supply	3. Sensory supply
<ul style="list-style-type: none"> <li>All muscles of palate are supplied by <u>cranial part of accessory nerve</u> via pharyngeal plexus except tensor veli palati which is supplied by <u>nerve to medial pterygoid</u>, a branch of mandibular nerve.</li> </ul>	<ul style="list-style-type: none"> <li><i>Preganglionic fibres</i> arise in superior salivatory ganglion and reach the pterygopalatine ganglion via facial nerve and nerve of pterygoid canal.</li> <li><i>Post-ganglionic fibres</i> run in the greater and lesser palatine nerves to supply the palatine glands.</li> </ul>	<p>The afferents pass to</p> <ul style="list-style-type: none"> <li>Greater and lesser palatine nerves</li> <li>Sphenopalatine nerves</li> <li>Glossopharyngeal nerves</li> </ul>

## APPLIED ASPECTS

### I. Cleft palate

- Congenital abnormal gap in the palate area is called cleft palate.

#### Classification

##### Vaeus classification

**Class 1:** Incomplete cleft involving only soft palate

**Class 2:** Cleft involving the hard and soft palate

**Class 3:** Complete unilateral cleft involving lip and plate

**Class 4:** Complete bilateral cleft

#### 1. *Bilateral complete cleft*

- Failure of fusion of both palatine processes of maxilla with premaxilla.
- A y-shaped cleft will be present between primary and secondary palate and between the two halves of secondary palate.
- It presents bilateral cleft of upper lip also

#### 2. *Unilateral complete cleft*

- Non-fusion of one side palatine process of maxilla with premaxilla. It presents unilateral cleft of upper lip

### 3. Incomplete cleft palate

- Cleft of hard and soft palate: Cleft limited to hard palate
- Cleft of soft palate: Cleft limited to soft palate.
- Bifid uvula: Cleft limited to uvula.

#### Prosthetic significance

- The ideal treatment of cleft area is closure by bone graft and orthodontics. In conditions when surgical correction is not feasible prosthodontic rehabilitations comes into play
- Prosthetic rehabilitation involves treatment options like
  - Fixed partial dentures
  - Removable partial dentures
  - Complete dentures
  - Implant supported dentures

## II. Muscle paralysis

- Paralysis of muscles of soft palate due to lesion of vagus nerve produces:
  - Nasal regurgitation of liquids.
  - Nasal twang in voice.
  - Flattening of the palatal arch on the side of lesion.
  - Deviation of uvula, opposite to the side of lesion.

## III. Developmental swellings of palate

- Palatal exostoses
- Torus palatinus
- Palatal cysts of newborn
- Nasopalatine duct cyst
- Cysts of incisive papilla
- Median palatal cyst
- Oral lymphoepithelial cyst
- Epidermal inclusion cyst

## PROSTHODONTIC SIGNIFICANCE

### Posterior palatal seal

- It is the seal area at the posterior border of maxillary dentures

Divided into:

- **Pterygomaxillary seal:** Extends through pterygomaxillary notch 3 - 4mm anterolaterally
- **Post palatal seal:** Area between anterior and posterior vibrating line
- **Vibrating lines** are imaginary lines across the posterior part of the palate, marking the difference between movable and immovable part of the soft palate

- The anatomic structures which help in recording these vibrating lines are palatal aponeurosis, hamular notch, median palatal raphe, fovea palatini

### Proper record of posterior palatal seal provides

- Retention and stability to maxillary denture within physiologic limit
- Decreases patient discomfort
- Decreases food accumulation
- Compensates volumetric shrinkage of PMMA

## CONCLUSION

- Prosthodontist must be able to restore the function and correct the defects in the oral cavity.
- Hence proper knowledge in the development and anatomy of palate leads to a greater advantage

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*Please Give Your Feedback on this Answer*

**Q. 10: Development of the face (7M)**

**CONTENTS/SYNOPSIS**

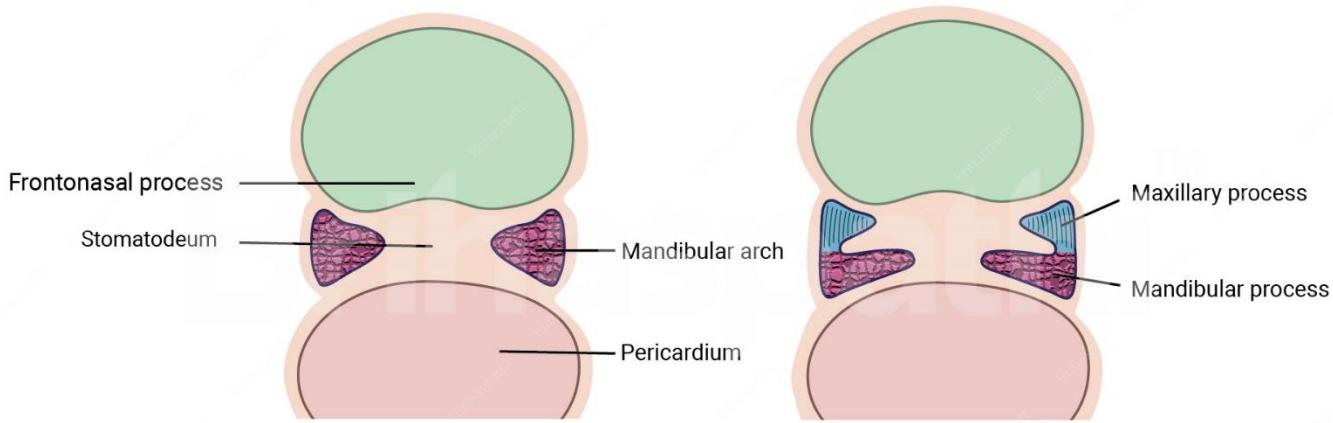
- Introduction
- Development of the face
- Development of various parts of face
  - Lower Lip
  - Upper Lip
  - Cheeks
  - Eye
  - Nose
  - Development of palate
  - External Ear
  - Development of Nasal Cavities
  - Paranasal Sinuses
- Congenital anomalies of the face
- References

## INTRODUCTION

- During the 4th week of development, after the formation of the head fold, two prominent bulgings appear on the ventral aspect of the developing embryo, separated by the stomatodeum.
- They are:
  - Developing brain cranially
  - Pericardium caudally
- The floor of the stomatodeum is formed by the buccopharyngeal membrane, which separates it from the foregut.
- On each side, the stomatodeum is bounded by first arch.
- Soon, mesoderm covering the developing forebrain proliferates and forms a downward projection that overlaps the upper part of the stomatodeum.
- This downward projection is called the frontonasal process.

## DEVELOPMENT OF THE FACE

- The face is derived from the structures that lie around the stomatodeum
  - Unpaired: Frontonasal process from above.
  - Paired: First pharyngeal (or mandibular) arch of each side.
- Mandibular arch gives off a bud from its dorsal end.
- This bud is called the maxillary process.
- It grows ventromedially cranial to the main part of the arch which is now called the mandibular process.
- The five primordia for face development are an unpaired frontonasal process and paired maxillary and mandibular processes.
- The ectoderm overlying the frontonasal process soon shows bilateral localized thickenings that are situated a little above the stomatodeum on either side of midline.
- These are called the nasal placodes.
- The placodes soon sink below the surface to form nasal pits.
- The edges of each pit are raised above the surface: the medial raised edge is called the medial nasal process and the lateral edge is called the lateral nasal process.
- Lateral and cranial to the nasal placodes pair of thickenings appear and are called lens placodes.



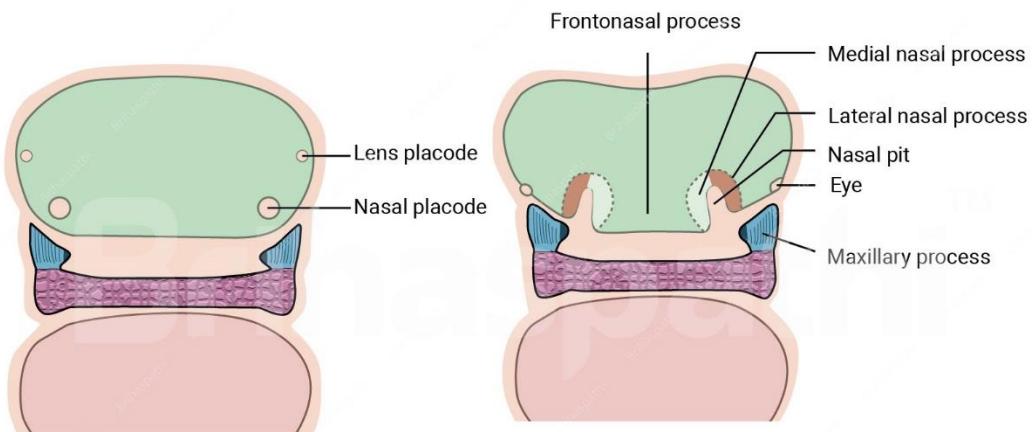
## DEVELOPMENT OF VARIOUS PARTS OF FACE

### I. Lower Lip

- The mandibular processes of the two sides grow toward each other and fuse in the midline giving rise to the lower lip, and lower jaw.

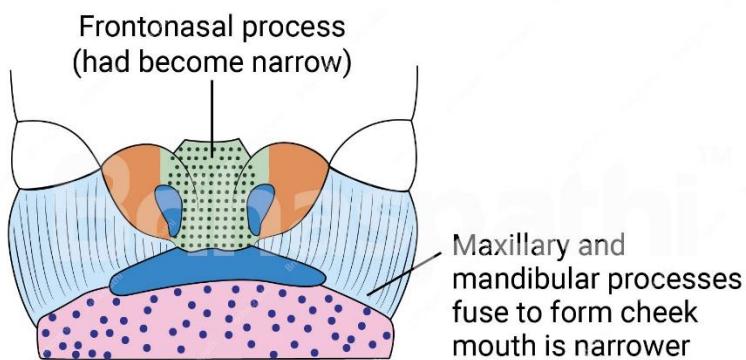
### II. Upper Lip

- Each maxillary process now grows medially below the developing eye and fuses, first with the lateral nasal process, and then with the medial nasal process.
- The medial and lateral nasal processes also fuse with each other.
- In this way, the nasal pits (now called external nares) are cut off from the stomatodeum.
- The maxillary processes undergo considerable growth.
- At the same time, the frontonasal process becomes much narrower from side to side, with the result that the two external nares come closer together.
- The stomatodeum is now bounded above by the upper lip that is derived as follows-
  - The mesodermal basis of the lateral part of the lip is formed from the maxillary process. The overlying skin is derived from ectoderm covering this process.
  - The mesodermal basis of the median part of the lip (called philtrum) is formed from the frontonasal process. The ectoderm of the maxillary process overgrows this mesoderm to meet that of the opposite maxillary process in the midline.



### III. Cheeks

- After formation of the upper and lower lips, the stomatodeum (which can now be called the mouth) is very broad.
- In its lateral part, it is bounded above by the maxillary process and below by the mandibular process.
- These processes undergo progressive fusion with each other to form the cheeks



### IV. Eye

- The region of the eye is first seen as an ectodermal thickening, the lens placode, which appears on the ventrolateral side of the developing forebrain, lateral and cranial to the nasal placode
- The lens placode sinks below the surface and is eventually cut off from the surface ectoderm
- The developing eyeball produces a bulging in this situation.

- With the narrowing of the frontonasal process, they come to face forward
- The eyelids are derived from folds of ectoderm that are formed above and below the eyes, and by mesoderm enclosed within the folds

## V. Nose

- The external form of the nose is established with the fusion of five processes as follows:
  - Frontonasal process forms the bridge of the nose
  - Fused medial nasal processes form the dorsum and tip of nose
  - Lateral nasal processes form the alae of the nose

## VI. Development of palate

- Fusion of the two medial nasal processes of frontonasal process at a deeper level forms a wedge-shaped mass of mesenchyme opposite upper jaw carrying four incisor teeth
- The part of the palate derived from the frontonasal process forms the premaxilla or primary palate which carries the incisor teeth
- The palatine processes of maxilla are hook like projections on either side of tongue. Later they assume horizontal position above the tongue and fuse with each other forming the secondary palate
- At a later stage, the mesoderm in the palate undergoes intramembranous ossification to form the hard palate
- However, ossification does not extend into the most posterior portion, which remains as the soft palate
- The definitive/permanent palate is formed by the fusion of these three parts as follows:
  - Fusion of palatal processes of maxilla with primitive palate
  - Fusion of both palatal processes of maxilla
  - Fusion of palatal processes with nasal septum

## VII. External Ear

- The external ear is formed around the dorsal part of the first ectodermal cleft
- A series of mesodermal thickenings (often called tubercles or hillocks) appear on the mandibular and hyoid arches where they adjoin this cleft
- The pinna (or auricle) is formed by fusion of these thickenings

### **VIII. Development of Nasal Cavities**

- The nasal pits now deepen to form the nasal sacs which expand both dorsally and caudally
- The dorsal part of this sac is, at first, separated from the stomatodeum by a thin membrane called the bucconasal membrane which soon breaks down
- The nasal sac now has a ventral orifice that opens on the face (anterior or external nares), and a dorsal orifice that opens into the stomatodeum (primitive posterior nasal aperture)
- The two nasal sacs are at first widely separated from one another by the frontonasal process
- Later, the frontonasal process becomes progressively narrower
- This narrowing of the frontonasal process, and the enlargement of the nasal cavities themselves, brings them closer together
- The intervening tissue becomes much thinned to form the nasal septum
- The ventral part of the nasal septum is attached below to the primitive palate
- The lateral wall of the nose is derived, on each side, from the lateral nasal process. The nasal conchae appear as elevations on the lateral wall of each nasal cavity
- The original olfactory placodes form the olfactory epithelium that lies in the roof, and adjoining parts of the walls, of the nasal cavity

### **IX. Paranasal Sinuses**

- The paranasal sinuses appear as diverticula from the nasal cavity
- The diverticula gradually invade the bones after which they are named, i.e. the sphenoid, maxilla, frontal, ethmoid and then expand
- They are named accordingly into sphenoidal, maxillary, ethmoidal and frontal air sinuses
- The paranasal sinuses are ectodermal in origin
- The maxillary and sphenoidal sinuses begin to develop before birth
- The other sinuses develop after birth
- Enlargement of paranasal sinuses is associated with overall enlargement of the facial skeleton, including the jaws
- This provides space in the jaws for growth and eruption of teeth

## CONGENITAL ANOMALIES OF THE FACE

### I. Unilateral cleft lip

- Failure of fusion of maxillary process with medial nasal process on one side

### II. Bilateral cleft lip

- Failure of fusion of both maxillary processes with the medial nasal process

### III. Midline cleft of upper lip

- Defective development of the lowermost part of the frontonasal process may give rise to a midline defect of the upper lip

### IV. Cleft of lower lip

- When the two mandibular processes do not fuse with each other the lower lip shows a defect in the midline. The defect usually extends into the jaw

### V. Bilateral complete cleft palate

- Failure of fusion of both palatine processes of maxilla with premaxilla
- A y-shaped cleft will be present between primary and secondary palate and between the two halves of secondary palate
- It presents bilateral cleft of upper lip also

### VI. Unilateral complete cleft palate

- Non-fusion of one side palatine process of maxilla with premaxilla. It presents unilateral cleft of upper lip

### VII. Incomplete cleft palate

- Cleft of hard and soft palate: Cleft limited to hard palate
- Cleft of soft palate: Cleft limited to soft palate
- Bifid uvula: Cleft limited to uvula

### VIII. Oblique facial cleft

- Non-fusion of the maxillary and lateral nasal process gives rise to a cleft running from the medial angle of the eye to the mouth. The nasolacrimal duct is not formed

**IX. Lateral facial cleft**

- Unilateral non-fusion of the maxillary and lateral nasal process

**X. Macrostomia**

- Inadequate fusion of the mandibular and maxillary processes with each other may lead to an abnormally wide mouth

**XI. Microstomia**

- Various early fusions result in a small mouth

**XII. Treacher Collins syndrome**

- Also called as first arch syndrome.
- The entire first arch may remain underdeveloped on one or both sides, affecting the lower eyelid coloboma type defect), the maxilla, the mandible, and the external ear.
- The prominence of the cheek is absent, and the ear may be displaced ventrally and caudally.
- There may be presence of cleft palate and of faulty dentition

**XIII. Agnathia**

- Absence of the formation of jaw

**XIV. Micrognathia**

- Development of small jaw

**XV. Macrognathia**

- Abnormally large jaw

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4. Susan Standring, "Gray's Anatomy - The Anatomic Basis of Clinical Practice", 40th Edition, Elsevier, 2008
5. Chaurasia BD. BD Chaurasia's Human anatomy: Head, neck and brain.3rd volume. 7<sup>th</sup> edition. CBS Publishers & distributors, 2016.

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*Please Give Your Feedback on this Answer*

**Q. 12: Developmental defects of oral cavity (7M)****CONTENTS/SYNOPSIS**

- Introduction
- Developmental defects of mandible
  - Facial hemiatrophy
  - Agnathia
  - Micrognathia
  - Macrognathia
  - Facial hemihypertrophy
- Developmental defects of maxilla
  - Cleft lip
  - Cleft palate
- Developmental defects of tongue
  - Macroglossia
  - Microglossia
  - Aglossia
  - Nonfusion
  - Ankyloglossia
  - Lingual thyroid
  - Fissured tongue
- Developmental defects of teeth
  - Microdontia
  - Macrodontia
  - Gemination
  - Fusion
  - Concrescence
  - Taurodontism
  - Dilaceration
  - Dens in Dente (dens invaginatus)
  - Dens evaginatus
  - Disturbances in number of tooth
  - Amelogenesis imperfecta
- References

## INTRODUCTION

- Development of face and oral cavity involves the development of various facial process that fuse with each other.
- Any disturbance in growth of these processes may result in formation of defects.

## DEVELOPMENTAL DEFECTS OF MANDIBLE

<b>1. Agnathia</b>	<ul style="list-style-type: none"> <li>• Hypoplasia or absence of mandible</li> <li>• The entire mandible or one side may be missing or only the condyle or the entire ramus.</li> </ul>
<b>2. Micrognathia</b>	<ul style="list-style-type: none"> <li>• Means small jaw</li> <li>• Can be due to small jaw or to an abnormal positioning or abnormal relation of one jaw to another.</li> </ul>
<b>3. Macrognathia</b>	<ul style="list-style-type: none"> <li>• Abnormally large jaws</li> </ul>
<b>4. Facial hemihypertrophy</b>	<ul style="list-style-type: none"> <li>• Exhibits an enlargement which is confined to one side of the body, unilateral macroglossia, and premature development, and eruption as well as increased size of dentition.</li> </ul>
<b>5. Facial hemiatrophy</b>	<ul style="list-style-type: none"> <li>• Progressive wasting of subcutaneous fat accompanied by atrophy of skin, cartilage, bone and muscle.</li> </ul>

## DEVELOPMENTAL DEFECTS OF MAXILLA

### I. Cleft palate

- Congenital abnormal gap in the palate area is called cleft palate.

### Classification

#### Vaeus classification

**Class 1:** Incomplete cleft involving only soft palate

**Class 2:** Cleft involving the hard and soft palate

**Class 3:** Complete unilateral cleft involving lip and plate

**Class 4:** Complete bilateral cleft

**1. *Bilateral complete cleft:***

- Failure of fusion of both palatine processes of maxilla with premaxilla.
- A y-shaped cleft will be present between primary and secondary palate and between the two halves of secondary palate.
- It presents bilateral cleft of upper lip also

**2. *Unilateral complete cleft:***

- Non-fusion of one side palatine process of maxilla with premaxilla. It presents unilateral cleft of upper lip

**3. *Incomplete cleft palate:***

- Cleft of hard and soft palate: Cleft limited to hard palate
- Cleft of soft palate: Cleft limited to soft palate.
- Bifid uvula: Cleft limited to uvula.

**4. *Oblique facial cleft:***

- Non-fusion of the maxillary and lateral nasal process gives rise to a cleft running from the medial angle of the eye to the mouth.
- The nasolacrimal duct is not formed.

**5. *Lateral facial cleft:***

- Unilateral non-fusion of the maxillary and lateral nasal process

**Prosthetic significance**

- The ideal treatment of cleft area is closure by bone graft and orthodontics. In conditions when surgical correction is not feasible prosthodontic rehabilitations comes into play
- Prosthetic rehabilitation involves treatment options like
  - Fixed partial dentures
  - Removable partial dentures
  - Complete dentures
  - Implant supported dentures

## II. Cleft lip

- Congenital abnormal gap in the pre maxillary and palatine area leads to called cleft lip.

1. <i>Unilateral cleft lip:</i>	2. <i>Bilateral cleft lip:</i>	3. <i>Midline cleft of upper lip:</i>	4. <i>Cleft of lower lip:</i>
<ul style="list-style-type: none"> <li>Failure of fusion of maxillary process with medial nasal process on one side.</li> </ul>	<ul style="list-style-type: none"> <li>Failure of fusion of both maxillary processes with the medial nasal process.</li> </ul>	<ul style="list-style-type: none"> <li>Defective development of the lowermost part of the frontonasal process may give rise to a midline defect of the upper lip.</li> </ul>	<ul style="list-style-type: none"> <li>When the two mandibular processes do not fuse with each other the lower lip shows a defect in the midline. The defect usually extends into the jaw.</li> </ul>

## DEVELOPMENTAL DEFECTS OF TONGUE

- The tongue may be too large (**macroglossia**) or too small (**microglossia**).
- Very rarely the tongue may be absent (**aglossia**).
- The tongue may be bifid because of **nonfusion** of the two lingual swellings.
- The apical part of the tongue may be anchored to the floor of the mouth by an overdeveloped frenulum. This condition is called **ankyloglossia** or **tongue-tie**. It interferes with speech.
- Occasionally, the tongue may be adherent, to the palate called as **ankyloglossia superior**.
- Thyroid tissue may be present in the tongue either under the mucosa or within the muscles and is termed as **lingual thyroid**.
- The surface of the tongue may show fissures called as **fissured tongue**.

## DEFECTS IN TOOTH DEVELOPMENT

### 1. Microdontia

- Presence of unusually small teeth.
- True generalized microdontia- Teeth are smaller than normal.  
Example: pituitary dwarfism, Down syndrome
- Relative generalized microdontia- normal sized teeth widely spaced in jaws

that are larger than normal

- Isolated microdontia or microdontia of single tooth- Maxillary Lateral Incisor (peg shaped crown), 3rd molars

## 2. Macrodontia

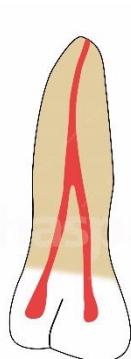
- Teeth are larger than the normal
- True generalized macrodontia- teeth are bigger than normal.  
Example: pituitary gigantism, pineal hyperplasia with hyperinsulinism
- Relative generalized macrodontia- normal or slightly larger than normal teeth in small jaws
- Isolated macrodontia or macrodontia of single tooth- seen in hemi facial hypertrophy

## 3. Gemination

- Single tooth germ attempts to divide resulting in the formation of two completely or incompletely separated crowns that share a common root & root canal

## 4. Fusion

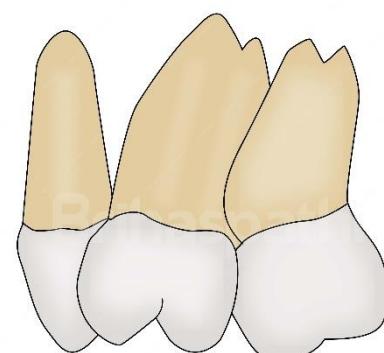
- Union of 2 separate tooth buds resulting in the formation of a joined tooth with confluence of dentin, but separate canals
- Also, can occur between normal and supernumerary teeth



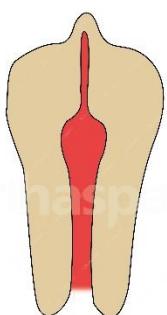
Gemination



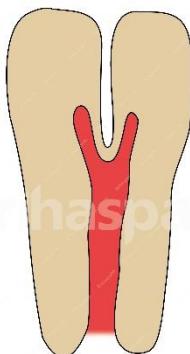
Fusion



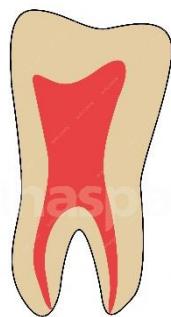
Concrescence



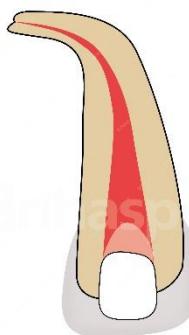
Dens evaginatus



Dens invaginatus



Taurodontism



Dilacerated root

## 5. Concrescence

- Roots of two or more teeth united by cementum
- Space is restricted during development
- Could be due to trauma locally, excessive occlusal forces, local infection after development
- Commonly seen in maxillary molars, 3rd molar and supernumerary teeth

## 6. Taurodontism

- Pulp chamber is enlarged longitudinally
- Increased distance between CEJ to the bifurcation
- Consists of normal crown size and length but with shortened roots
- Cannot be seen clinically
- Mostly in molars

## 7. Dilaceration

- It is a sharp bend or curve in the crown or root
- Commonly seen in maxillary premolars

## 8. Dens in Dente (dens invaginatus)

- Infolding of the outer enamel surface is called dens in dente
- Infold is at pits
- Leads to caries and pulpal infections easily

## 9. Dens evaginatus

- It is also called as out folding of enamel organs
- Appears as a tubercle on the outer surface with enamel, dentin and pulp horn extended into evagination
- Commonly seen in premolar and molar
- Causes pulp infection

## 10. Disturbances in number of tooth

- Anodontia → Total lack of tooth development.
- Hypodontia → Lack of development of one or more teeth.
- Oligodontia → Lack of development of six or more teeth.
- Hyperdontia → Development of increased number of teeth & the additional teeth are called Supernumerary teeth.

## 11. Amelogenesis imperfecta

- Incomplete or defective formation of organic enamel matrix of teeth.
- Synonyms- Hereditary enamel dysplasia/ Hereditary brown enamel/ Hereditary brown opalescent teeth
- Amelogenesis imperfecta is a group of conditions caused by defects in the genes encoding enamel matrix proteins.
- Inheritance can be autosomal dominant, recessive or X-linked.
- Genetic mutations have been associated with Amelogenesis Imperfecta-

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6. Sharma G, Mutneja AR, Nagpal A, Mutneja P. Dens evaginatus and dens invaginatus in a double tooth: A rare case report. Indian J Dent Res 2015;26:545-9

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*Please Give Your Feedback on this Answer*

**Q. 07: Extra cranial course of facial nerve and its clinical significance (6M)**

**Applied anatomy of facial nerve (7M)**

**Write in detail about facial nerve (20M)**

### CONTENTS/SYNOPSIS

Introduction  
Development of facial nerve  
Origin  
Types of nucleus & its function  
Courses  
Branches of facial nerve  
Branches of communication  
Blood supply of facial nerve  
Functions  
Ganglion related to the nerve  
Applied anatomy  
Prosthodontic significance  
References

## INTRODUCTION

- Mixed nerve (7<sup>th</sup> cranial nerve)
  - Motor root
  - Sensory root / Nervus Intermedius
- Referred to as Facial Nerve as it supplies the muscles of facial expression
- Most regularly paralyzed of all the peripheral nerves of the body

## DEVELOPMENT OF FACIAL NERVE

- Facial nerve course, branching pattern, and anatomical relationships are established during the first 3 months of prenatal life
- The nerve is not fully developed until about 4 years of age
- The first identifiable FN tissue is seen at the third week of gestation-facioacoustic primordium or crest
- It is the nerve of the second branchial arch

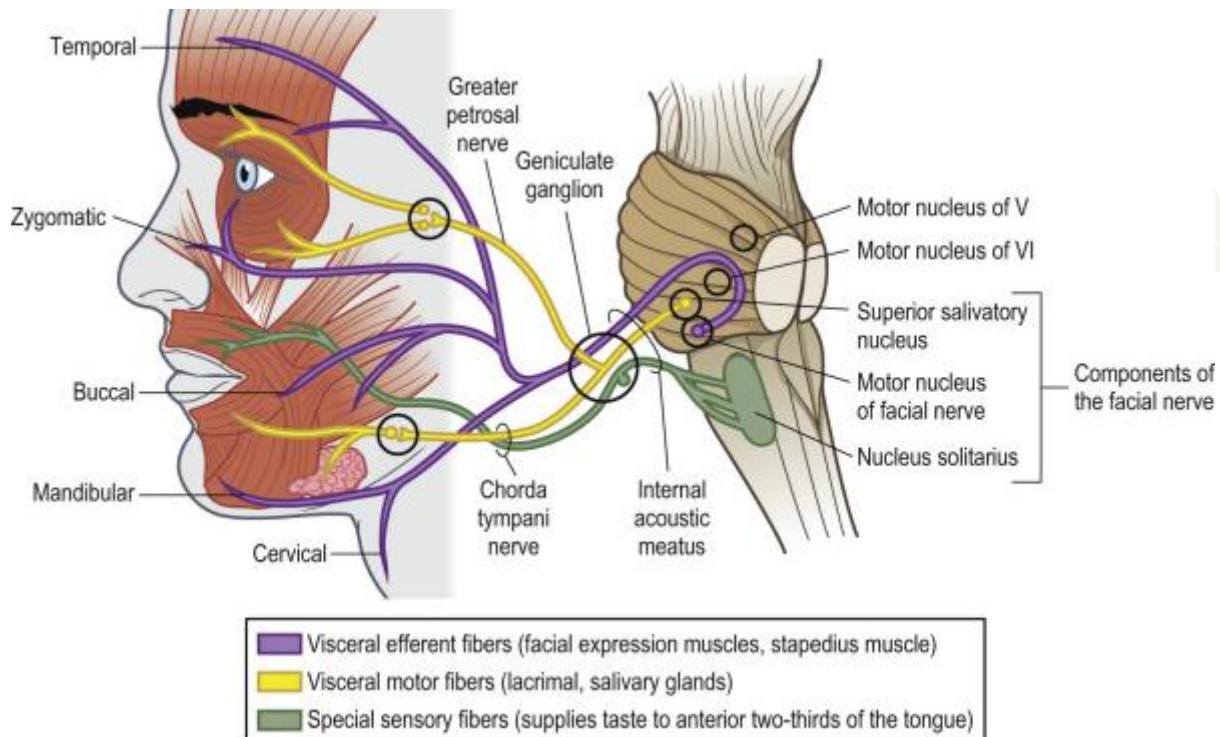
## ORIGIN

- It originates from cerebellopontine angle – lateral part of pontomedullary junction
- Two adjacent roots
  - Motor root (larger, more medial)
  - Nervus intermedius (smaller, more lateral): it is found between two larger nerves (main root of VII and VIII).
- Nervus intermedius conveys parasympathetic and sensory fibres and may be part of VIII initially

## TYPES OF NUCLEUS & ITS FUNCTION

Type	Origin	Function
GVE	Superior salivatory nucleus (caudal pons)	Lacrimal gland (via pterygopalatine ganglion) Submandibular and Sublingual glands (via submandibular ganglion)
SVE	Facial motor nucleus (caudal pons)	Muscles of facial expression Elevation of hyoid bone
GSE	Geniculate ganglion (temporal bone)	Tactile sensation to skin of ear
SVA	Geniculate ganglion	Taste sensation from the anterior two-thirds of tongue (via chorda tympani)

SVE (Special visceral efferent), SVA (Special visceral afferent), GVE (General visceral efferent), GVA (General visceral afferent), GSA (General somatic afferent)



## COURSE

### I. Intracranial

Enters the cranial cavity, and the cranium itself

Before the facial nerve leaves the brainstem, its motor fibers wind around the abducens nucleus and form the internal genu of the nerve.

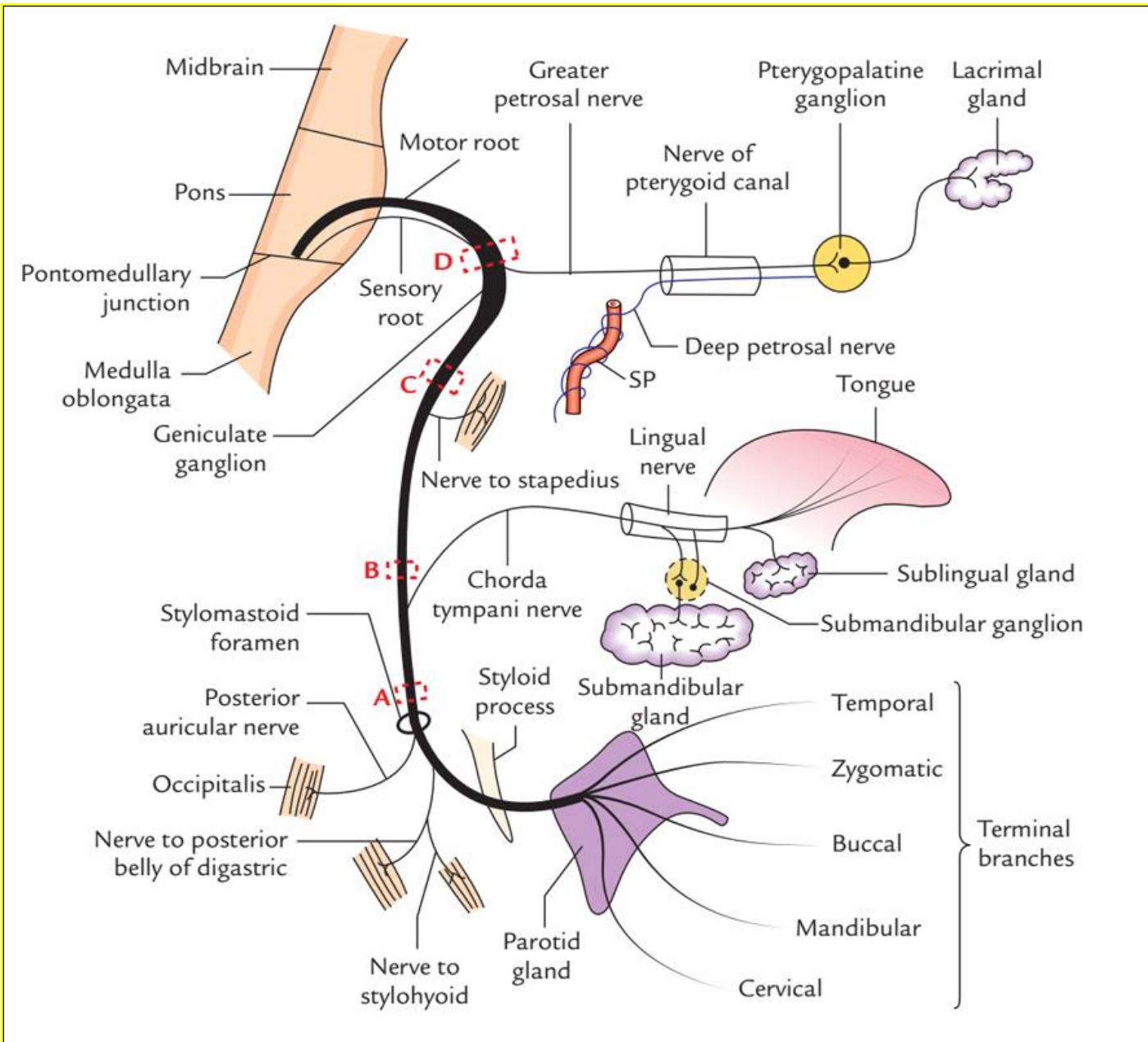
From cerebellopontine angle, crosses posterior cranial fossa and enters internal acoustic meatus (IAM; with VIII).

Nervus intermedius joins main root of facial nerve in IAM

In the IAM, at the bottom the two roots fuse to form a single trunk, which lies in the petrous temporal bone-the facial nerve enter the facial canal.

### II. Extracranial

- Outside the cranium, through the face and neck
- After emerging from the stylomastoid foramen, the facial nerve enters the parotid gland, where it branches at the pes anserinus



## BRANCHES OF FACIAL NERVE

Anatomical Region	Branches	Distribution
1. In Facial Canal	Greater Petrosal	<ul style="list-style-type: none"> <li>Mucous glands</li> <li>Lacrimal gland</li> </ul>
	Nerve to Stapedius	<ul style="list-style-type: none"> <li>Stapedius muscle</li> </ul>
	Chorda Tympani	<ul style="list-style-type: none"> <li>Anterior 2/3<sup>rd</sup> of tongue</li> <li>Submandibular and Sublingual glands</li> </ul>
2. At Stylomastoid Foramen	Posterior Auricular	<ul style="list-style-type: none"> <li>Muscles around Ear</li> <li>Occipital part of the</li> </ul>

		Occipitofrontalis muscle
	Posterior belly of Digastric	<ul style="list-style-type: none"> <li>Digastric – Posterior Belly</li> </ul>
	Stylohyoid	<ul style="list-style-type: none"> <li>Stylohyoid muscle</li> </ul>
<b>3. On the Face</b>	Temporal	<ul style="list-style-type: none"> <li>Frontalis</li> <li>Orbicularis Oculi</li> <li>Corrugator Supercilii</li> </ul>
	Zygomatic	<ul style="list-style-type: none"> <li>Orbicularis Oculi</li> </ul>
	Buccal	<ul style="list-style-type: none"> <li>Orbicularis Oris</li> <li>Buccinator</li> <li>Zygomaticus</li> </ul>
	Marginal Mandibular	<ul style="list-style-type: none"> <li>Mentalis muscle</li> </ul>
	Cervical	<ul style="list-style-type: none"> <li>Platysma</li> </ul>

### BRANCHES OF COMMUNICATION

Area	Communication
1. Internal Acoustic Meatus	VIII cranial nerve
2. Geniculate ganglion	Pterygopalatine ganglion and Otic ganglion
3. Facial canal	Auricular branch of Vagus
4. Below Styломastoid Foramen	IX, X, Auriculotemporal Nerve
5. Behind Ear	Lesser Occipital nerve
6. Face	Trigeminal Nerve
7. Neck	Transverse Cervical Cutaneous Nerve

### BLOOD SUPPLY OF FACIAL NERVE

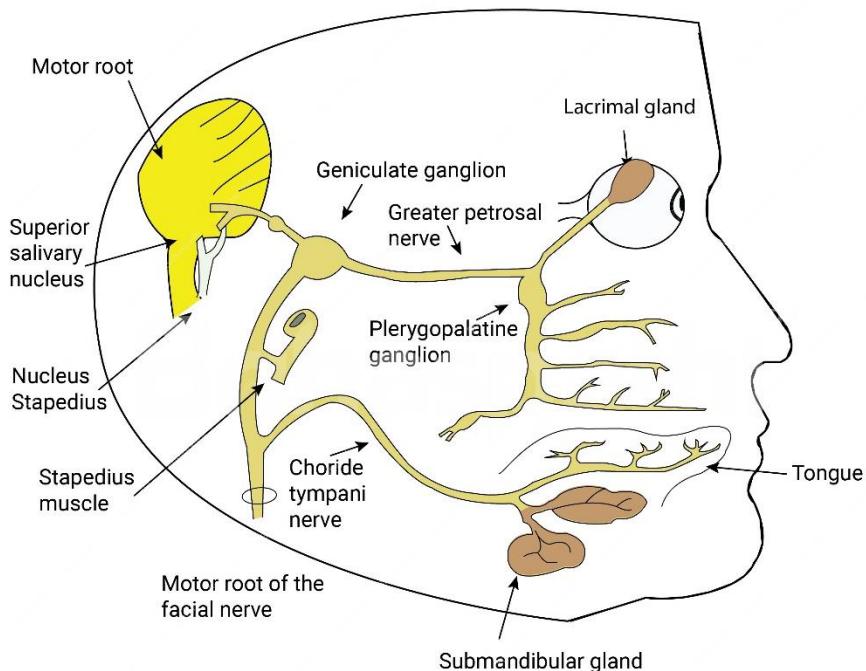
- Intracranial/Meatal: Labyrinthine branches from anterior inferior cerebellar artery
- Peri geniculate: Superficial petrosal branch of middle meningeal artery
- Tympanic/Mastoid: Styломastoid branch of posterior auricular artery

## FUNCTIONS

The facial nerve is responsible for:

- Contraction of the muscles of the face
- Production of tears from a gland (Lacrimal gland)
- Conveying the sense of taste from the front part of the tongue (via the Chorda tympani nerve)
- The sense of touch at auricular conchae

## GANGLIA RELATED TO THE NERVE



### I. Geniculate ganglion

- Located on the 1st bend of facial nerve, in relation to the medial wall of the middle ear
- It is a sensory ganglion
- The taste fibers present in the nerve are peripheral processes of pseudo-unipolar neurons present in the geniculate ganglion

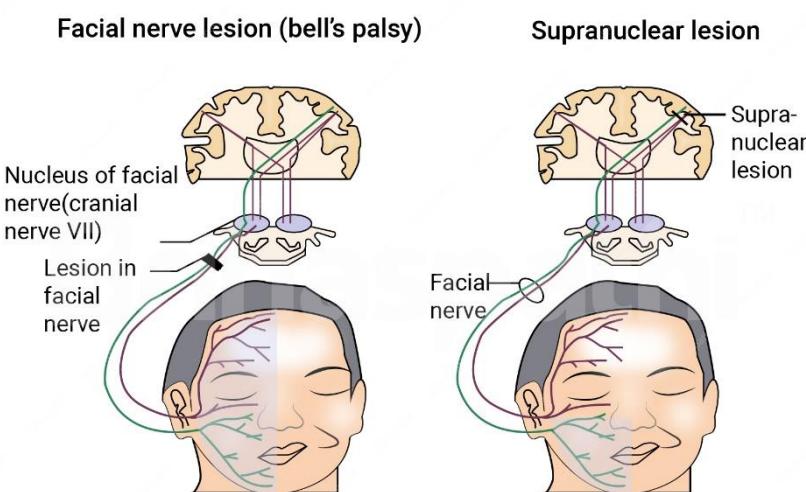
II. Submandibular ganglion	III. Pterygopalatine ganglion
<ul style="list-style-type: none"> <li>Parasympathetic ganglion</li> <li>For relay of secretomotor fibres to the submandibular and sublingual glands</li> </ul>	<ul style="list-style-type: none"> <li>Parasympathetic ganglion</li> <li>Secretomotor fibers meant for the lacrimal gland relay in this ganglion</li> </ul>

## APPLIED ANATOMY

### I. Supranuclear and infranuclear lesions

- In Supranuclear lesions usually a part of hemiplegia, only lower part of the opposite side of the face is paralyzed.
- The upper part with the frontalis and orbicularis oculi escapes due to bilateral representation in the cerebral cortex

- Infranuclear lesions is also known as Bell's palsy
- The whole of the face of the same side gets paralyzed.
- The face becomes asymmetrical and is drawn up to the normal side.
- The affected side is motionless.
- Wrinkles disappear from the forehead.
- Eye cannot be closed.
- Food accumulates b/w cheek and teeth during mastication



- The symptoms are according to the level of injury of facial nerve
- **At internal auditory meatus**
  - Loss of lacrimation
  - Stapedial reflex
  - Taste from most of anterior two-third of tongue
  - Lack of salivation and paralysis of muscles of facial expression
- **Below geniculate ganglion**
  - Loss of stapedial reflex
  - Taste from anterior two-third of tongue
  - Lack of salivation and paralysis of facial expression muscles

**Region b/w nerve to Stapedius and Chorda tympani:**

- Loss of taste from anterior two-third of tongue
- Lack of salivation and
- Paralysis of facial expression muscles

- **Region below stylomastoid foramen:** Paralysis of facial expression muscles

**PROSTHODONTIC SIGNIFICANCE****I. Objectives of prosthodontic management in patients with facial paralysis**

- To support the weakened muscles
- Decrease the amount of surgical procedures
- Provide comfort and esthetics
- Increase the confidence

**II. Complications during prosthetic phase**

- Poor coordination of muscle
- Mask like facial expressions
- Uncontrolled saliva
- Mandibular movements are unpredictable
- Problems with phonetics especially labial (p, b) and labiodental sounds (f, v)
- Dryness of mouth and cheek biting

### III. Stages requiring modifications

Stages	Modifications
Impression making and Jaw relation records	<ul style="list-style-type: none"> <li>Neutral zone impression technique</li> <li>Muscle activity is recorded by asking the patient to perform functional border movements: <ul style="list-style-type: none"> <li>Swallowing</li> <li>Speaking</li> <li>Sucking</li> <li>Pursing lips</li> <li>Sipping of water</li> <li>Protrude the tongue slightly</li> <li>Pronouncing vowels</li> </ul> </li> </ul>
Teeth arrangement	<ul style="list-style-type: none"> <li>Lingualized occlusion</li> </ul>
Denture retention	<ul style="list-style-type: none"> <li>Immediate dentures</li> <li>Liquid supported dentures</li> </ul>
Denture stability	<ul style="list-style-type: none"> <li>Larsen's modifications</li> <li>Face lift prosthesis</li> <li>Extended buccal flange techniques</li> <li>Cheek plumper</li> </ul>
Phonetics	<ul style="list-style-type: none"> <li>Speech prosthesis</li> </ul>
Maintenance	<ul style="list-style-type: none"> <li>Management of dryness of mouth using mouth washes, salivary substitutes, reservoir bite guard etc</li> </ul>

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*Please Give Your Feedback on this Answer*

**Q. 03: Major salivary glands (10M)****Minor salivary glands (7M)****CONTENTS/SYNOPSIS**

- Introduction
- Classification of salivary glands
  - Based on Size and Location
    - Major salivary glands
      - Parotid glands
      - Submandibular glands
      - Sublingual glands
    - Minor salivary glands
  - Based on Nature of Secretory Products
    - Serous salivary glands
    - Mucous salivary glands
    - Mixed salivary glands
- Development of salivary glands
  - Stages of development
- Anatomy of parotid glands
- Anatomy of submandibular glands
- Anatomy of sublingual glands
- Anatomy of minor salivary glands
  - Labial and buccal glands
  - Glossopalatine glands
  - Palatine glands
  - Lingual glands
- Histology of salivary glands
  - Secretory Units
  - Serous Demilunes
  - Myoepithelial Cells
  - Duct system
  - Connective tissue elements
- Applied anatomy
- Conclusion
- References

## INTRODUCTION

- Salivary glands are group of exocrine, compound tubulo-acinar and merocrine glands
- There are 3 major and 600-1000 minor salivary glands
- The basic functional unit of salivary gland is called as the acini

## CLASSIFICATION

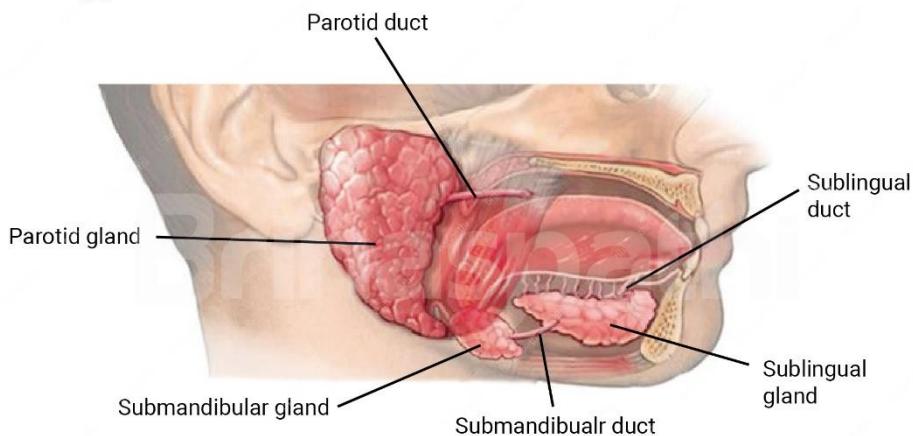
### I. Based on Size and Location

#### 1. Major Salivary Glands (Located extra orally)

- i. Parotid gland
- ii. Submandibular gland
- iii. Sublingual gland

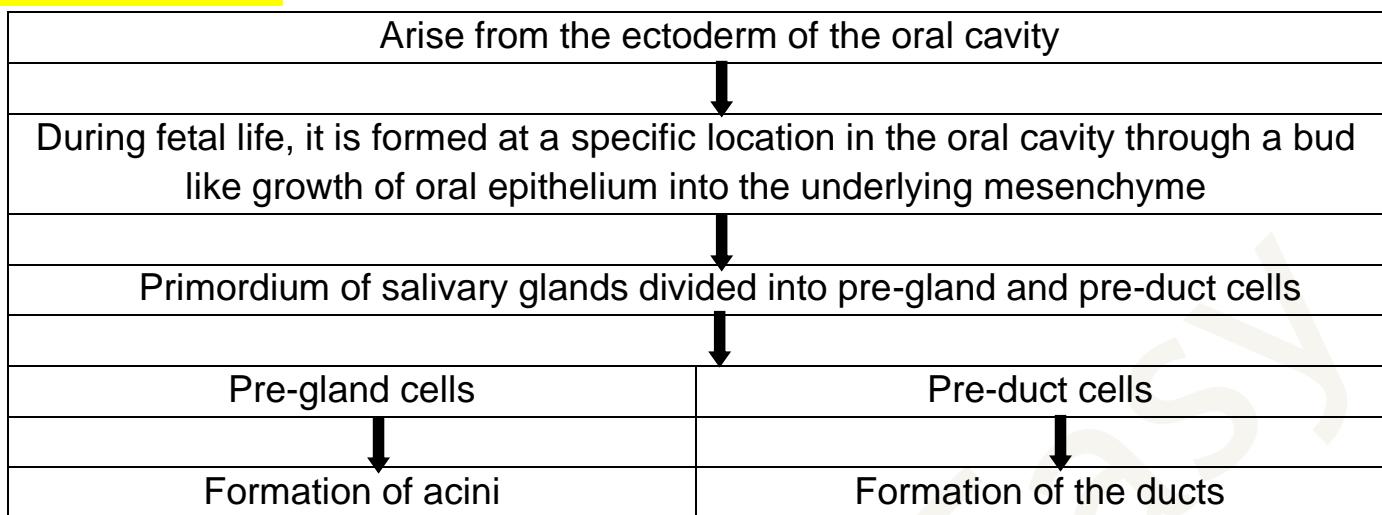
#### 2. Minor Salivary Glands (Located intraorally)

- i. Labial and buccal glands
- ii. Glossopalatine glands
- iii. Palatine glands
- iv. Lingual glands
  - Anterior lingual glands
  - Posterior lingual glands (Von Ebner glands)



### II. Based on Nature of Secretory Products

1. Serous salivary gland Ex: Parotid gland
2. Mucous salivary glands Ex: Von Ebner gland
3. Mixed salivary glands Ex: Submandibular gland

**DEVELOPMENT****Stages**

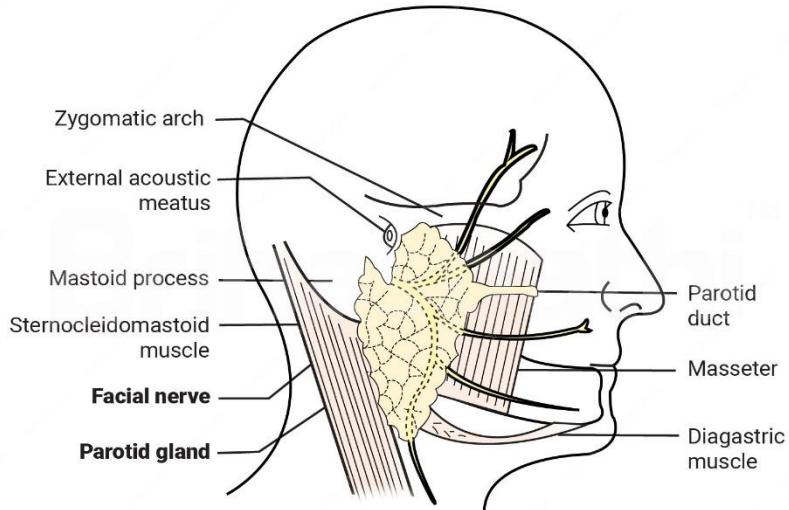
- Formation: Induction of oral epithelium by underlying mesenchyme
- Formation & growth of the epithelial cord
- Initiation of branching in terminal parts of the epithelial cord & continuation of glandular differentiation
- Repetitive branching of the epithelial cord & lobule formation
- Canalisation of presumptive ducts
- Cytodifferentiation

**PAROTID GLAND**

- It is the largest salivary gland, purely serous type
- Weights approximately 15grams
- Shape: Pyramid with 4 surfaces and 3 borders, with apex directed downwards
- Accessory parotid is a forward extension of gland
- Gland is enclosed in a parotid capsule

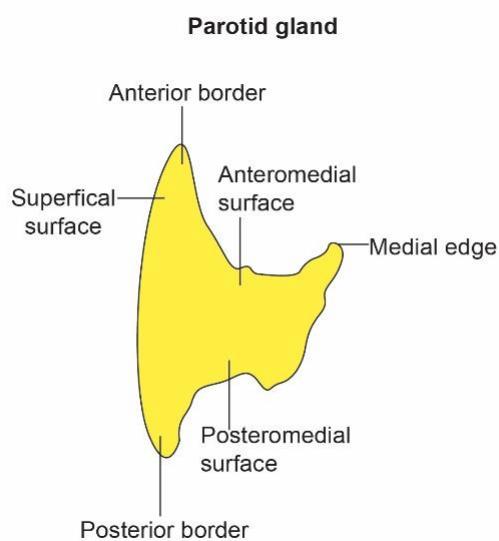
**Boundaries**

Superior	External Auditory Meatus
Inferior	Upper part of the Carotid triangle
Medial	Styloid process (gland wraps around neck of mandible)
Posterior	Overlaps Sternocleidomastoid
Anterior	Extends over Masseter



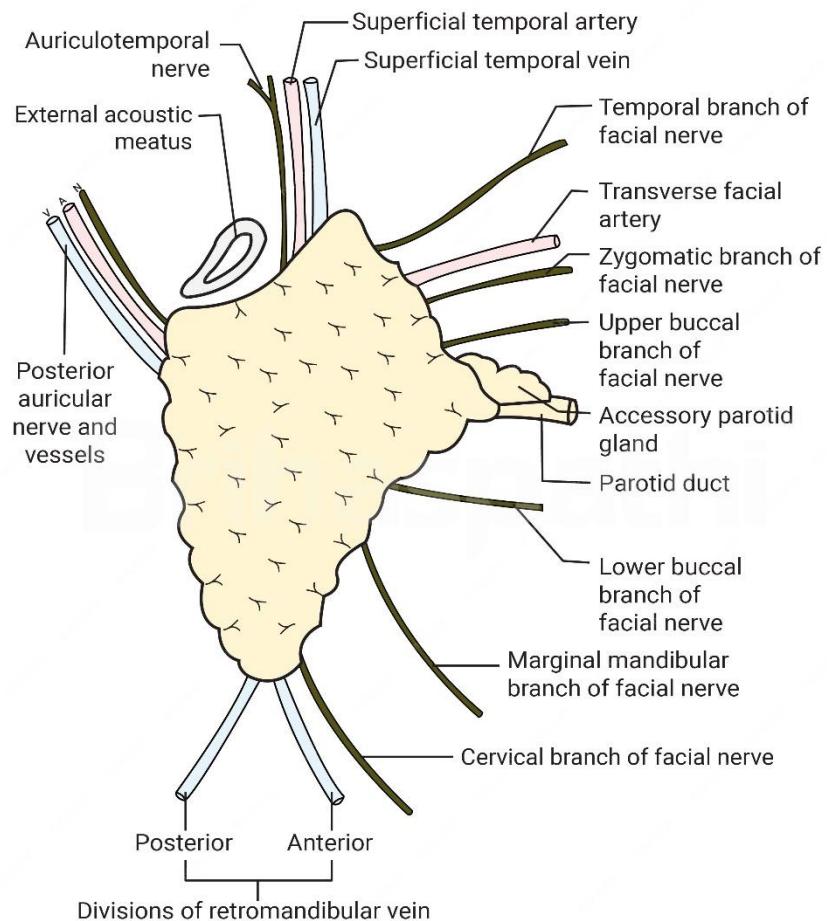
## External Features

- Represents 3-sided Pyramid
- An Apes (directed downwards)
- Has 4 surfaces
  1. Superior (Base of pyramid)
  2. Superficial
  3. Anteromedial
  4. Posteromedial
- Four surfaces separated by 3 borders
  1. Anterior
  2. Posterior
  3. Medial/Pharyngeal



## Anatomical relations

1. Superior surface	2. Antero-medial surface
<ul style="list-style-type: none"> <li>• Superficial temporal vessels</li> <li>• Auriculotemporal nerve</li> <li>• Cartilaginous part of external auditory meatus</li> <li>• Temporal branch of facial nerve</li> </ul>	<ul style="list-style-type: none"> <li>• Ramus of the mandible</li> <li>• Masseter muscle</li> <li>• Medial pterygoid muscle</li> </ul>
3. Postero-medial surface	4. Apex
<ul style="list-style-type: none"> <li>• Mastoid process</li> <li>• Sternocleidomastoid</li> <li>• Posterior belly of digastric</li> <li>• Styloid process and the muscle &amp; ligaments attached to it</li> <li>• Internal carotid artery &amp; internal jugular vein</li> </ul>	<ul style="list-style-type: none"> <li>• Cervical branch of facial nerve</li> <li>• Retromandibular vein</li> <li>• Posterior belly of digastric</li> <li>• External carotid artery</li> </ul>
5. Superficial surface	6. Anterior border
<ul style="list-style-type: none"> <li>• Skin and superficial fascia</li> <li>• Great auricular nerve</li> <li>• Parotid lymph nodes</li> </ul>	<ul style="list-style-type: none"> <li>• Zygomatic branch of facial nerve</li> <li>• Transverse facial artery</li> <li>• Buccal branch of facial nerve</li> <li>• Accessory parotid gland</li> <li>• Parotid duct</li> <li>• Mandibular branch of facial nerve</li> </ul>



### Blood supply

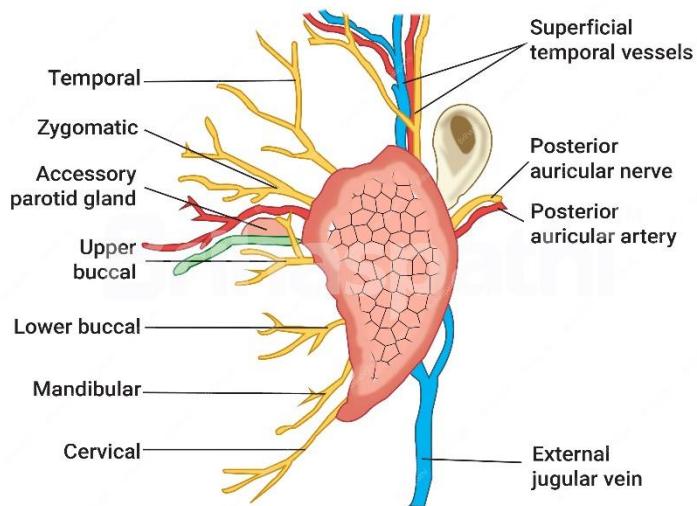
- External carotid artery

### Venous drainage

- Into external jugular vein

### Lymphatic drainage

- Parotid nodes
- Upper cervical nodes



## Nerve supply

<i>Sensory</i>	<i>Sympathetic</i>	<i>Parasympathetic</i>
<ul style="list-style-type: none"> <li>• Auriculotemporal nerve</li> <li>• Greater auricular nerve for the capsule</li> </ul>	<ul style="list-style-type: none"> <li>• Plexus around the middle meningeal artery</li> </ul>	<ul style="list-style-type: none"> <li>• Reaches the gland through auriculotemporal nerve</li> </ul>

## Structures Present Within the Parotid Gland

### I. Facial nerve and its branches

- Facial nerve emerges from the stylomastoid foramen and enters the gland by piercing upper part of its posteromedial surface.
- It then divides into two trunks:
  - 1. Temporo-facial trunk**
    - It gives rise to temporal nerve and zygomatic nerve
  - 2. Cervico-facial trunk**
    - This further divides into three branches: Buccal, Marginal mandibular and Cervical

### II. Retromandibular vein

- It is formed within the substance of parotid gland by union of superficial temporal and maxillary veins and lies below the facial nerve.

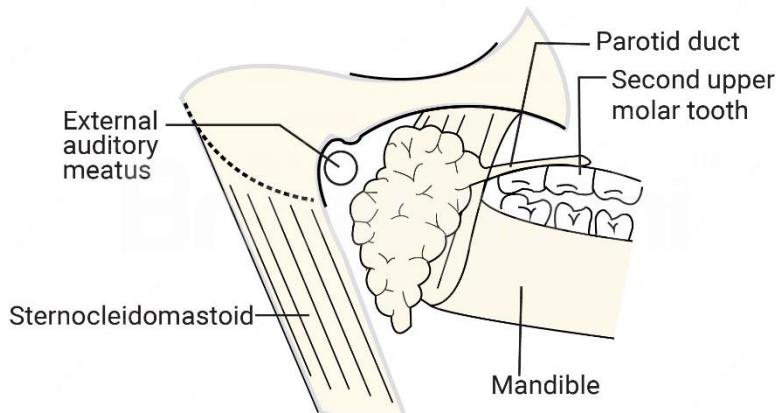
### III. External carotid artery

- It occupies the deep part of gland

### IV. Deep parotid lymph nodes

#### Parotid Duct

- **Synonym:** Stenson's duct
- Thick walled
- 5 cm long, passing 2 finger breadths inferior to the zygomatic arch
- Turns medially at the anterior border of the masseter, pierces buccinator, enters the oral cavity adjacent to the upper second molar tooth.
- The duct has a relation to many structures as it passes through all of them. It opens at the vestibule of the mouth after it crosses the **buccal fat, buccopharyngeal fascia** and buccinator muscle. This vestibule lies close to the parotid papilla, across the second molar tooth of the upper jaw. During blowing, the buccinator muscle keeps a check on the parotid duct and prevents its inflation.

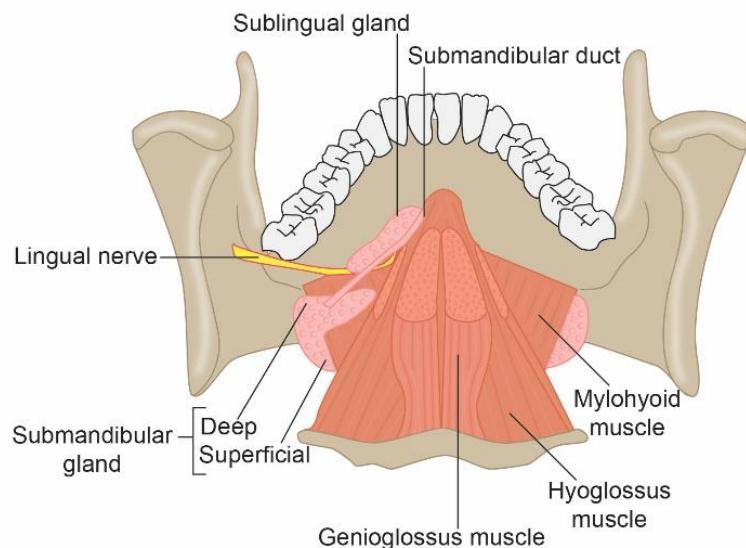
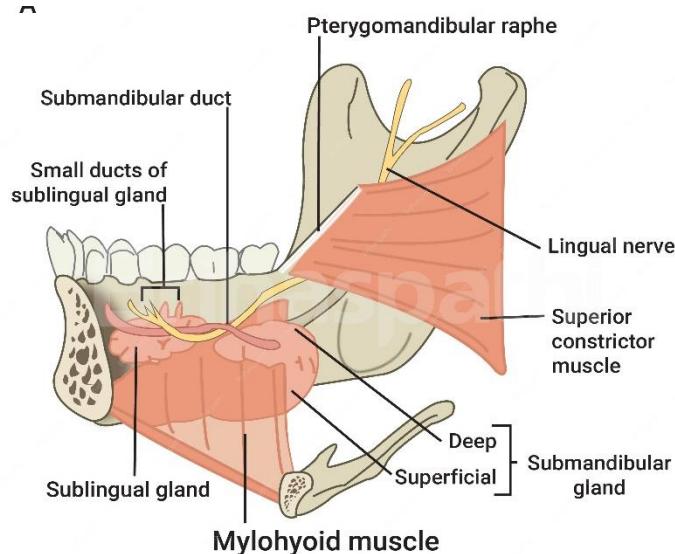


### SUBMANDIBULAR SALIVARY GLAND

- Large salivary gland: Mixed gland with predominant serous units
- Size: Walnut
- Location: Seen in anterior part of Digastric triangle
- Shape: J shaped

## Parts

- Divided by Mylohyoid muscle
  - Larger Superficial part (body)
  - Smaller Deep part
  - Submandibular duct



## 1. Superficial part (Body)

- Fills the Digastric triangle & extends upwards deep to Mandible till Mylohyoid line
- Has three surfaces
  - Inferior – covered by skin and Platysma
  - Lateral – related to the medial surface of the Mandible
  - Medial – related to the Mylohyoid, Hyoglossus and Digastric muscles
- Enclosed between 2 layers of deep cervical fascia

### Anatomic relations

Inferior Surface	Lateral Surface	Medial Surface
<ul style="list-style-type: none"> <li>• Skin</li> <li>• Platysma</li> <li>• Cervical branch of Facial nerve</li> <li>• Deep fascia</li> <li>• Facial vein</li> <li>• Submandibular lymph nodes</li> </ul>	<ul style="list-style-type: none"> <li>• Submandibular gland fossa</li> <li>• Insertion of Medial Pterygoid</li> <li>• Facial artery</li> </ul>	<ul style="list-style-type: none"> <li>• Mylohyoid</li> <li>• Hyoglossus</li> <li>• Styloglossus</li> <li>• Stylohyoid</li> <li>• Posterior belly of Digastric</li> </ul>

## 2. Deep part

- Smaller in size
- Lies between the Mylohyoid & Hyoglossus muscles

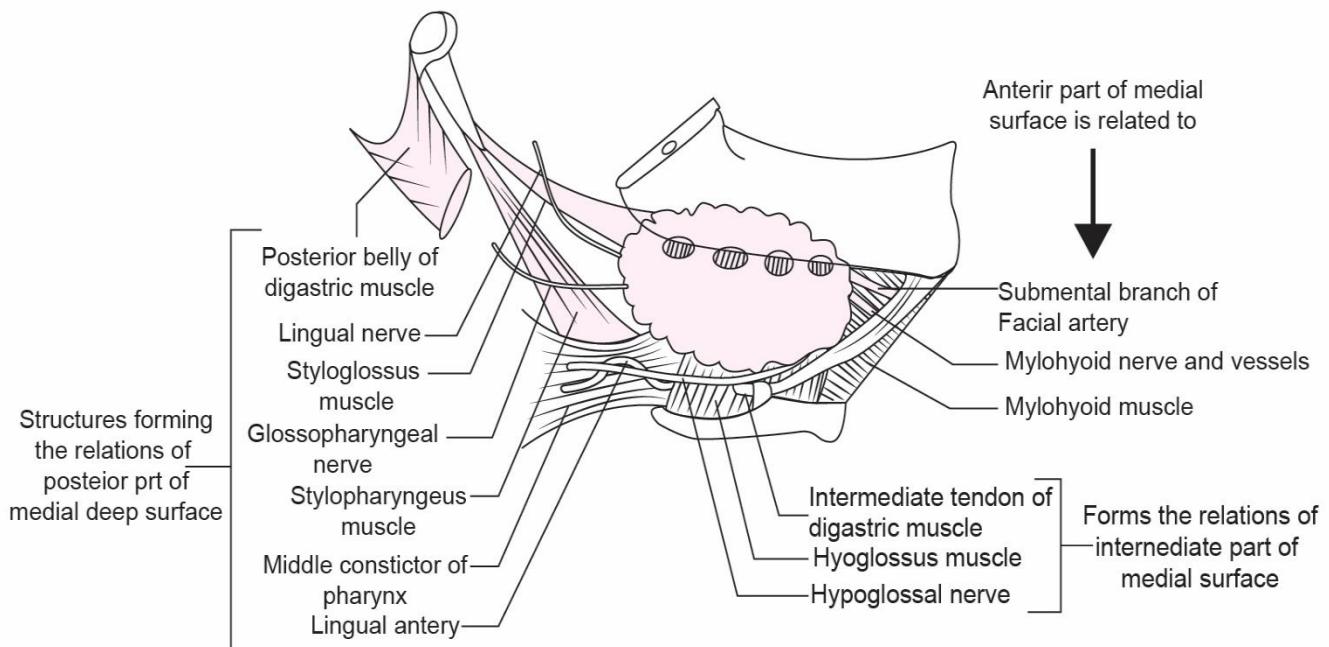
### Anatomic relations

Laterally	<ul style="list-style-type: none"> <li>• Mylohyoid</li> </ul>
Medially	<ul style="list-style-type: none"> <li>• Hyoglossus</li> </ul>
Above	<ul style="list-style-type: none"> <li>• Lingual nerve with Submandibular ganglion</li> </ul>
Below	<ul style="list-style-type: none"> <li>• Hypoglossal nerve</li> </ul>

## 3. Submandibular duct

- Synonym: Wharton's duct
- Thin walled, 5 cm long
- Emerges: At the anterior end of deep part, runs forwards on hyoglossus, opens at the floor of the mouth, at the side of the tongue frenum

## Anatomic relations of submandibular gland



I. Arterial supply	II. Venous drainage	III. Lymphatic drainage
<ul style="list-style-type: none"> <li>Facial artery</li> </ul>	<ul style="list-style-type: none"> <li>Common facial &amp; lingual veins</li> </ul>	<ul style="list-style-type: none"> <li>Submandibular lymphnode</li> </ul>
<b>IV. Nerve supply</b>		
<p>Supplied by submandibular ganglion branches:</p> <ul style="list-style-type: none"> <li>Sensory fibers of lingual nerve</li> <li>Secretomotor fibers</li> <li>Vasomotor sympathetic fibers from the plexus on the facial artery</li> </ul>		

## SUBLINGUAL SALIVARY GLAND

- It is the smallest of all three major salivary glands
- Shape: Almond
- Weight: 3 - 4 grams
- Mixed gland with predominant mucous type

### I. Anatomic relations

- Gland lies above the mylohyoid
- Underneath the floor of the mouth
- Medial to sublingual fossa of mandible
- Lateral to genioglossus

## II. Parts:

Consists as one main gland with several smaller ducts

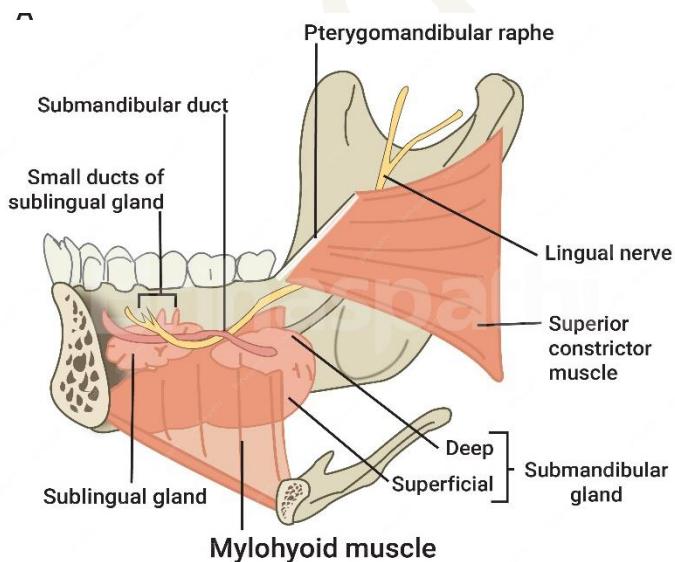
### 1. Bartholin's duct:

- It is the main duct of sublingual gland.
- Opens near the submandibular duct

### 2. Duct of Rivinus:

- Smaller ducts (approximately 15) of sublingual gland
- Opens at the sublingual fold

III. Blood supply	IV. Neural supply
<ul style="list-style-type: none"> <li>• Lingual and submental arteries</li> <li>• Venous drainage corresponds with the arteries</li> </ul>	<p>Supplied by submandibular ganglion branches:</p> <ul style="list-style-type: none"> <li>• Sensory fibers of lingual nerve</li> <li>• Secretomotor fibers</li> <li>• Vasomotor sympathetic fibers from the plexus on the facial artery</li> </ul>



## MINOR SALIVARY GLANDS

- Minor salivary glands are present below the epithelium in the oral cavity
- Consists of numerous small groups of secreting units opening directly into the mouth using minute ducts
- They do not have a separate capsule, instead they are combined with connective tissue of submucosa and fibers of muscles of tongue and cheek.

**I. Labial and buccal glands (Mixed glands)**

- Present on the lips and cheeks
- Consists of tubules of mucous glands with serous demilunes

**II. Glossopalatine glands (Purely mucous glands)**

- Located at the isthmus of glossopalatine fold, may extend from posterior body of sublingual gland to the glands of soft palate

**III. Palatine glands (Purely mucous glands)**

- Located in the glandular region in the lamina propria of posterolateral aspect of the hard palate, submucosa of soft palate and uvula

**IV. Lingual glands**

- These are the glands of tongue, divided into three types

1. Anterior lingual glands/ Glands of Blandin and Nuhn	2. Posterior lingual glands (Mucous)	3. Posterior lingual glands (Serous)/ von Ebner's glands
<ul style="list-style-type: none"> <li>• Located at the apex of the tongue.</li> <li>• Opens on the ventral surface of the tongue near lingual frenum</li> <li>• Chiefly mucous in nature</li> </ul>	<ul style="list-style-type: none"> <li>• Located lateral and posterior to Circumvallate papillae along with lingual tonsil.</li> <li>• Opens on to the dorsal surface of the tongue</li> </ul>	<ul style="list-style-type: none"> <li>• Located between fibres of tongue muscle below the circumvallate papillae</li> <li>• Opens into the circumvallate papillae and foliate papillae on the sides of the tongue</li> </ul>

**HISTOLOGY (Light and ultra-microscopic features)**

- Consists of two main elements:
  - Glandular secretory tissue (parenchyma)
  - Supporting connective tissue (stroma)

Parenchymal elements consist of branched ducts (epithelium lined tubes that convey the secretions from the secretory units to a specific area) that terminate as spherical or tubular acini (secretory units)

Stroma forms a capsule around the gland & enters the gland, dividing the groups of secretory units and ducts into lobes & lobules

### 1. Secretory Units

- Basic functional unit of a salivary gland → Terminal secretory unit → Acinus (Acini)
- Acini
  - Consists of epithelial secretory cells (serous & mucous cells) & myoepithelial cells
  - Spherical or tubular in shape with a central lumen
- Secretory cells in acini → Rest on the basement membrane, arranged in a single layer & held together by junctional complexes
- Myoepithelial cells → Located on the surface of acini
- Central lumen → Appears star shaped → Because of extension of lumen in between the cells → Called as intercellular canaliculi

1. Serous Acini	2. Mucous Acini
<ul style="list-style-type: none"> <li>Composed of serous cells</li> <li>Spherical shaped acini with 8-12 cells surrounding a <i>small central lumen</i></li> </ul> <p><b>Serous cells</b></p> <ul style="list-style-type: none"> <li>Pyramidal in shape with a broad base adjacent to connective tissue stroma &amp; narrow apex towards lumen</li> <li><i>Centrally located spherical nucleus</i></li> <li>Basal surface also shows regular folds</li> <li>Secretory granules → <i>Zymogen granules</i> → present in the apical cytoplasm</li> <li>Laterally junctional complexes seen</li> <li>Well stained cytoplasm</li> </ul>	<ul style="list-style-type: none"> <li>Composed of mucous cells</li> <li>Tubular shaped acini with a <i>large central lumen</i></li> </ul> <p><b>Mucous cells</b></p> <ul style="list-style-type: none"> <li>Triangular / pyramidal in shape</li> <li><i>Nucleus is oval or flattened in shape &amp; present just above the basal plasma membrane</i></li> <li>Large amounts of secretory product → mucus → present at the apical cytoplasm</li> <li>Lightly stained cytoplasm</li> </ul> <p><b>Mucin granules</b></p> <ul style="list-style-type: none"> <li>Mucous secretion differs from serous secretion in two important respects           <ul style="list-style-type: none"> <li>Little or no enzymatic action</li> <li>Ratio of carbohydrate to protein is greater</li> </ul> </li> </ul>

## 2. Serous Demilunes

- Mucous end pieces of the major salivary glands & some minor glands have serous cells associated with them in the form of a crescent covering the mucous cells covering at the end of the tubule → Serous demilunes

## 3. Myoepithelial Cells

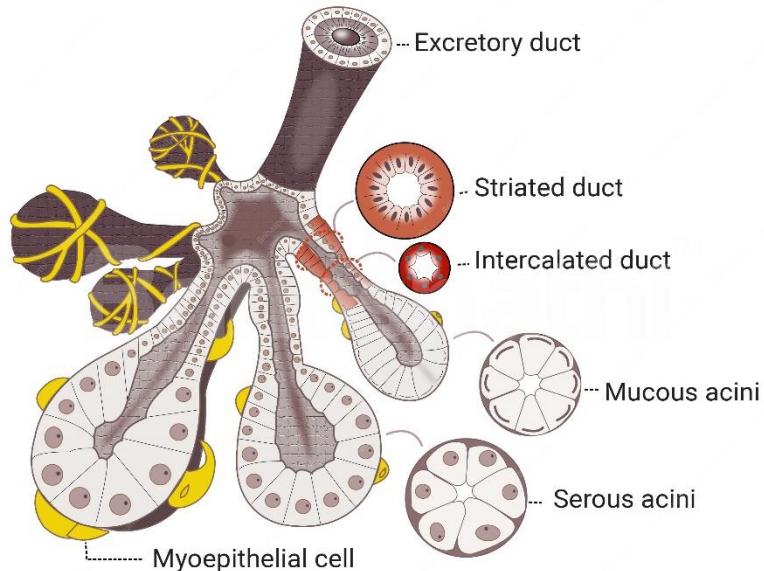
- Contractile cells associated with the secretory end pieces (serous & mucous acini) & intercalated duct cells
- Located between the basal lamina & the secretory or intercalated ductal cells
- Similar to smooth muscle cells but derived from epithelium*
- Are also called as Basket cells because of their appearance simulates the basket cradling the secretory unit

Myoepithelial cells	
<ul style="list-style-type: none"> <li>Associated with acini</li> </ul>	<ul style="list-style-type: none"> <li>Associated with intercalated ducts</li> </ul>
<ul style="list-style-type: none"> <li>Stellate shape</li> </ul>	<ul style="list-style-type: none"> <li>Fusiform shape</li> </ul>

Myoepithelial cells consists of both cytokeratin intermediate filament and contractile actin filaments.

### Functions of myoepithelial cells

- Provide support to the acini during active secretion
- Help acini to expel primary saliva into ducts
- Help in maintaining the patency of intercalated ducts by shortening & widening them
- Provide signals to acini cells that are necessary for maintaining cell polarity & structural organisation
- Produce some tumour suppressor proteins & act as a barrier against invasive epithelial neoplasm



#### 4. Duct System

- Ducts are hollow tubes lined by epithelium
- Progressively increases in diameter, starting at the secretory end piece & extending into the oral cavity.
- Functions: passage of saliva, production & modification of saliva
- Types of ducts
  - Intercalated duct (Intralobular duct)
  - Striated duct (Intralobular duct)
  - Excretory duct (Interlobular duct)

Intercalated duct  
(connects the striated ducts to acini)



Striated duct  
(plays a role in modification of primary saliva  
produced by acini)



Excretory duct  
(empties into oral cavity)

## 5. Connective Tissue Elements

- Connective tissue (Stroma) forms the capsule and septae of salivary glands and surrounds the duct and acini
- Contain cells, ground substance, nerves and blood vessels
- Cells: plasma cells, fibroblasts, macrophages and lymphocytes
- Ground substance: collagen fibres & proteoglycans
- Nerves: both sympathetic & parasympathetic divisions of the autonomic nervous system Parasympathetic stimulation → copious flow of watery saliva

## APPLIED ANATOMY IN RELATION TO PROSTHODONTICS

### 1. Xerostomia (dry mouth)

- It is a subjective symptom of dry mouth caused due to decreased production of saliva.
- It is a symptom caused by several factors

<b>Etiology</b>	<b>Symptoms</b>	<b>Signs</b>
<ul style="list-style-type: none"> <li>• Sjogren's syndrome</li> <li>• Radiation of head and neck</li> <li>• Surgical removal of salivary glands</li> <li>• Viral infections involving salivary glands</li> <li>• Anxiety, mental stress and depression</li> <li>• Diabetes mellitus</li> </ul>	<ul style="list-style-type: none"> <li>• Dryness of mouth</li> <li>• Halitosis</li> <li>• Burning sensation</li> <li>• Difficulty in swallowing</li> <li>• Loss of sense of taste</li> <li>• Tongue tends to stick to the palate</li> <li>• Denture retention is decreased</li> </ul>	<ul style="list-style-type: none"> <li>• Salivary pool disappears</li> <li>• Dryness of mucosa</li> <li>• Glossitis of tongue</li> <li>• Mucosa atrophied</li> <li>• Angular cheilitis</li> <li>• Rampant caries</li> <li>• Candidiasis</li> <li>• Periodontitis</li> </ul>

### 2. Sialorrhea

- Excessive salivation
- Some systemic & local factors causing Sialorrhea:
  - Drugs
  - Bethanechol, Cevimeline, Clozapine, lithium, Nitrazepam, Physostigmine, Pilocarpine, Resperidone.
  - Oral conditions
  - Teething, ill-fitting prostheses, mucosal ulcerations (aphthous ulcers)
  - Vomiting/Diarrhoea

- Other conditions
- Cerebral palsy
- Parkinson's
- Amyotrophic lateral sclerosis (ALS)
- Heavy metal poisoning
- Rabies

## CONCLUSION

- Salivary glands are compound and exocrine in nature which secrets saliva to keep the oral cavity hydrated and moist.
- The secretory units are called acini and the saliva produced reaches to oral cavity through ducts. Saliva plays a major role in the field of dentistry especially prosthodontics as it aids in retention of prosthesis, maintenance of self-cleansing action in and around the prosthesis etc.
- Hence it is important to understand the anatomy and physiology of salivary glands for a successful rehabilitation

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**Please Give Your Feedback on this Answer**

**Q. 04: Discuss various mandibular movements and their regulations by muscles and ligaments (10M)**

**Movements of mandible (7M)**

**Discuss significance of mandibular movements in prosthodontics (20M)**

## CONTENTS/SYNOPSIS

- Introduction
- Significance of understanding mandibular movements
- Methods to study mandibular movements
- Factors controlling mandibular movements
  - Condylar path
  - Opposing tooth contacts
  - Neuromuscular system
- Classification of Mandibular Movements
  - According to Okeson
    - Based on the movement of condyle within TMJ
    - Based on the border movements plane
- Basic movements
  - Rotation (hinge movement)
  - Translation
- Excursive movements
  - Opening & closing
  - Protrusion & retrusion
  - Lateral excursion
- Border movements
  - Movement in sagittal plane
  - Movement in horizontal plane
  - Movement in frontal plane
- Functional movements
- Para functional movements
- Conclusion
- References

## INTRODUCTION

- Mandibular movements are complex and varies within individuals. Several mandibular movements occur during:
  - Mastication
  - Speech
  - Swallowing
  - Respiration
  - Facial expressions
  - Parafunctional habits like bruxism, clenching
- It is determined by simultaneous and combined activities of both TMJ's.
- An articulator simulates the mandibular movements so that the prosthesis will function properly

## SIGNIFICANCE OF UNDERSTANDING MANDIBULAR MOVEMENTS

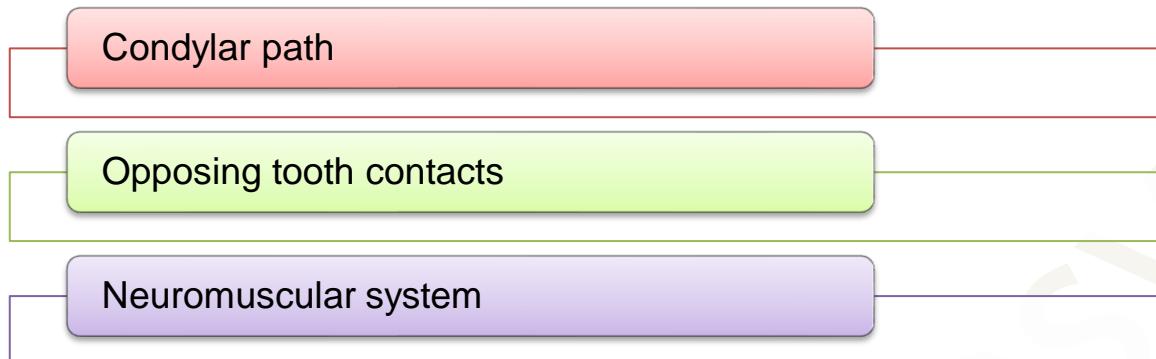
- To understand the concepts of occlusion
- Proper arrangement of artificial teeth
- To develop proper tooth forms for restorations
- Selection and adjustment of articulators and recording devices
- To treat TMJ disorders
- Preserve the periodontal health

## METHODS TO STUDY MANDIBULAR MOVEMENTS

- Direct observation (clinically)
- Electronic instrumentation
  - Facial clinometers
  - Roentgen fluoroscopy
  - Radionuclide tracking
  - Gnathic replicator
  - Optical pantography

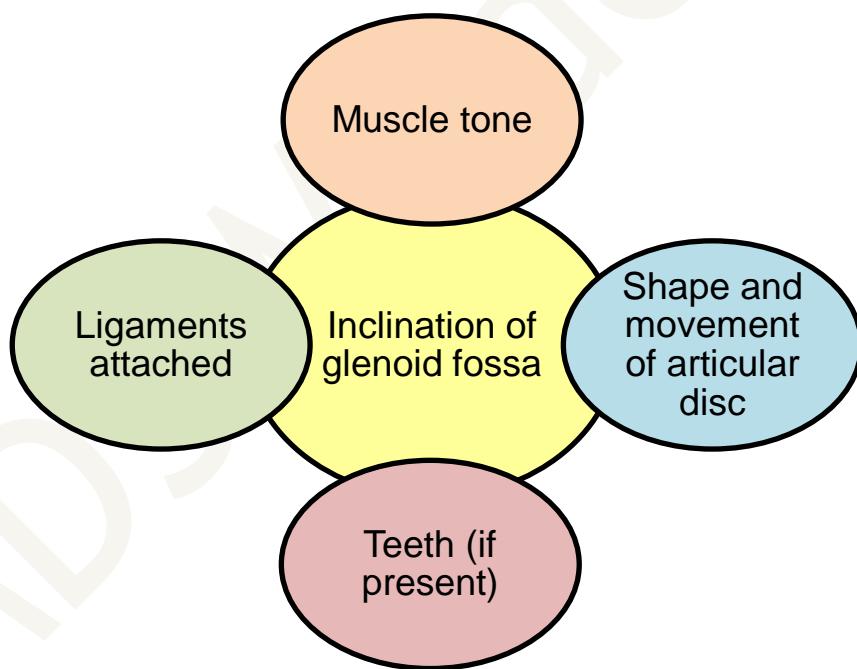
## FACTORS CONTROLLING THE MANDIBULAR MOVEMENTS

- Also called as determinants or controlling factors



### I. Condylar path

- It is the path of the condyle within the glenoid fossa and articular eminence during mandibular movements.
- Condylar path neither can be controlled by dentist nor can be altered
- It is influenced by following factors:



### II. Opposing tooth contact

- Opposing tooth surfaces are related to
  - Occlusal surfaces of teeth
  - Muscles involved
  - Temporomandibular joint
  - Neurophysiological components

- Inclines of the artificial tooth during mandibular movements should not deflect the influence of incisal guidance and condylar guidance.
- To prevent mandibular deflections and denture displacements, a balanced occlusion is essential in complete denture.
- This factor can be altered to achieve a balanced smooth occlusion.

### III. Neuromuscular system

- It is an important factor in regulation of mandibular movement due to the associated neuro muscular activity.
- Eg., Muscles of mastication, suprathyroid muscles.
- Mastication is a programmed event with a chewing centre within brain stem (reticular formation of pons)
- The functions performed by the muscle are due to the impulses from the central nervous system resulting in voluntary or involuntary muscular activity
- But due to loss of proprioceptors located in periodontal ligaments of the extracted tooth, eliminates an important source of control in positioning of mandible (Centric relation) especially for edentulous patients

<i>Muscles Involved</i>	<i>Mandibular Movements</i>
Masseter	<ul style="list-style-type: none"> <li>• Closing and retrusion</li> </ul>
Temporalis	<ul style="list-style-type: none"> <li>• Elevation and retrusion</li> </ul>
Medial pterygoid	<ul style="list-style-type: none"> <li>• Closing and lateral movement</li> </ul>
Lateral pterygoid	<ul style="list-style-type: none"> <li>• Opening, protrusion and lateral movements</li> </ul>
Suprathyroid muscles	<ul style="list-style-type: none"> <li>• Mouth opening by depressing the mandible</li> </ul>

## CLASSIFICATION OF MANDIBULAR MOVEMENTS

According to Okeson

1. ***Based on the movement of condyle within TMJ***
  - Rotational movement
  - Transitional movement
2. ***Based on the border movements plane***
  - Horizontal plane
  - Frontal plane
  - Sagittal plane

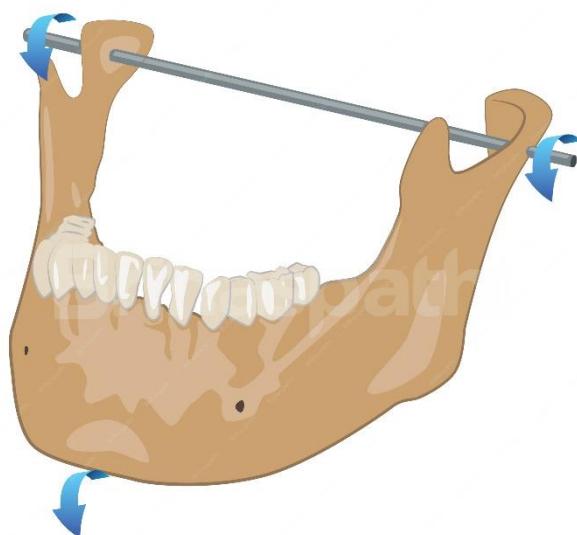
## BASIC MOVEMENTS

### I. Rotation (Hinge Movement)

- It is defined as the rotation of the condyle on an axis.
- Condyle rotates without any bodily movement.
- Seen in the inferior cavity (lower compartment) of TMJ.
- Rotation can occur in horizontal, frontal and sagittal axis and can be viewed in sagittal, frontal, horizontal planes.
- Rotation around frontal and sagittal axis is seen during lateral movements.

#### 1. Horizontal axis of rotation (sagittal plane)

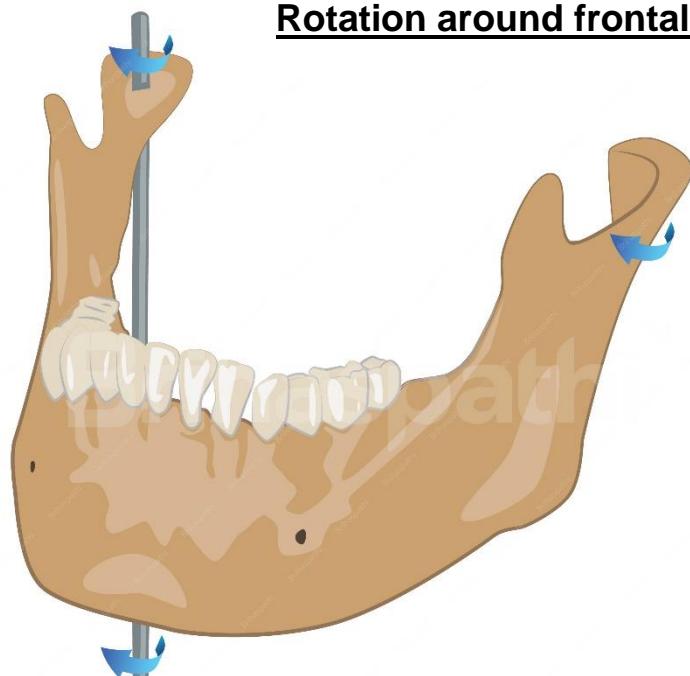
- Rotation around horizontal axis is seen during mouth opening and closing.
- Also referred as hinge movement, and the horizontal axis around which it rotates is called hinge axis
- When the condyles are in the superior most position in the articular fossa, mouth is purely rotated open and the axis around which it moves is called terminal hinge axis.
- This movement is seen rarely during normal functions
- It is the only example of mandibular movement in which pure rotational movement is seen



Rotation around horizontal axis

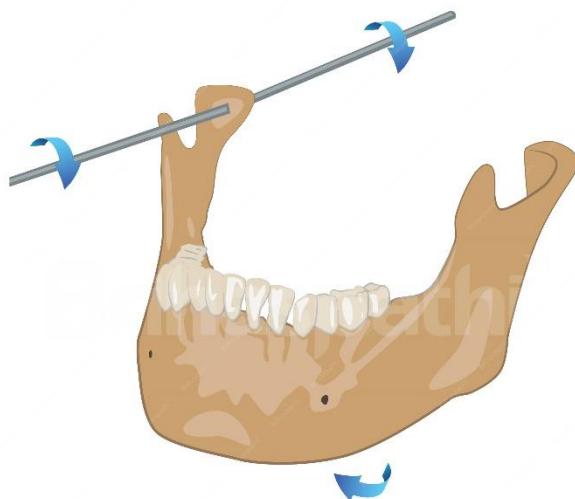
**2. Frontal / Vertical axis of rotation (Frontal plane)**

- Mandibular movement around this axis occurs when the condyles move towards anterior from the terminal hinge axis, with the frontal axis of opposite condyle within terminal hinge position
- Does not occur naturally

**Rotation around frontal axis****3. Sagittal axis of rotation (Horizontal plane)**

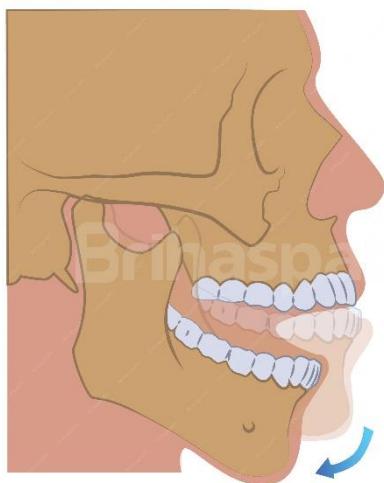
- Mandibular movement around sagittal axis occurs when one condyle moves downwards or inferiorly while the other condyle remains in its terminal hinge position
- Due to the presence of ligaments and musculature of TMJ controlling the movements, displacement of condyle (dislocation) is not seen naturally.
- Occurs in conjunction with movements like when the orbiting condyle moves downward and forward through the articular eminence

## Rotational movement around the sagittal axis

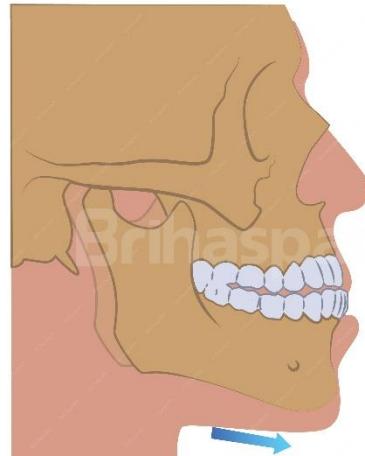


### **II. Translation**

- It is defined as bodily movement of a condyle at any period where all the points in the body move at same velocity and direction.
- Seen in the superior cavity (upper compartment) of TMJ.
- The teeth, condyles and mandibular ramus all move in the same forward direction, to the same degree
- Translation occurs in all excursive movements.



**Rotation movement**



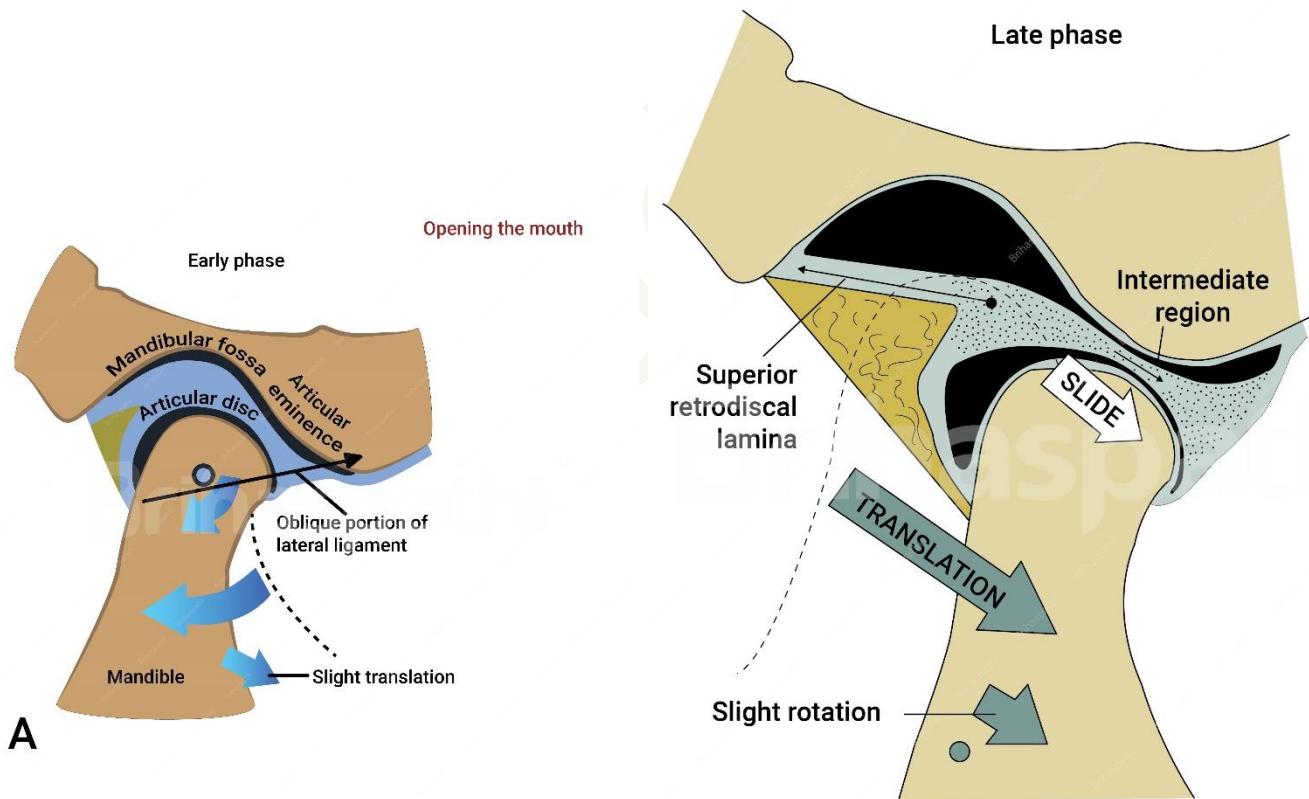
**Translation movement**

## EXCURSIVE MOVEMENTS

- These are defined as movements that occur when mandible is moving away from maximum intercuspsation. They are a combination of rotation and translation

### I. Opening & Closing

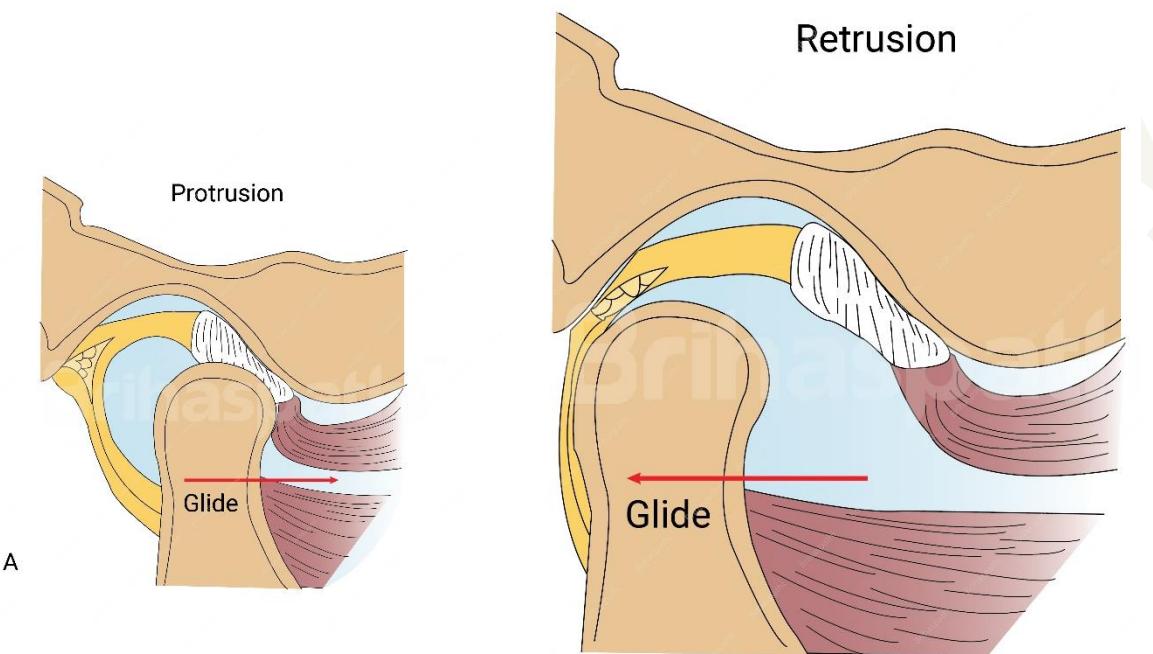
- Lateral pterygoid is the main muscle responsible for opening of mouth and is limited by superior lamina of articular disc
- Mouth opening initiates from centric relation (CR)
- Rotation is seen upto 12 mm of opening followed by translation
- Condyles move downward and forward and can be viewed in sagittal plane.
- Eg., During intake of food initially, crushing brittle foods
- Reverse of this movement is referred to mouth closure.



### II. Protrusion & Retruson

- Protrusion is defined as a mandibular position anterior to centric.
- Based on degree of protrusion and contour of glenoid fossa, condyles translate downward and forward

- The angle made by the advancing condyle with frontal plane is called protrusive condylar inclination/ guidance angle. Found based on protrusive records of patient
- Eg., Used to incise or grasp the food
- Retrusion is defined as movement of condyle posteriorly



- In natural teeth, when positioned edge to edge protrusive manner, it will create a gap between posterior teeth called a Christensen's phenomenon
- This feature must be eliminated during fabrication of dentures as they affect the stability of prosthesis

### III. Lateral excursion

- It is defined as movement when mandible moves laterally
- Eg., Commonly used for chewing and reduction of fibrous food

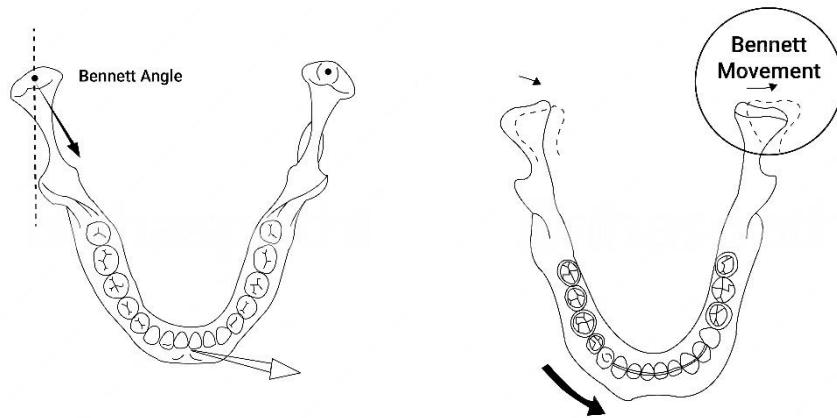
<ul style="list-style-type: none"> <li>• The lateral side to which mandible shifts is called <u>working or functional side</u></li> </ul>	<ul style="list-style-type: none"> <li>• The contralateral side is called <u>non-working or balancing side</u></li> </ul>
<p>↓</p> <ul style="list-style-type: none"> <li>• The condyles on working side are called <u>working condyle</u></li> </ul>	<p>↓</p> <ul style="list-style-type: none"> <li>• The other side is called <u>non-working condyle</u></li> </ul>

## Bennett shift

- Dr Norman Bennett described Bennett shift in 1908.
- According to him it is the direct lateral side shift that occurs simultaneously with a lateral excursion
- **Primary cause:** Due to the contraction of lateral pterygoid muscle

<ul style="list-style-type: none"> <li>• When mandible shifts to the side, its movement occurs in two segments</li> </ul>	
<b>Immediate side shift:</b> <ul style="list-style-type: none"> <li>• In which the major movement is mediolateral</li> </ul>	<b>Progressive side shift:</b> <ul style="list-style-type: none"> <li>• Begins thereafter and continues with mediolateral movement anteriorly</li> </ul>

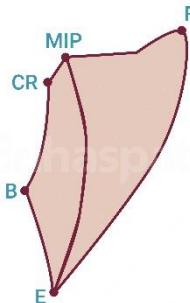
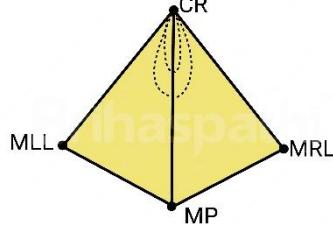
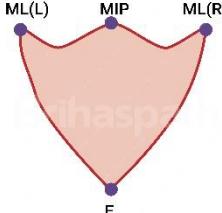
- Working condyle will either rotate on its axis or move outward and laterally called as **Bennett movement**
- Balancing condyle moves forward, downward and medially, also called as mediotrusion. Path of this condyle makes an angle with sagittal plane called as **Bennet angle/ lateral condylar guidance angle**.
- It is either determined by lateral records or Hanau formula  $L = H/8 + 12$  (range  $2^0 - 44^0$ ), mean -  $16^0$

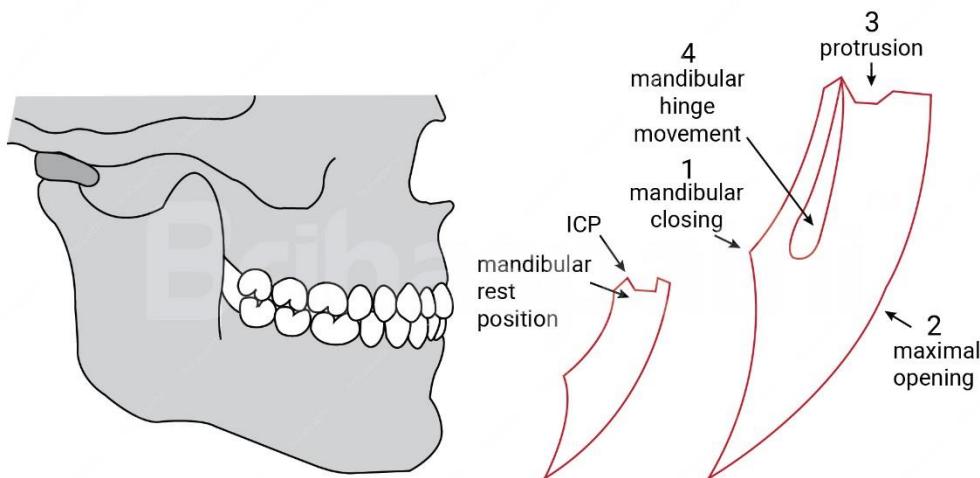


## BORDER MOVEMENTS

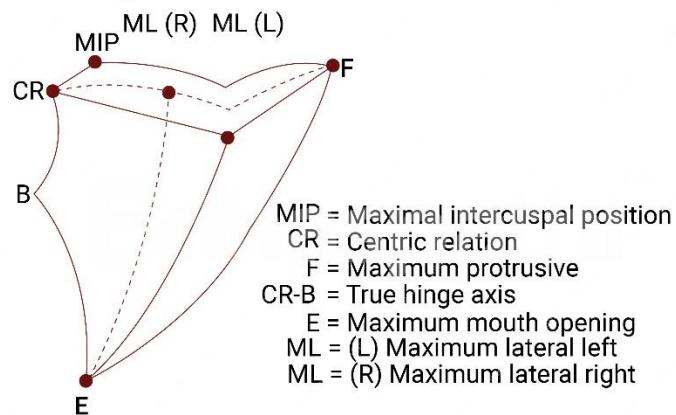
- It is defined as mandibular movements limited by anatomic structures when viewed in each plane
- These are extreme positions of mandible limited by muscles, nerves and ligaments

- Can be recorded using pantograph in three anatomic planes. All mandibular movements occur as border movements
- Eg., Parafunctional habits like bruxism, yawning

I. Movement in Sagittal Plane	II. Movement in Horizontal Plane	III. Movement in Frontal Plane
<ul style="list-style-type: none"> <li>• Movement is traced as mandible moves from Centric occlusion (CO) to maximal protrusion (F) to maximal mouth opening (E) and then closing returning to CO</li> <li>• Characteristic <u>beak tracing</u> is seen</li> </ul> 	<ul style="list-style-type: none"> <li>• Movement is traced when mandible moves from centric relation (CR) to right and left lateral extremes, maximal protrusion and returns to CR.</li> <li>• Used to record centric and eccentric jaw relations</li> <li>• Characteristic <u>diamond tracing</u> is seen</li> </ul> 	<ul style="list-style-type: none"> <li>• Traces the movement of mandible from centric relation to right and left lateral extremes to mouth opening and back.</li> <li>• Characteristic <u>shield tracing</u> is seen.</li> </ul> 



#### Envelope of motion



#### Envelope of Motion

- Described by Posselt
- Consists of all border movements in a three-dimensional view
- All mandibular functional movements occur within this envelope.

#### Neys Mandibular Excursion Guide

- Used to train the mandible to perform mandibular movements effectively.

## Maximum border movements

- Opening: 50 - 60 mm
- Lateral: 10 - 12 mm
- Protrusive: 8 - 11 mm
- Retrusive range: 1 mm

## FUNCTIONAL MOVEMENTS

- Activities:
  - Chewing
  - Swallowing
  - Speech
  - Respiration
  - Yawning
  - Facial expression
- Occurs chiefly around centric and free movements takes place within border movements
- The envelope of motion during chewing has a characteristic tear drop appearance which varies with consistency, type of food; size and number of teeth present; saliva quantity; musculature and forces.
- Mandibular movements during speech are highly variable, they can be used as a guide during jaw relations and teeth arrangements.
- Mandible is stable during swallowing, hence can be used as a guide to verify centric position

## PARA FUNCTIONAL MOVEMENTS

- Activities
    - Bruxism
    - Clenching
    - Habits like pencil biting, smoking through pipe etc
  - These are the movements seen other than in normal ones due to increased muscle activity.
- Mandibular movements during parafunction serves no use, instead they are harmful to the dental and supporting structures.

## CONCLUSION

- Knowledge of mandibular movements is essential for a better treatment planning.
- It is necessary to learn these jaw movements to reproduce them for proper functioning of occlusion either natural or prosthetic restoration.

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3. Buckley WF. Envelope of motion vs. envelope of function. Int J Orthod Milwaukee 2013;24(1):67-8
4. Lundee HC, Shryock EF and Gibbs CH. an evaluation of mandibular border movements: Their character and significance. J Prosthet Dent 1978;40(4):442-52.
5. Okeson JP. Management of temporomandibular Disorders and Occlusion, 5<sup>th</sup> ed. St Louis: Mosby, 2002

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*Please Give Your Feedback on this Answer*

**Q. 06: Muscles of tongue and its applied aspect (10M) (6M).**

**Anatomy of tongue (6M).**

**Discuss the anatomy of the tongue and its prosthetic rehabilitation (20M).**

**Discuss the development, muscular, neurovascular and lymphatic drainage of the tongue (20M) (7M)**

**Write the applied anatomy and development of tongue (20M)**

### CONTENTS/SYNOPSIS

- Introduction
- Development of tongue
  - Mechanism
  - After growth and fusion
  - Clinical implications of the development of tongue
- Functions of the tongue
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- Conclusion
- References

MDS Made Easy

## INTRODUCTION

- The word tongue is derived from the latin word 'lingua' and greek word 'glossa'.
- The tongue is a highly muscular organ which is partly oral and partly pharyngeal in position.
- The core of the tongue consists of connective tissue and interlacing bundles of skeletal muscle fibres.
- It is attached by its muscles to the hyoid bone, mandible, styloid process, soft palate and the pharyngeal wall.

## DEVELOPMENT OF THE TONGUE

- The tongue develops in relation to the pharyngeal arches (1st to 4th) in the floor of the developing mouth.
- It develops during 4th to 8th weeks of intra-uterine life.

### I. Mechanism

The medial most parts of the mandibular arches proliferate to form two lingual swellings



The lingual swellings are partially separated from each other by another swelling that appears in the midline which is called the tuberculum impar



Behind the tuberculum impar, the epithelium proliferates to form a growth downwards (thyroglossal duct) from which the thyroid gland develops



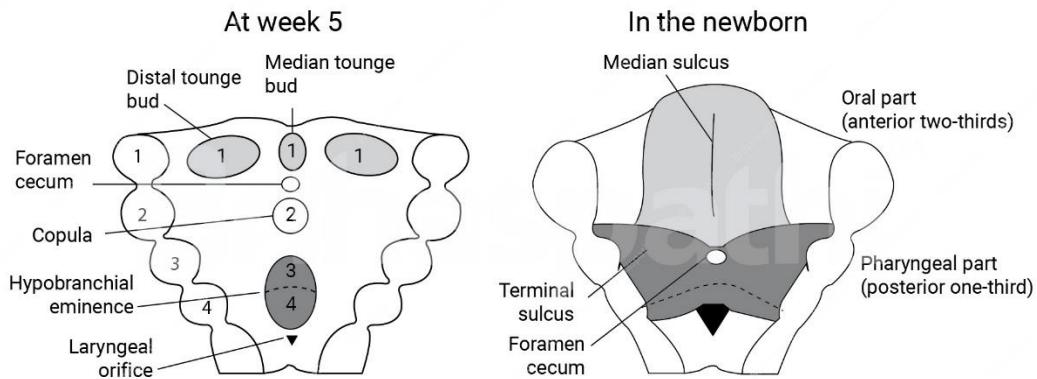
The site of this down growth is subsequently marked by a depression called the foramen cecum



Another, midline swelling is seen in relation to the medial ends of the second, third and fourth arches. This swelling is called the hypobranchial eminence or copula of His



This eminence shows a subdivision into a cranial part related to the second and third arches (copula) and a caudal part related to the fourth arch. The caudal part forms the epiglottis



## II. After growth and fusion

The anterior two thirds of the tongue (derived from mandibular arch) is formed by the fusion of the tuberculum impar and the two lingual swellings.

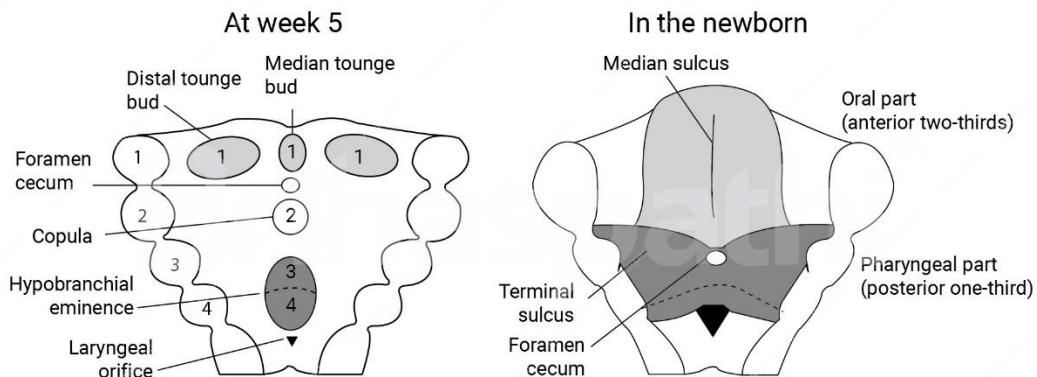


The posterior one-third of the tongue is formed from the cranial part of the hypobranchial eminence (copula)



The third arch mesoderm grows over it to fuse with the mesoderm of the first arch, forms posterior one third of tongue

The posterior most part of the tongue is derived from the fourth arch.



### III. Clinical Implications of the development of tongue

- The tongue may be too large (**macroglossia**) or too small (**microglossia**).
- Very rarely the tongue may be absent (**aglossia**).
- The tongue may be bifid because of **nonfusion** of the two lingual swellings.
- The apical part of the tongue may be anchored to the floor of the mouth by an overdeveloped frenulum. This condition is called **ankyloglossia** or **tongue-tie**. It interferes with speech.
- Occasionally, the tongue may be adherent, to the palate called as **ankyloglossia superior**.
- Thyroid tissue may be present in the tongue either under the mucosa or within the muscles and is termed as **lingual thyroid**.
- The surface of the tongue may show fissures called as **fissured tongue**.

### FUNCTIONS OF THE TONGUE

#### Mastication

- During mastication tongue is used to soften the food by crushing it against the palate

#### Deglutition

- Formation of bolus and passage of food into oesophagus

#### Speech

- Muscles of tongue facilitate speech by contacting lips, teeth, palate
- Principal articulator

#### Taste

- Tongue consists of a large number of taste buds on its dorsal and lateral surfaces enabling it for taste perception

## ANATOMY OF TONGUE

- The tongue can be divided into
  - Root
  - Apex
  - Curved dorsum
  - Inferior surface
  - Mucosa – The mucosa is normally pink, velvety and moist.
- The dorsum of the tongue is divided by a V shaped sulcus terminalis into
- Anterior or oral (pre sulcal) part is movable
- Posterior, pharyngeal ( post sulcal) part is immovable
- Median fibrous septum separates the tongue into right and left halves

### I. Oral part of the tongue

- The presulcal part of the tongue is located in the floor of the oral cavity.
- It has an apex touching the incisor teeth, a margin in contact with the gums & teeth and a superior surface (dorsum) related to the hard and soft palates.

<i>1. Superior surface/ dorsum</i>	<i>2. Inferior surface/ventral surface</i>
<ul style="list-style-type: none"><li>• Has a longitudinal median sulcus.</li><li>• It is covered by filiform, fungiform and circumvallate papillae.</li></ul>	<ul style="list-style-type: none"><li>• It is smooth, purplish and reflected onto the oral floor and gums.</li><li>• It is connected to the floor anteriorly by the lingual frenum.</li><li>• The deep lingual vein which is visible lies lateral to the frenum on either side.</li><li>• On each side, in front of the palatoglossal arch, there are four to five vertical folds, the foliate papillae.</li></ul>

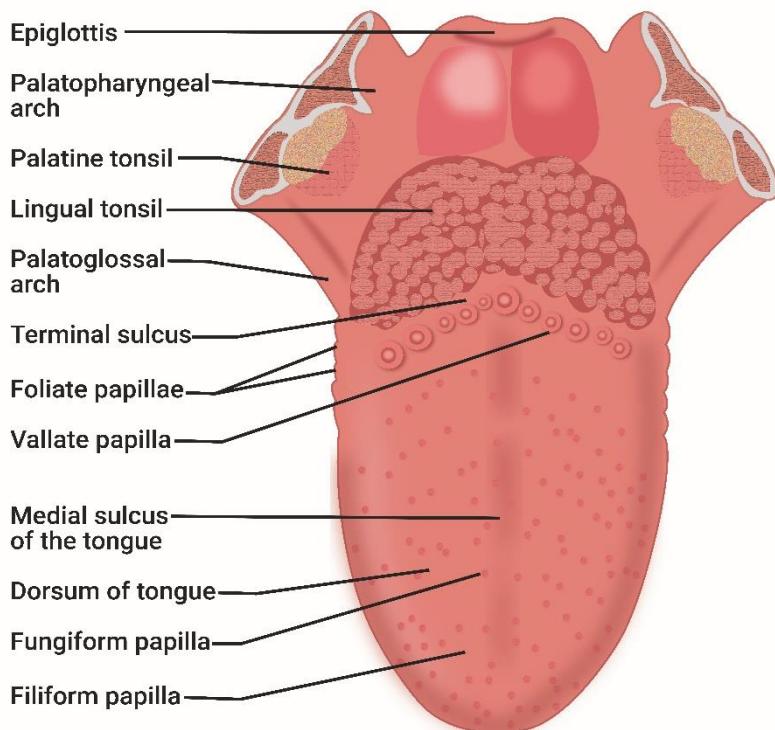
## II. Pharyngeal / post sulcal part

- It constitutes the base of the tongue and lies posterior to the palatoglossal arches.
- The pharyngeal part of the tongue is devoid of papillae, and exhibits low elevations.
- The ducts of small seromucous glands open on the apices of these elevations.
- There are underlying lymphoid nodules which are embedded in the submucosa and collectively termed the lingual tonsil.

## III. Papillae of tongue

1. Filiform papillae	2. Fungiform papillae
<ul style="list-style-type: none"> <li>• Give a velvety appearance to the tongue</li> <li>• Most numerous of all lingual papillae</li> <li>• Conical or flame shaped with tips often showing several points</li> <li>• They are 2 mm long, arranged in rows parallel to the sulcus terminalis</li> <li>• <i>Taste buds are absent</i></li> <li>• Number of secondary papillae: 7–30</li> <li>• Reflected on the epithelial surface as irregular or projections or points</li> <li>• Increase the friction between tongue and food.</li> <li>• Facilitate the movement of particles by tongue.</li> </ul>	<ul style="list-style-type: none"> <li>• Randomly distributed among filiform papillae, upto 200 in number</li> <li>• Height of up to 2 mm</li> <li>• Mushroom shaped ; intensely pink in colour</li> <li>• Dome shaped upper surface and a narrower base</li> <li>• They bear one or more taste buds on their apical surfaces</li> </ul>
3. Foliate papillae	4. Circumvallate papillae
<ul style="list-style-type: none"> <li>• Parallel mucosal folds at posterior lateral body of the tongue</li> <li>• Well developed at birth</li> <li>• With growth – undergo atrophy –at</li> </ul>	<ul style="list-style-type: none"> <li>• 7 to 11 in number</li> <li>• Largest of the lingual papillae</li> <li>• Over 1 mm in height and 3 mm in diameter</li> </ul>

<p>maturity reduced to rudimentary structures</p> <ul style="list-style-type: none"> <li>• 3 to 8 in number</li> <li>• Taste buds are contained along the walls of the folds</li> <li>• Serous secretion of von ebners glands are emptied into the base of the clefts</li> <li>• Serve to flush debris from the folds and to dissolve the substances to be tasted</li> </ul>	<ul style="list-style-type: none"> <li>• They result as mucosal invaginations</li> <li>• Characterized by deep furrows that completely encircle them .</li> <li>• Numerous excretory ducts – serous Von Ebner's glands empty into the base of the furrows.</li> <li>• The secondary papillae exist only on the superior surface</li> <li>• With advancing age number of taste buds is reduced</li> <li>• Contain numerous taste buds; upto 250 per papilla</li> </ul>
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## IV. Glands of the tongue

### *Lingual salivary glands*

- Tip of the tongue (mixed) - Glands of blandin and nuhn
- Base & the body of tongue (serous) - Von Ebner's glands
- Posteriorly under the tonsillar tissue - Mucous glands

- Each minor gland is small consisting of a cluster of acini and each is drained by a short duct.

## MUSCLES OF THE TONGUE

- The tongue is divided by a median fibrous septum, attached to the body of the hyoid bone which divides the tongue into right and left halves.
- Each half contains four intrinsic and four extrinsic muscles.

Tongue muscles	Vascular supply	Nerve supply	Action
<b>1. Extrinsic muscles</b>			
i. <i>Genioglossus</i>	Sublingual branch of the lingual artery, Submental branch of the facial artery	Hypoglossal nerve	Protrusion of tongue, Makes tongue concave

### Course

- The muscle is triangular in sagittal section, lies near and parallel to the midline.
- Arises from a short tendon attached to the superior genial tubercle behind the mandibular symphysis, above the origin of geniohyoid.
- The fibres fan into the substance of tongue and some attach to the body of hyoid bone.

ii. <i>Hyoglossus</i>	Lingual artery, facial artery	Hypoglossal nerve	Depression of tongue
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### Course

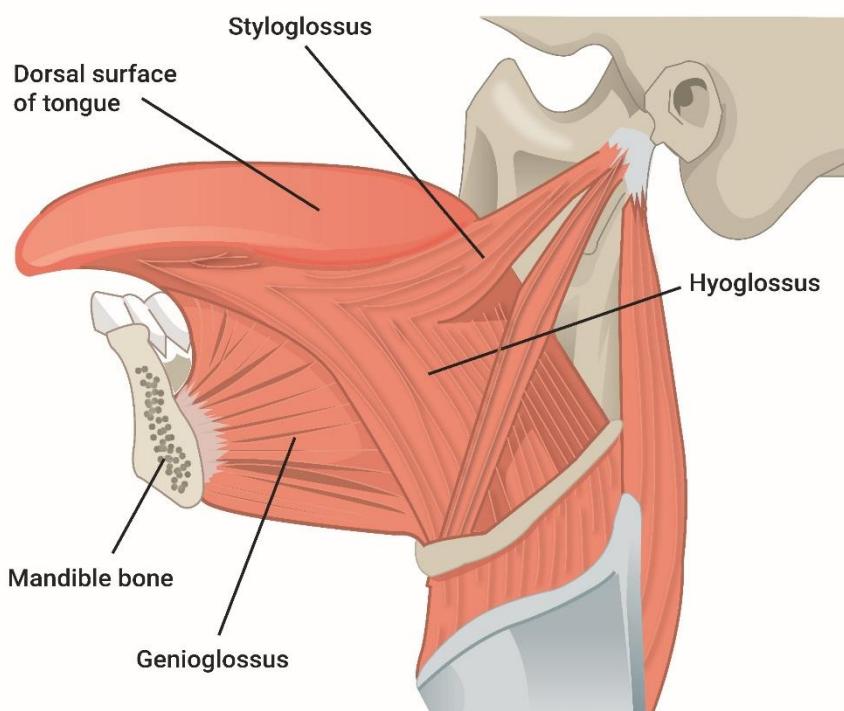
- Hyoglossus is a thin, quadrilateral muscle that arises from whole length of greater cornu of hyoid bone and front of body of hyoid bone.
- It passes vertically up to enter the side of the tongue between Styloglossus laterally and the inferior longitudinal muscle medially.

iii. <i>Styloglossus</i>	Lingual artery	Hypoglossal nerve	Draws tongue up
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			and backwards
<b>Course</b>			
<ul style="list-style-type: none"> <li>Shortest and smallest of the tongue muscles.</li> <li>It arises from the anterolateral aspect of styloid at its apex and from the styloid end of the stylomandibular ligament.</li> </ul>			
iv. <i>Palatoglossus</i>	Maxillary artery, facial artery	Pharyngeal plexus from cranial part of accessory nerve	Pulls up root of the tongue.

**Course**

- This muscle inserts into the oral surface of the palatine aponeurosis.
- Descends in the palatoglossal arch to the side of the tongue at the junction of its oral and pharyngeal parts.
- It is supplied by the pharyngeal plexus from the cranial part of the accessory nerve through the vagus.

**2. Intrinsic muscles**

v. <i>Superior longitudinal</i>	Lingual artery	Hypoglossal nerve	Shortens the tongue, Makes dorsum concave
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**Course**

- It is a thin stratum of oblique and longitudinal muscle fibres lying beneath the

mucosa of the dorsum of the tongue.

- Extends from the submucous fibrous tissue near the epiglottis and median lingual septum to the lingual margins.

vi. <i>Inferior longitudinal</i>	Lingual artery	Hypoglossal nerve	Shortens the tongue
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### Course

- A narrow band of muscle close to inferior lingual surface between the genioglossus and the hyoglossus.
- Extends from the root of the tongue to the apex.

vii. <i>Transverse</i>	Lingual artery	Hypoglossal nerve	Narrows and elongates the tongue.
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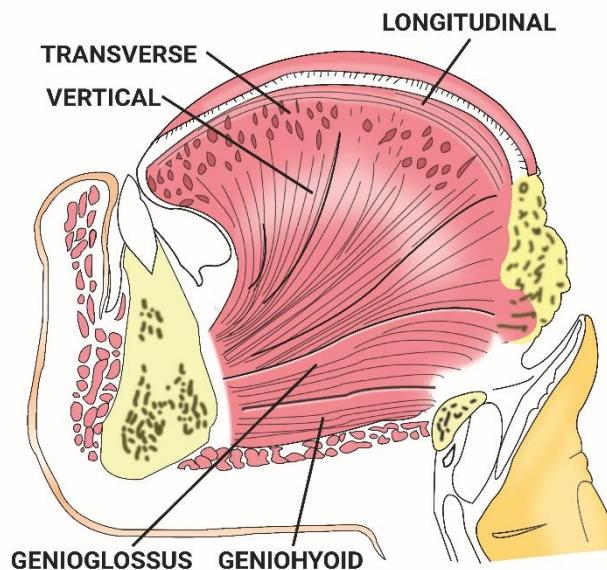
### Course

- Passes from the median fibrous septum to the submucous fibrous tissue at the lingual margins and blends with the palatopharyngeus muscle.

viii. <i>Vertical</i>	Lingual artery	Hypoglossal nerve	Widens and flattens the tongue
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### Course

- Extends from the dorsal to the ventral aspects of the tongue in the anterior borders.



## INNERVATIONS OF THE TONGUE

### I. General sensory innervations

- Since the mucosa covering the anterior two third or body of the tongue originates from the first pharyngeal arch therefore, the sensory innervation to this area is by the lingual branch of the mandibular nerve (branch of the trigeminal nerve).
- The posterior part or root of the tongue originates from the second, third, and part of the fourth pharyngeal arch. But since the third arch overgrows the other two, the sensory innervation to this part of the tongue is supplied by the glossopharyngeal nerve (nerve of the third arch).
- The epiglottis and the extreme posterior part of the tongue is developed from fourth arch and are therefore innervated by the superior laryngeal nerve (branch of vagus nerve).

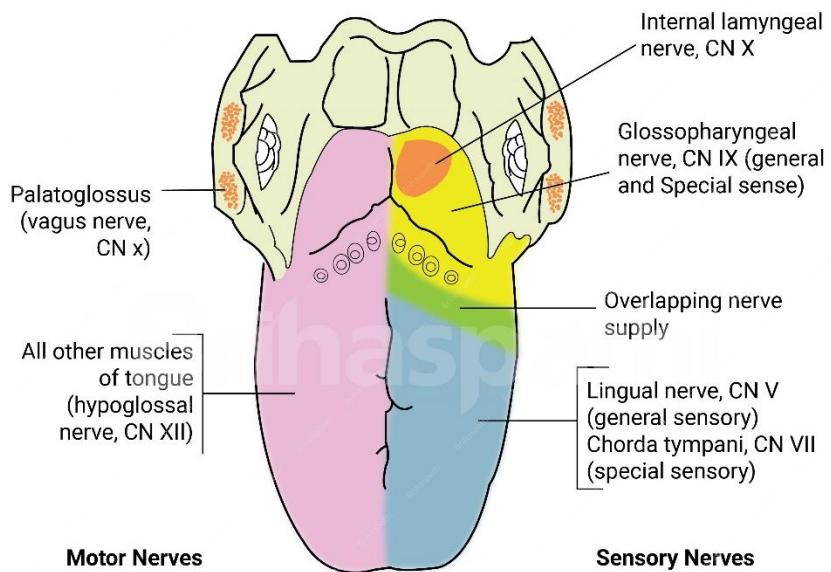
### II. Motor innervations

- The tongue musculature is derived from myoblasts originating in occipital somites and are innervated by the hypoglossal nerve.

### III. Special sensory innervations

- Taste to the anterior two thirds of the tongue is provided by the chorda tympani branch of the facial nerve, while the posterior third is supplied by the glossopharyngeal nerve.

Nerve supply	Anterior two-third	Posterior one-third	Posterior most part
I. General sensory	Lingual nerve	Glossopharyngeal nerve	Superior laryngeal nerve
II. Special sensory	Chorda tympani nerve	Glossopharyngeal nerve	-
III. Motor	Hypoglossal		

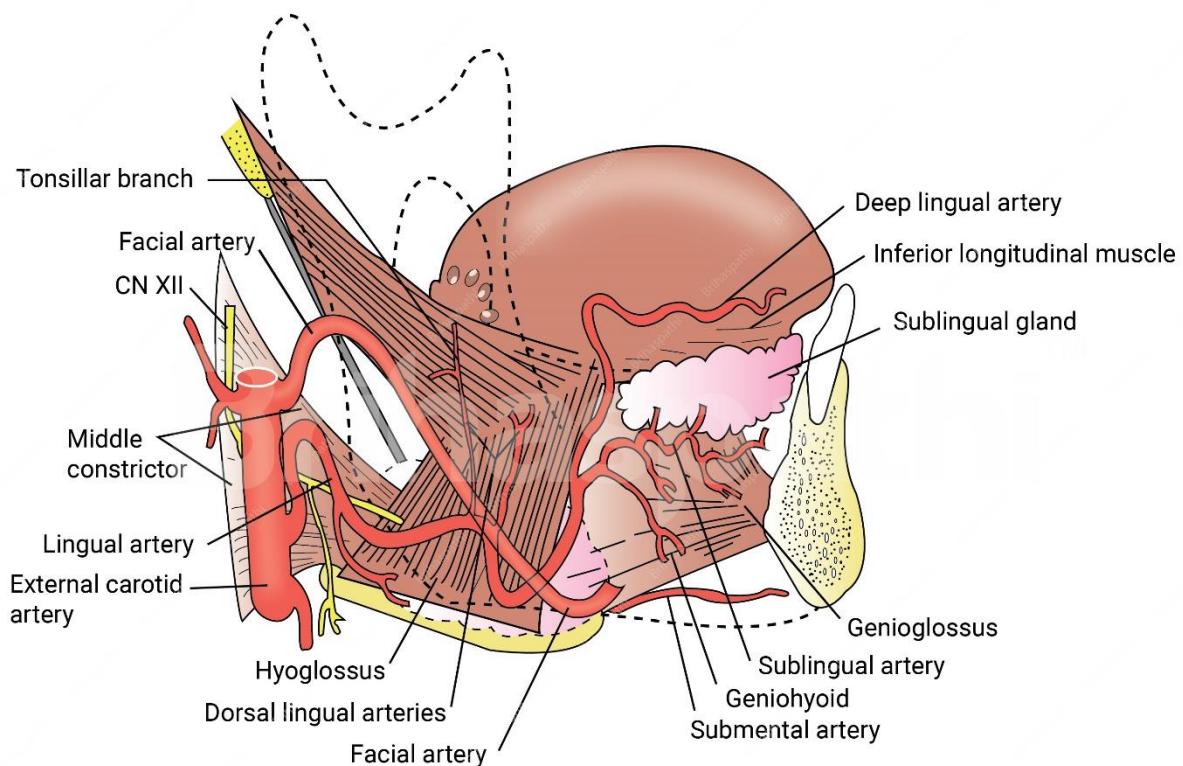


## BLOOD SUPPLY

### I. Arterial supply

- Chief artery supplying the tongue and the floor of the mouth the tongue and floor of the mouth is lingual artery.
- Lingual artery is the anterior branch of the external carotid artery.
- In addition to the lingual artery, tonsillar and ascending palatine branches of the facial and pharyngeal arteries also supply tissue in root of the tongue.

1. Dorsal lingual arteries	2. Sublingual artery
<ul style="list-style-type: none"> <li>Usually 2 or 3 small vessels.</li> <li>Lie medial to hyoglossus and ascend to posterior part of the dorsum of the tongue.</li> <li>Supply mucous membrane of tongue, palatoglossal arch tonsil soft palate and epiglottis.</li> </ul>	<ul style="list-style-type: none"> <li>Arises at anterior margin of hyoglossus.</li> <li>Passes forward between genioglossus and mylohyoid to the sublingual gland.</li> <li>Supplies the gland, mylohyoid and buccal and gingival mucous membranes.</li> <li>One branch pierces the mylohyoid and joins submental branches of the facial artery.</li> <li>Another branch anastomosis with its contralateral fellow.</li> <li>A single artery arises from this anastomosis and enters a lingual foramen in the mandible.</li> </ul>
3. Deep lingual artery	
<ul style="list-style-type: none"> <li>Terminal part of the lingual artery and is found on the inferior surface of the tongue near the lingual foramen.</li> </ul>	



## II. Venous supply

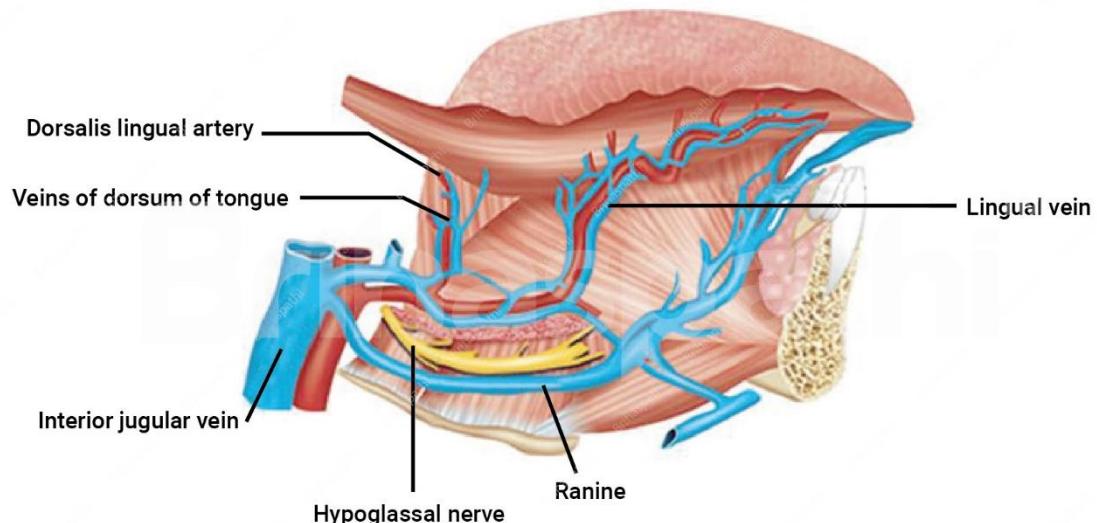
- Blood from tongue drains into the Lingual veins which follow two routes-

### 1. Dorsal lingual veins

- Join lingual veins accompanying lingual artery.
- Empty into internal jugular vein near greater cornu of the hyoid bone.

### 2. Deep lingual vein

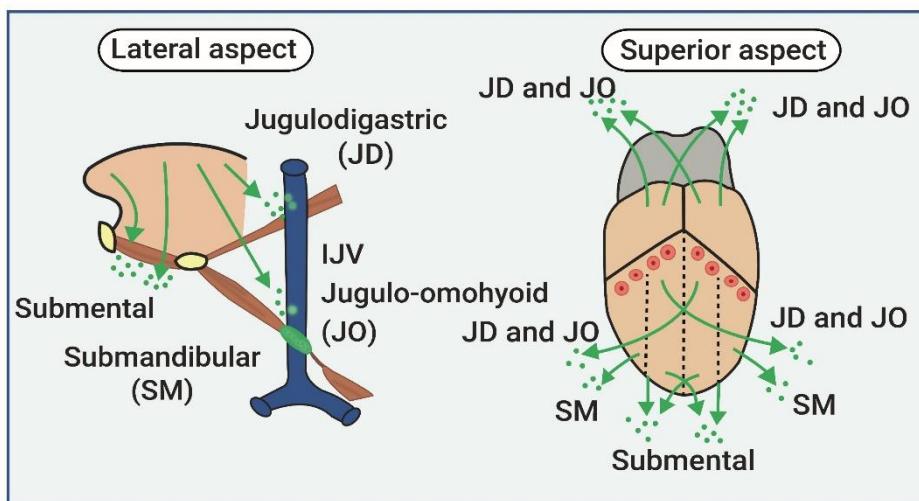
- Begins near tip of tongue
- Joins a sublingual vein and forms the vena comitans nervi hypoglossi.
- This runs back with hypoglossal nerve to joins facial, internal jugular or lingual vein.



## LYMPHATIC DRAINAGE

- Lymphatic drainage of the tongue can be divided into three main regions

<i>Tip of the tongue</i>	<ul style="list-style-type: none"> <li>It drains bilaterally to the sub mental lymph nodes</li> </ul>
<i>Anterior two third of tongue</i>	<ul style="list-style-type: none"> <li>Right and left halves of remaining part of anterior two thirds drain unilaterally into the submandibular nodes</li> <li>A few central lymphatic's drain bilaterally to the deep cervical lymph nodes</li> </ul>
<i>Posterior one third of the tongue</i>	<ul style="list-style-type: none"> <li>Lymph from the posterior one-third and posterior most part of the tongue drains bilaterally to the upper deep cervical lymph nodes including the jugulo-digastric lymph nodes</li> </ul>
<i>Jugulo omohyoid lymph nodes</i>	<ul style="list-style-type: none"> <li>Lymph from the tongue ultimately drains into the jugulo–omohyoid lymph nodes</li> <li>These are known as the lymph nodes of the tongue</li> </ul>



## APPLIED ANATOMY OF THE TONGUE

### I. Glossitis

- A condition in which the tongue is swollen and changes colour. Finger-like projections on the surface of the tongue (called papillae) are lost, causing the tongue to appear smooth.
- Such bald tongue is frequently noted in some types of anemias.

### II. Developmental disorders

- The congenital **cysts and fistulae** may develop from persistent remains of thyroglossal duct.

#### **Median rhomboid glossitis (kissing lesion):**

- It is an asymptomatic erythematous patch on mid dorsal surface of the tongue.
- Congenital anomaly due to failure of tuberculum impar to retract before the lateral halves of tongue fuse
- Tongue is devoid of papillae, susceptible for chronic fungal infections

### III. Geographic tongue (Benign migratory glossitis)

- It is a psoriaform mucositis on the dorsum of the tongue
- White lines are characteristic features
- Commonly seen in psychological stress and patients who have psoriasis of skin

Glossodynia	Glossopyrosis	Jaundice
<ul style="list-style-type: none"> <li>• Pain localized in the tongue</li> </ul>	<ul style="list-style-type: none"> <li>• Burning sensation in the tongue</li> </ul>	<ul style="list-style-type: none"> <li>• The ventral surface of the tongue is a good site (along with the bulbar conjunctiva) for observation of jaundice.</li> </ul>

### IV. Black hairy tongue

- It is a condition of desquamation of filiform papillae
- Occurs due to hypertrophy of papilla, lack of mechanical stimulation and debridement.
- Seen commonly in patients with poor oral hygiene
- **Features:** Halitosis, tingling sensation in soft palate and oropharynx, growth of candida albicans
- **Treatment:** Maintenance of proper oral hygiene

### V. Nerve injury

- Injury to the hypoglossal nerve produces paralysis of the muscles of the tongue on the side of lesion.
- If the lesion is infranuclear, there is gradual atrophy of the affected half of the tongue (hemiatrophy). Muscular twitching is also observed. Infranuclear lesions of the hypoglossal nerve are also seen typically in motor neuron disease.
- Supranuclear lesions of the hypoglossal nerve produce paralysis without wasting. This is best seen in pseudobulbar palsy where the tongue is stiff, small and moves very sluggishly resulting in defective articulation.

## VI. Carcinoma of the tongue

- Most common type of cancer.
- Better treated by radiotherapy, followed by surgery if carcinoma still exists.
- All the deep cervical lymph nodes are also removed (block dissection of neck) because recurrence of malignant disease occurs in lymph nodes.
- Carcinoma of the posterior one third of the tongue is more dangerous due to bilateral lymphatic spread.

## PROSTHODONTIC SIGNIFICANCE OF TONGUE

### I. Position of tongue

- According to Wright, position of tongue is classified into three

Class I	Class II	Class III
Tongue lies in the floor of the mouth with the tip forward and slightly below the incisal edges of mandibular anterior teeth	Tip of the tongue is in a normal position but the tongue is broadened and flattened	Tongue is in a retracted and depressed position into the floor of the mouth with the tip curled upward and downward
<b>Clinical significance</b>		
<ul style="list-style-type: none"> <li>• Most favourable to get adequate peripheral seal, as the floor of the mouth is high enough to cover the lingual flange</li> </ul>	<ul style="list-style-type: none"> <li>• Causes instability of dentures because of enlarged size of tongue.</li> <li>• Lateral sides of tongue might get irritated due to dentures</li> </ul>	<ul style="list-style-type: none"> <li>• Very unfavourable position.</li> <li>• Peripheral seal is not achieved.</li> <li>• Any attempt to extend the flange to achieve peripheral seal may lead to over extension which results in dislodgement of dentures</li> </ul>

### II. Role of tongue during impression making

- Factors affecting retention of mandibular denture
  - Peripheral seal
  - Position of tongue in the floor of the mouth at rest and in function
  - Degree of freedom for tongue
  - Design of the denture flange on lingual surface

## 1. Anterior lingual sulcus/ Sublingual crescent area

- To record anterior sulcus patient is asked to protrude the tongue which;
  - Activates the fibres (posterior) of genioglossus muscle.
  - Determines the height of the lingual flange in the anterior lingual sulcus by raising floor of the mouth
- Followed by retracting the tongue which
  - Activates the anterior fibres of genioglossus, during which the border molding material will mold between the ventral surface of tongue and lingual surface of the mandible on either sides
  - Determines the width of the border in the anterior lingual sulcus

## 2. Mylohyoid region

- Mylohyoid region extends from premylohyoid fossa to the distal end of mylohyoid ridge
- To obtain peripheral seal in this area, patient is asked to protrude the tongue followed by swallowing which
  - Activates the mylohyoid muscle and raises floor of the mouth to contact border molding material.

## 3. Retromylohyoid area

- To record retromylohyoid curtain area, the special tray is placed in the mouth and patient is asked to protrude the tongue and then close which activates the superior constrictor muscle and molds distolingual border of the denture

## III. Post insertion problems related to tongue

### Mandibular denture displacement

- Loose mandibular dentures are the most common complaint of patients using complete denture.
- Patient should be educated and demonstrate about maintaining proper position of tongue to achieve retention and stability followed by practising the denture placement and positioning of tongue in front of mirror

## CONCLUSION

- Proper knowledge of anatomy and functions of tongue is essential in prosthodontics to understand the changes in morphology and function with the process of ageing to achieve proper stability and retention of the prosthesis

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Please Give Your Feedback on this Answer

**Q. 08: Paranasal sinuses (20M)****CONTENTS/SYNOPSIS**

- **Introduction**
- **Development of paranasal sinuses**
- **Types of paranasal sinuses**
- **Frontal sinus**
  - Anatomical relations
  - Vascular supply
  - Lymphatic drainage
  - Nerve supply
  - Functions of frontal sinus
- **Maxillary sinus**
  - Age changes
  - Relations
  - Anatomy
  - Vascular supply
  - Nerve supply
  - Lymphatic drain
  - Functions of the maxillary sinus
  - Applied aspect
- **Ethmoidal sinus**
  - Anatomical relations
    - Anterior ethmoidal sinus
    - Middle ethmoidal sinus
    - Posterior ethmoidal sinus
  - Functions of ethmoidal sinus
- **Sphenoidal sinus**
  - Anatomical relations
  - Vascular supply
  - Lymphatic drainage
  - Nerve supply
  - Functions of sphenoidal sinus
- **Clinical considerations**
- **Conclusion**
- **References**

## INTRODUCTION

- Paranasal sinuses are also called as air containing spaces
- 4 spaces on each side of the face
- Clinically:
  - Anterior: Maxillary, frontal, anterior ethmoidal
  - Posterior: Posterior ethmoidal and sphenoidal
- They make the skull lighter and adds resonance

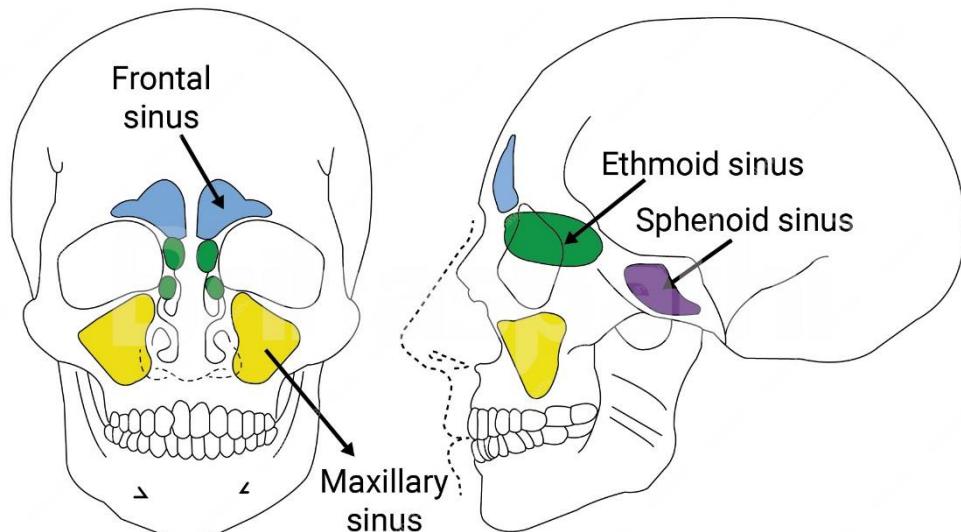
## DEVELOPMENT OF PARANASAL SINUSES

- They are rudimentary or absent at birth
- Enlarges until 6 - 7 years
- Develops from outpouchings from mucous membrane of lateral wall of nose
- Maxillary sinus is first of the PNS to develop
- It starts as a shallow groove on the medial surface of maxilla during the 4th month of intrauterine life
- Expansion occurs more rapidly until all the permanent teeth have erupted
- It reaches to maximum size around 18years of age

Sinus	Status at birth	Growth	1 <sup>st</sup> radiologic evidence
Maxillary	At birth with a volume 6 - 8ml	Rapid growth from birth to 3 years, From 7 -12 years	4 - 6 months after birth
Frontal	Not present	Invades frontal bone at 4 years. Increases until 20 years	6 years
Ethmoidal	At birth Anterior: 5x2x2mm Posterior: 5x4x2mm	Reaches adult size by 12 years	1 year
Sphenoid	Not present	Reaches sella turcica by 7 years, Dorsum sellae late teens and basisphenoid at adult age	4 years

## TYPES OF PARANASAL SINUSES

- Based on their location there are four types of paranasal sinuses
  - Frontal sinus
  - Maxillary sinus
  - Ethmoid sinus
  - Sphenoidal sinus



## FRONTAL SINUS

- Well developed in males
- Asymmetric

### I. Anatomy

- Located in between inner and outer frontal bone tables, above and deeper to supraorbital margin
- Thin bony septum and oblique
- Opens into middle meatus

**1. Dimensions:**  $32 \times 24 \times 16\text{mm}$

### 2. Relations

**Anterior:** skin over forehead

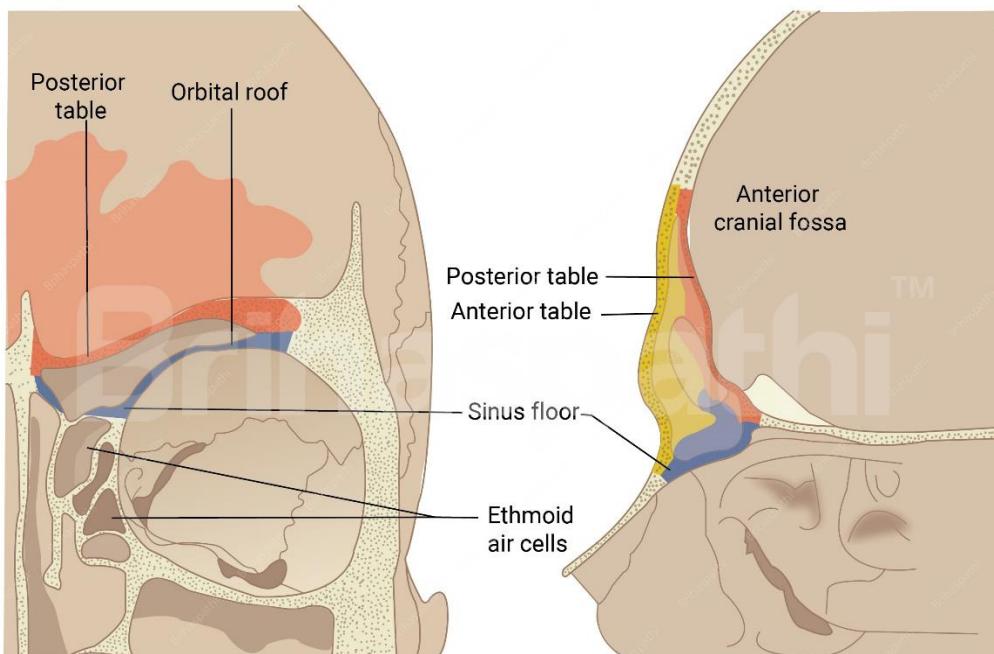
**Posterior:** Meningeal layers and frontal lobe of brain

**Inferior:** Orbit and orbital contents

II. Arterial supply	III. Venous drainage	IV. Lymphatic drainage	V. Nerve supply
<ul style="list-style-type: none"> <li>Supraorbital artery</li> </ul>	<ul style="list-style-type: none"> <li>Supraorbital &amp; superior</li> </ul>	<ul style="list-style-type: none"> <li>Submandibular nodes</li> </ul>	<ul style="list-style-type: none"> <li>Supraorbital nerve</li> </ul>

	ophthalmic veins		
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*Anatomical relations of frontal sinus*



## VII. Functions of frontal sinus

- Lining of frontal sinuses consists of mucous forming cells that helps the nose from drying out

## MAXILLARY SINUS

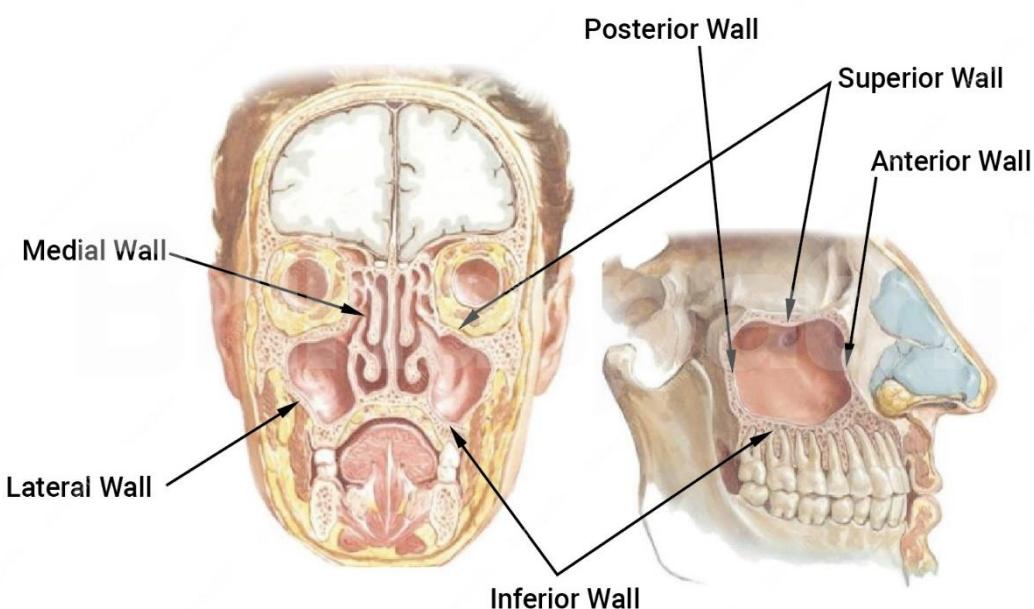
### I. Development and Age changes

0-3 years	<ul style="list-style-type: none"> <li>Ovoid appearance</li> <li>7 mm x 4mm x 4mm</li> <li>Volume: 6-8 ml</li> </ul>
3-4 years	<ul style="list-style-type: none"> <li>Increase in width with facial growth</li> <li>Position: 2<sup>nd</sup> deciduous molars &amp; crypts of 1<sup>st</sup> permanent molars</li> </ul>
7-9 years	<ul style="list-style-type: none"> <li>27 x 18 x 17mm</li> <li>Volume:10-12 ml</li> </ul>
9-12 years	<ul style="list-style-type: none"> <li>Antral floor same level with nasal floor</li> <li>Assumes pyramidal shape</li> </ul>
12-18 years	<ul style="list-style-type: none"> <li>Floor of sinus 5 - 12.5 mm below nasal floor</li> <li>Dimensions 3234mm x 28 - 33mm x 23-25mm</li> <li>Volume 15-20 ml</li> </ul>

	<ul style="list-style-type: none"> <li>Floor is with respect to 1<sup>st</sup> &amp; 2<sup>nd</sup> molars &amp; 2<sup>nd</sup> premolar</li> </ul>
Old age	<ul style="list-style-type: none"> <li>Resorption of ridge</li> <li>Thinning of sinus wall</li> <li>Extension of sinus till crest</li> <li>Anterior &amp; infratemporal surface reverts to infantile condition</li> <li>Maxillary sinus is tubular at birth, ovoid in childhood and pyramidal in adulthood</li> </ul>

## II. Anatomy

- Largest of Para Nasal Sinuses
- It communicates with other sinuses through lateral nasal wall
- Horizontal Pyramidal shaped
  - Base
  - Apex
- 4 walls
  - Formed by Lateral nasal wall
  - Below-inferior nasal conchae
  - Behind-palatine bone
  - Above-uncinate process of ethmoid, lacrimal bone
- Contains double layer of mucous membrane (pars membranacea)



**1. Medial wall****Associated structures**

- Sinus ostium
- Hiatus semilunaris
- Ethmoidal bulla
- Uncinate process
- Infundibulum

**2. Ostium**

- Opening of the maxillary sinus into middle meatus at the lower part of the hiatus semilunaris
- Lies above the level of nasal floor
- Ostium lies approximately 2/3rds up the medial wall of the sinus, making drainage of the sinus inherently difficult
- In 15% to 40% of cases, a small, accessory ostium is also found
- Blockage of the ostium can easily occur when there is inflammation of the mucosal lining of the ostium

<b>3. Superior wall</b>	<b>4. Posterolateral wall</b>
<ul style="list-style-type: none"> <li>• Forms roof of sinus and floor of orbit</li> </ul> <p><b>Associated structures</b></p> <ul style="list-style-type: none"> <li>• Infraorbital canal</li> <li>• Infraorbital foramen</li> <li>• Infraorbital nerve and vessels</li> </ul>	<ul style="list-style-type: none"> <li>• Made of zygomatic and greater wing of sphenoid bone</li> <li>• Thick laterally, thin medially</li> </ul> <p><b>Associated structures</b></p> <ul style="list-style-type: none"> <li>• PSA nerve</li> <li>• Maxillary artery</li> <li>• Pterygopalatine ganglion</li> <li>• Nerve of pterygoid canal</li> </ul>

**5. Anterior wall**

- Extends from pyriform aperture anteriorly to ZM suture & Inferior orbital rim superiorly to alveolar process inferiorly
- Convexity towards sinus
- Thinnest in canine fossa

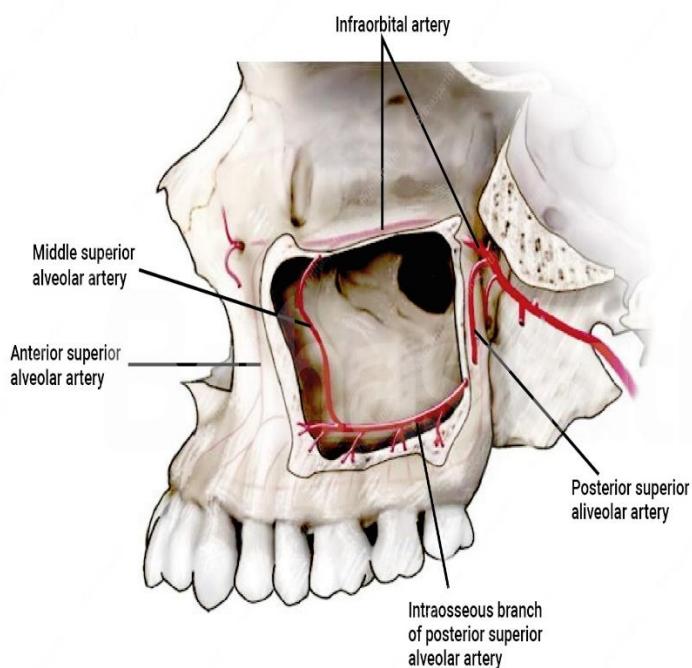
**Associated structures**

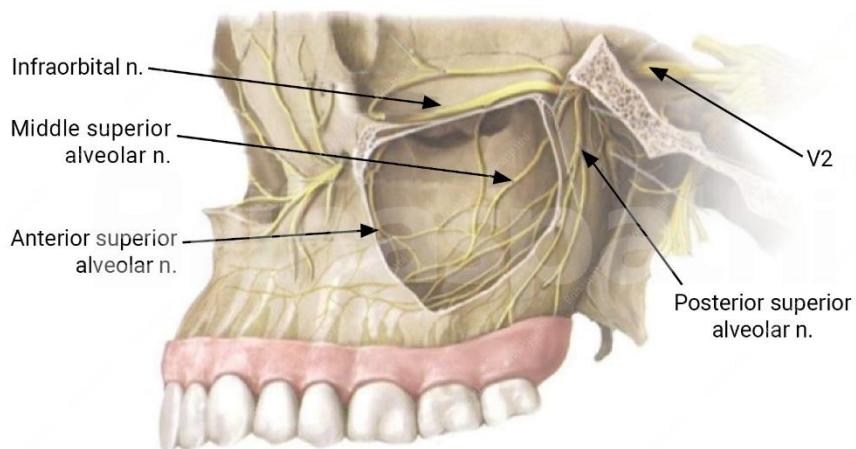
- Infraorbital foramen
- ASA, MSA nerves

## 6. Floor of sinus

- Formed by junction of anterior sinus wall and lateral nasal wall 1-1.2 cm below nasal floor
- Close relationship between sinus and teeth facilitate spread of pathology

III. Arterial supply	IV. Venous drainage	V. Nerve supply	VI. Lymphatic drainage
<ul style="list-style-type: none"> <li>• Greater palatine arteries</li> <li>• Infraorbital artery</li> <li>• Facial artery</li> </ul>	<ul style="list-style-type: none"> <li>• Pterygoid venous plexus</li> <li>• Sphenopalatine vein</li> <li>• Facial vein</li> </ul>	<ul style="list-style-type: none"> <li>• Maxillary division of the trigeminal nerve</li> </ul>	<ul style="list-style-type: none"> <li>• Submandibular lymph nodes</li> </ul>





## VI. Functions of maxillary sinus

- Humidification and warming of inspired air
- Assisting in regulating intranasal pressure
- Lightening the skull to maintain proper head balance
- Imparting resonance to the voice
- Absorption of shocks to the head
- Filtration of the inspired air

## VII. Applied aspect

- Maxillary teeth are in direct relation to the maxillary sinus floor
- The distance between apical end of maxillary posterior tooth with the floor of the sinus is about 1 to 1.2 cm in adults ( $> 1.2\text{cm}$  in ages less than 15)
- So, chance of creating an oroantral fistula is lesser in paediatric patients
- In some patients, the floor of the sinus lies between the roots of the adjacent teeth or adjacent roots of the same tooth- causes elevation of the floor of the sinus

### ***Order of closest proximity to sinus***

Second maxillary, 1st molars, 3rd molars, 2nd premolars, 1st premolars, Canine

1. Oroantral fistula	2. Tumors
<ul style="list-style-type: none"> <li>Fistula formation during extraction of maxillary molars which are in close proximity to sinus</li> <li>Overextension of dental materials like sealers, gutta percha points into the maxillary sinus</li> <li>Patient complains of regurgitation of food through the nose during eating</li> </ul>	<ul style="list-style-type: none"> <li>The anterior and infra temporal walls of the maxillary sinus are very thin.</li> <li>Tumors</li> <li>Developing within the sinus: present as swellings in the cheek</li> <li>At the floor of the sinus: penetrates the floor, appears as a lump in the palate or as a swelling in the buccal sulcus</li> <li>Posteriorly: loosening of teeth near the sinus</li> <li>Roof of the sinus: cause paresthesia in the area supplied by infraorbital nerve</li> </ul>

## ETHMOIDAL SINUS

- Number of ethmoidal sinuses range from 3 -18
- Lies within labyrinth of ethmoidal bone

### I. Anatomical relations

**Superior:** Orbital plate of frontal bone

**Behind:** Sphenoidal conchae, orbital process of palatine

**Anterior:** Lacrimal bone

- They are divided into anterior, middle and posterior groups

1. Anterior ethmoidal sinus	2. Middle ethmoidal sinus	3. Posterior ethmoidal sinus
<ul style="list-style-type: none"> <li>Number: 1 - 11</li> <li>Opens at anterior part of hiatus semilunaris</li> </ul> <p><b>Supply:</b></p> <ul style="list-style-type: none"> <li>Anterior ethmoidal nerve and vessels</li> <li>Drains into submandibular nodes</li> </ul>	<ul style="list-style-type: none"> <li>Number: 1 - 7</li> <li>Opens into middle meatus</li> </ul> <p><b>Supply:</b></p> <ul style="list-style-type: none"> <li>Posterior ethmoidal nerve and vessels, orbital branches of pterygopalatine ganglion</li> <li>Drains into submandibular nodes</li> </ul>	<ul style="list-style-type: none"> <li>Number: 1 - 7</li> <li>Opens into superior meatus</li> </ul> <p><b>Supply:</b></p> <ul style="list-style-type: none"> <li>Posterior ethmoidal nerve and vessels, orbital branches of pterygopalatine ganglion</li> <li>Drains into retropharyngeal nodes</li> </ul>

## II. Functions of ethmoidal sinus

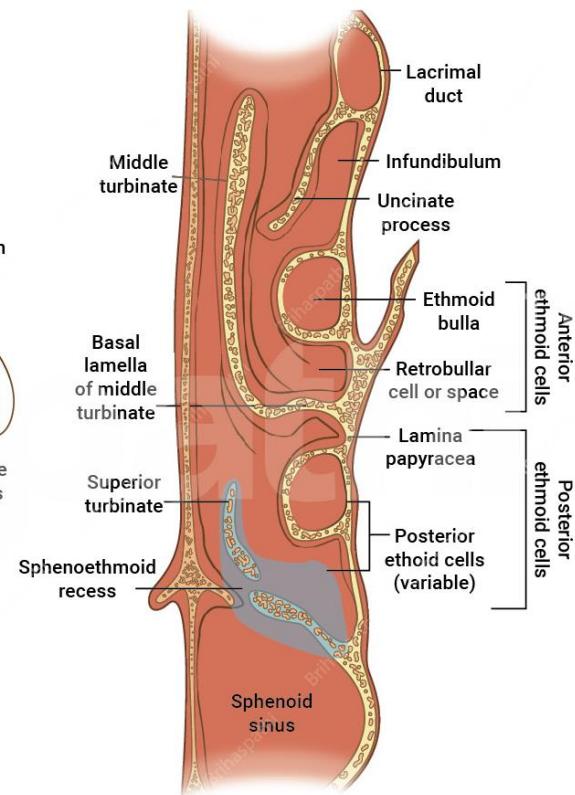
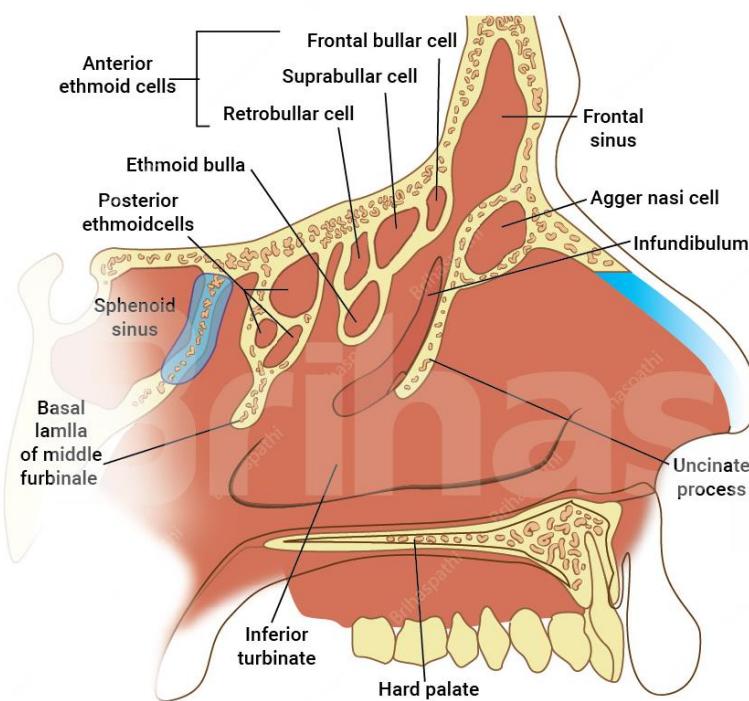
- Primary function is to produce mucus and lubricate the nasal cavity
- Reduces the weight of the skull
- Provides resonance to the voice

### Cells in anterior group

- Agger nasi cells
- Ethmoidal bulla
- Supraorbital cells
- Frontoethmoidal cells
- Haller cells

### Cells in posterior group

- Sphenoethmoid cells
- Onodi cells



## SPHENOIDAL SINUS

- Located within the body of sphenoid
- Separated from each by thin bony septum
- Asymmetric in shape
- Opens into ethmoidal recess

## I. Anatomical relations

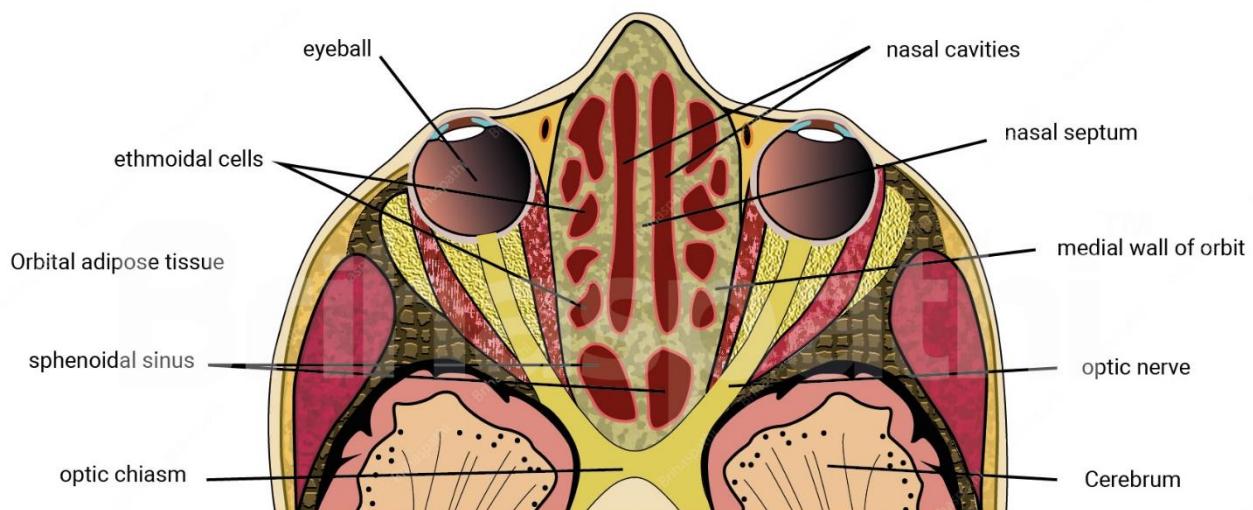
**Superior:** Optic chiasma, hypophysis cerebri

**Lateral:** Internal carotid artery, Cavernous sinus

II. Arterial supply	III. Venous supply	IV. Lymphatic drainage	V. Nerve supply
<ul style="list-style-type: none"> <li>Posterior ethmoidal, internal carotid artery</li> </ul>	<ul style="list-style-type: none"> <li>Pterygoid venous plexus,</li> <li>Cavernous sinus</li> </ul>	<ul style="list-style-type: none"> <li>Retropharyngeal nodes</li> </ul>	<ul style="list-style-type: none"> <li>Posterior ethmoidal nerve,</li> <li>Pterygopalatine ganglion branches</li> </ul>

## VI. Function:

- Cleans the inhaled air
- Aids in lightness of skull bone weight



**CLINICAL CONSIDERATIONS**

<b>I. Acute sinusitis</b>	<b>II. Chronic sinusitis</b>
<ul style="list-style-type: none"> <li>Acute inflammation of sinus mucosa</li> <li>Maxillary &gt; Ethmoid &gt; Frontal &gt; Sphenoid</li> </ul> <p><b>Etiology:</b></p> <ul style="list-style-type: none"> <li>Nasal infections, swimming, trauma, dental infections, accidental opening post extraction</li> </ul>	<ul style="list-style-type: none"> <li>Sinus infection since few months to years</li> </ul> <p><b>Complications due to chronic sinusitis:</b></p> <ul style="list-style-type: none"> <li>Mucocele, mucous retention cysts, osteomyelitis, edema of eyelids, orbital cellulitis, orbital abscess, meningitis, extradural abscess, cavernous sinus thrombosis, focal infection</li> </ul>

**CONCLUSION**

- Knowledge in anatomical relationship of paranasal sinuses is fundamental for the success of prosthodontic management as they are responsible for resonance of speech, protecting oral cavity from nasal cavity.
- Helps in sinus lifting, bone and ridge augmentation for the placement of implants and development of prosthesis.

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**Please Give Your Feedback on this Answer**

**Q. 01: Give a short account of the applied anatomy of temporomandibular joint. Discuss the degenerative changes that occur in the joint due to ageing. (20M).**

**Discuss the functional anatomy and biomechanics of temporomandibular joint. (20M), (10M).**

**Describe the anatomy of the Temporomandibular joint and mention its prosthodontic considerations. (15M).**

**Describe anatomy of Temporomandibular joint. (20M).**

## CONTENTS/SYNOPSIS

- **Introduction**
- **Embryonic development of TMJ**
- **Anatomic Components**
  - I. Articular surfaces
    - 1. Glenoid fossa
    - 2. Mandibular condyle
    - 3. Articular eminence
    - 4. Articular cartilage
  - II. Articular disc
    - 1. Disc attachments
    - 2. Fibrous capsule
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  - III. Synovial fluid
  - IV. Ligaments
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    - 3. Stylomandibular ligament
  - V. Muscular components
- **Biomechanics of TMJ**
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- **Blood supply**
- **Applied anatomy**
- **Age changes of the TMJ**
  - I. Articular layer
  - II. Condyle
  - III. Disc
  - IV. Synovial fold
  - V. Blood vessels and nerves
- **Prosthodontic implications**
  - I. Factors affecting
  - II. Prosthodontic management
- **Conclusion**
- **References**

## INTRODUCTION

- TMJ is a synovial joint responsible for the movements of the jaw formed by:
  - Articulation of the condylar head of mandible with the glenoid fossa of the temporal bone
  - Superficial and palpable part of the facial skeleton
- It is also called as ginglymoarthrodial joint because of its hinge and gliding motions

## EMBRYONIC DEVELOPMENT OF TMJ

- TMJ development takes place mostly between the 7th and 20th week of intrauterine life and a particularly sensitive period is morphogenesis between the 7<sup>th</sup> and 11<sup>th</sup> week
- Mutual approximation of the initial condylar and temporal base (blastema) is a characteristic feature of TMJ development
- There are three stages in TMJ development

- I. **Blastemic stage:** (7<sup>th</sup> -8<sup>th</sup> week; development of the condyles, articular fossa, articular disk and capsule),
- II. **Cavitation:** (9th-11th week; beginning of lower joint space development and condylar chondrogenesis),
- III. **Maturation stage:** (after the 12<sup>th</sup> week).

## ANATOMIC COMPONENTS

### I. Articular Surfaces

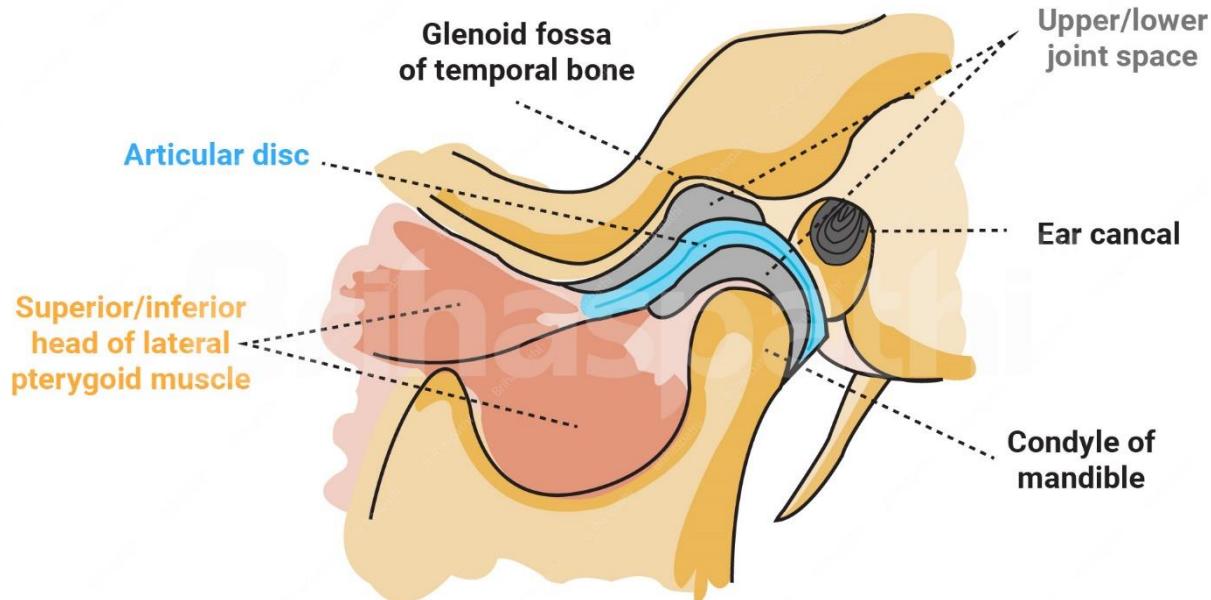
- Comprise of Glenoid fossa, articular eminence and mandibular condyle as osseous components
- Covered by dense collagen fibers and cavities are lined with synovial tissue

#### 1. Glenoid fossa

- The portion of temporal bone where condyle articulates is mandibular fossa which is also called articular or Glenoid fossa.

- Posteriorly : squamotympanic and petrotympanic fissures
- Medially : by the spine of the sphenoid.
- Laterally : root of the zygomatic process.
- Anteriorly : articular eminence.

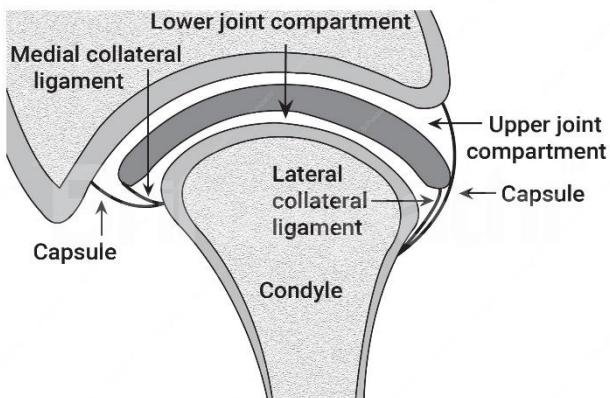
- The middle part of the fossa is fairly thin whose upper surface forms the middle cranial fossa.
- The shape of the fossa is to allow the positioning of the condyle as well as function (rotation) of the TMJ.
- It is triangular in shape with the apex related to the medial pole of the condyle.



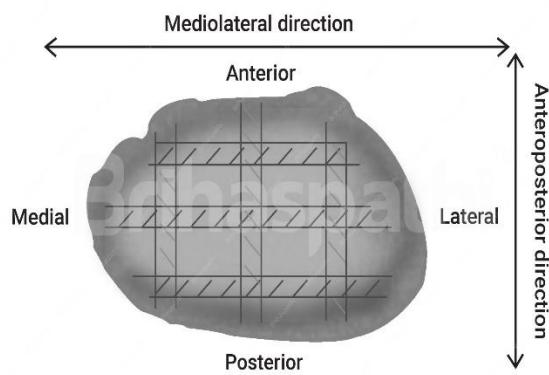
## 2. Mandibular Condyle

- Part of the mandible which articulates with the cranium during movements
- Ovoid or convex shaped projection.
- The articulating surface of condyle is quite convex anteroposterior and only slightly convex mediolaterally.
- Has a medial and a lateral pole in coronal view

- Medial pole is more prominent than lateral pole
- Lateral pole is slightly at a lower level
- Mediolateral length of condyle is 18 - 23 mm
- Anteroposterior width is 8 - 10mm
- Angle formed on extending the long axis of both the condyles medially until they meet at basion is 145 - 160°



**Anteroposterior view of condyle**



**Superior view of condyle**

### 3. Articular Eminence

- Bony projection at the anterior root of zygoma along the slope of which the condyle travels in normal jaw function
- Articular tubercle → bony knob at the outer end of the articular eminence where lateral collateral ligament of the joint attaches

### 4. Articular Cartilage

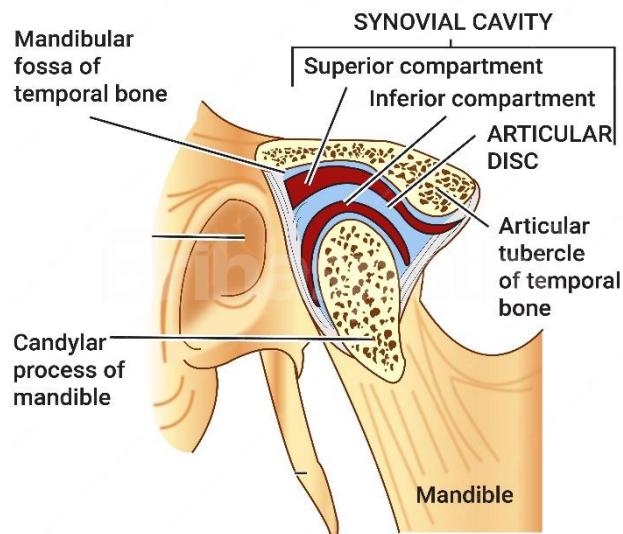
- Contains a higher proportion of collagen fibers (fibrocartilage) compared to other synovial joints, which are lined by hyaline cartilage

## II. Articular Disc

- Hypovascular, fibro-cartilaginous intra-articular sheet separating the condylar head from the glenoid fossa
- Biconcave, firm yet flexible

Consists of two compartments in the joint space: The larger superior (1.2ml) and the smaller inferior (0.5ml) cavity

- Gliding movements and Hinge movements take place in the upper and lower compartments respectively.
- can be roughly divided into anterior band (2mm thick), posterior band (3mm thick), an intermediate band (1mm thick) and a bilaminar or retrodiscal region most posteriorly



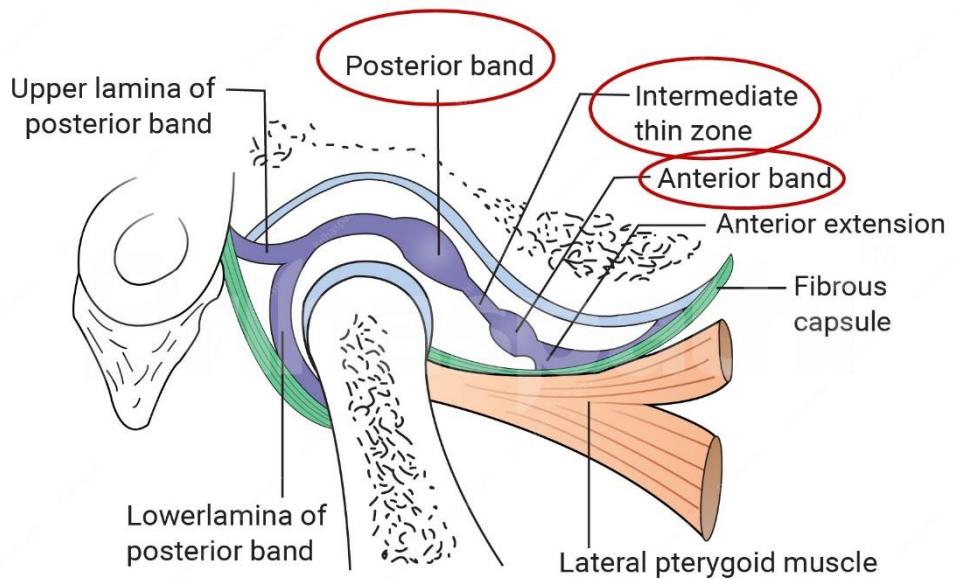
## 1. Disc Attachments

- Extent and attachments of Fibrous capsule

- Anteriorly*: Preglenoid plane
- Antero-laterally*: Articular tubercle
- Posteriorly*: Articular ridge
- Postero-laterally*: Post glenoid process
- Laterally*: Lateral rim of mandibular fossa and edge of eminence
- Medially*: Medial margin of the temporal fossa along the sphenosquamosal suture

## 2. Fibrous Capsule

- Forms functional as well as anatomic boundary of TMJ
- Surrounds the articular surface of condyle
- Lined by synovial membrane covering all articular surfaces except the fibrocartilage which bears the pressure.



### 3. Functions of the articular disc

i. <i>Stabilization</i>	<ul style="list-style-type: none"> <li>Articulating surface of the condyle and articular fossa fit poorly and are separated by an irregular space</li> </ul>
ii. <i>Reduce wear</i>	<ul style="list-style-type: none"> <li>Decrease frictional forces by separating slide and rotational movements into two compartments</li> </ul>
iii. <i>Lubrication of the joint</i>	<ul style="list-style-type: none"> <li>Storing fluid by storing fluid squeezed out from loaded areas to create weeping lubricant</li> </ul>
iv. <i>Destabilization</i>	<ul style="list-style-type: none"> <li>Slippery articular disc decreases the friction free surfaces of the joint thereby destabilizing the condyle</li> </ul>

## III. Synovial Fluid

1. Content	2. Sources
<ul style="list-style-type: none"> <li>High amount of hyaluronic acid helps in viscosity.</li> </ul>	<ul style="list-style-type: none"> <li>Plasma by dialysis</li> <li>Secretion from synoviocytes</li> </ul>
<b>3. Functions</b>	
<ul style="list-style-type: none"> <li>Lubricant for articulating surfaces – net coefficient of friction of normally working joint is 14 times less than a dry joint</li> <li>Nutrient carrier for avascular components</li> <li>Clear tissue debris caused by normal wear and tear of articulating surfaces</li> </ul>	

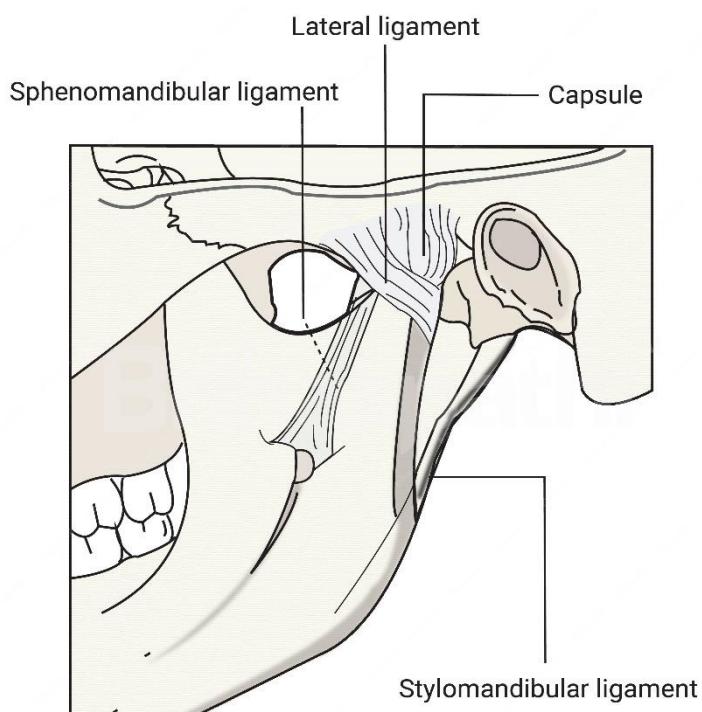
## IV. Temporomandibular Ligaments

### 1. Collateral Ligaments

- Present as two distinct layers:

A fan-shaped superficial layer arising from outer surface of articular tubercle and posterior part of zygomatic arch with fascicles running downward and backward towards their insertion at posterior-inferior part of mandibular neck

Narrow ligaments with inner or deep band arising from crest of articular tubercle running horizontally backwards to insert at lateral pole of condyle



### 2. Sphenomandibular Ligaments

- Runs downward and outward from spine of sphenoid and petrotympanic fissure to the lingula
- Pierced by mylohyoid nerve and vessels

### 3. Stylomandibular Ligament

- Local dense band of deep cervical fascia
- Arising from the apex of styloid process and inserting into the angle and posterior border of the mandible
- Covers the inner surface of the medial pterygoid muscle

## V. Muscular Components

- Grouped into 4 paired muscles which are collectively termed as “Muscles of mastication”- Masseter, Temporalis, Medial Pterygoid & Lateral Pterygoid

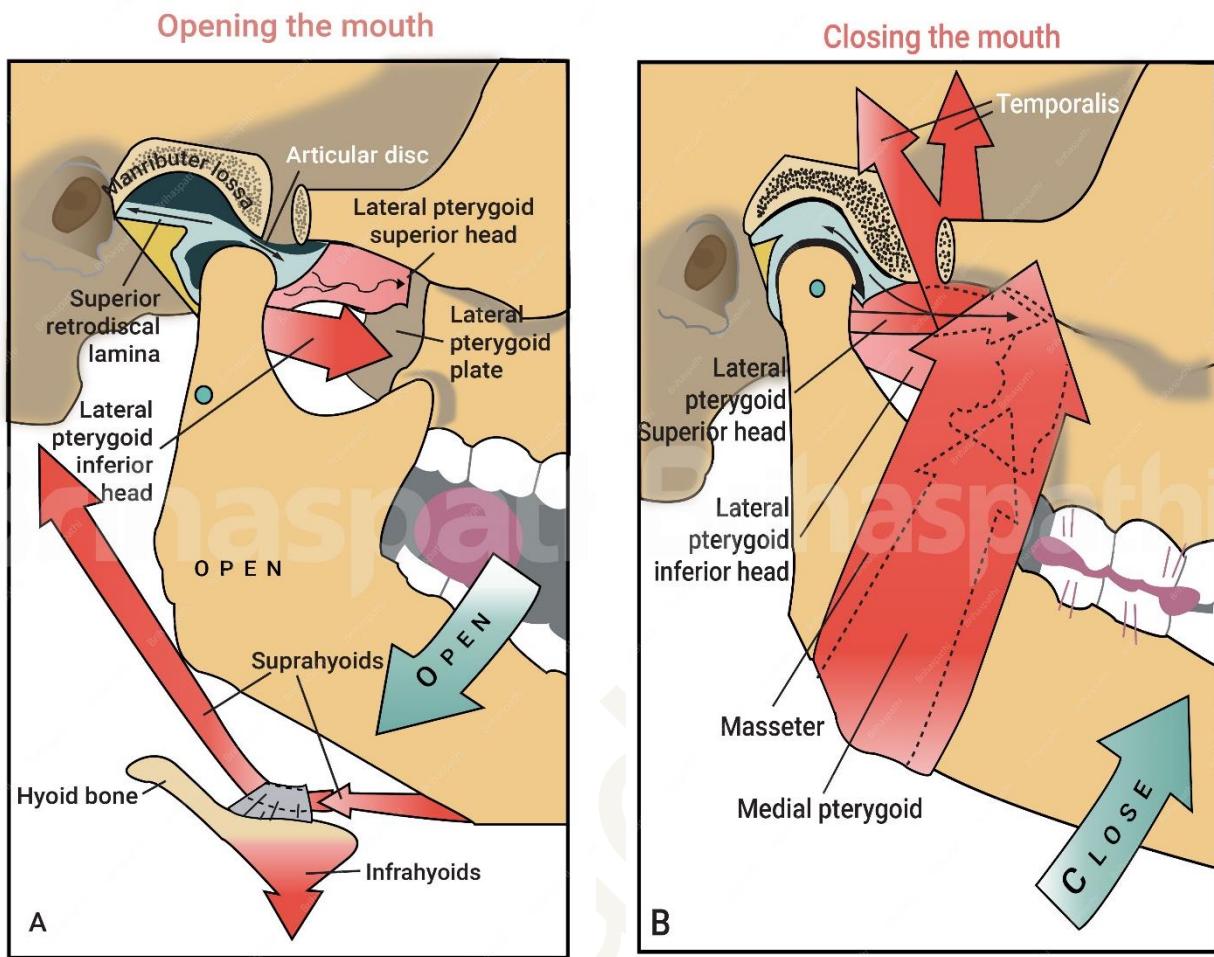
### BIOMECHANICS OF TMJ

#### Basic joint movements of TMJ

1. Hinge movement	2. Translatory movement
<ul style="list-style-type: none"> <li>The inferior portion of the joint between the head of the condyle and the lower surface of the disc undergoes hinge movement to permit opening of the mandible.</li> <li>Rotational / hinge movement in first 20-25mm of mouth opening.</li> </ul>	<ul style="list-style-type: none"> <li>Occurs in the superior part of the joint as the disc and the condyle traverse anteriorly along the inclines of the anterior tubercle to provide an anterior and inferior movement of the mandible.</li> <li>Translational movement takes place after rotational movement when the mouth is excessively opened.</li> </ul>

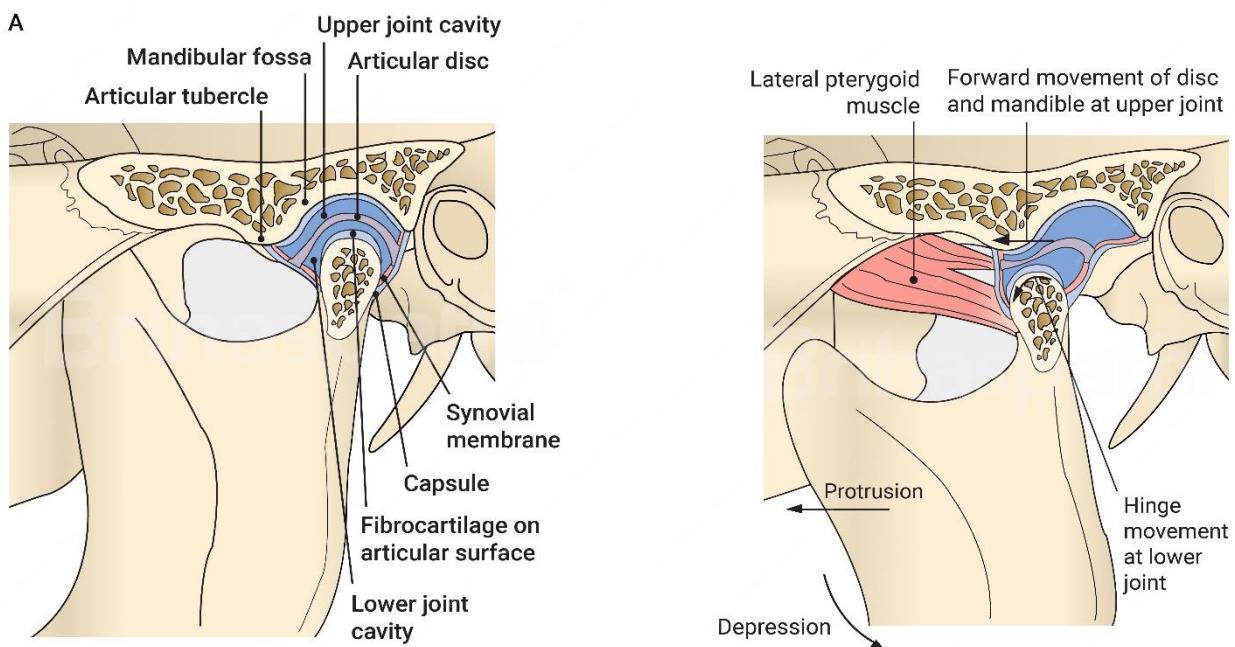
#### Movements of jaw influenced by TMJ

Movement	Mechanism	Muscle
Depression	Gliding: In meniscotemporal Rotatory: In meniscomandibular compartment	Lateral pterygoid Suprahyoid muscles: geniohyoid, mylohyoid, digastric
Elevation	Reversal of depression	Masseter Medial pterygoid Temporalis
Protrusion	Gliding: in meniscotemporal compartment	Medial pterygoid Lateral pterygoid
Retraction	Reverse of protrusion	Posterior fibres of temporalis Geniohyoid & Digastric
Chewing involving vertical & lateral movements	Gliding: in meniscotemporal compartment of 1 joint. Rotatory: in meniscomandibular compartment of other joint.	Alternate action of medial & lateral pterygoid of each side.



### Role of muscles

- Muscles act on TMJ to achieve opening & closure of the jaw, protrusion & retrusion & alternate lateral movements & to provide stability.
- Because these movements rarely occur in isolation, most involve complex combinations of muscle activity.
- The role of muscles in providing stability should not be overlooked, for during mastication the forces applied to the joint not only are great but also are constantly changing.
- When this is considered with the destabilizing effects of translatory movement, the functional role of muscle becomes more obvious.
- Because movements at the joint involve both rotation & translation, the functional significance of the disk becomes more apparent.



## NERVE SUPPLY

- Movements of synovial joint initiated & effected by muscle coordination.
- Achieved in part through sensory innervation.

### I. Hilton's Law

- The principle that the nerve supplying a joint also supplies both the muscles that move the joint and the skin covering the articular insertion of those muscles.
- Therefore, the branches of the mandibular division of the fifth cranial nerve supply the TMJ.

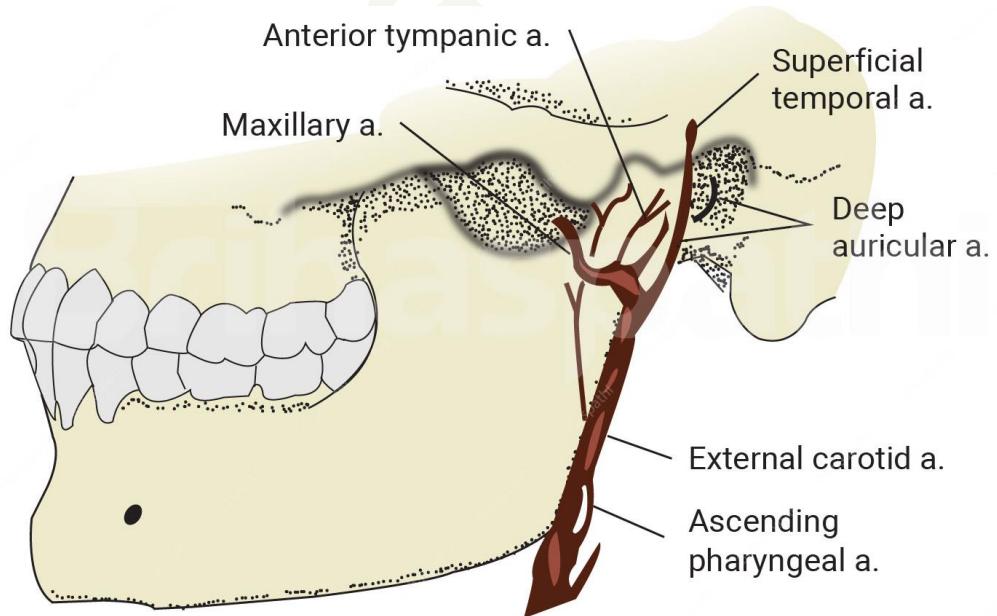
- Auriculotemporal nerve is the largest which supplies the posterior, medial & lateral parts the joint.
- Masseteric nerve.
- Branch from posterior deep temporal nerve, supply anterior part of the joint.

## II. Types of nerve endings

<b>1. Ruffini Endings</b>	<ul style="list-style-type: none"> <li>Position the mandible (proprioception), dynamic and static balance</li> </ul>
<b>2. Pacinian Receptors</b>	<ul style="list-style-type: none"> <li>Accelerate movement during Reflexes</li> </ul>
<b>3. Golgi tendon Organs</b>	<ul style="list-style-type: none"> <li>Protection of ligaments around TMJ and Static mechanoreception</li> </ul>
<b>4. Free Nerve Endings</b>	<ul style="list-style-type: none"> <li>Pain receptors</li> </ul>

### BLOOD SUPPLY

- Lateral aspect: Supplied by superficial temporal branch of **External carotid artery**
- Deep and posterior aspect of retrodiscal capsular part: Supplied by deep auricular, posterior auricular & masseteric branches of **internal maxillary artery**
- Vascular supply to lateral pterygoid muscle also supplies to head of condyle by penetration of numerous nutrient **foramina vessels**
- Venous pattern is more diffuse forming a plentiful plexus all around the capsule



## APPLIED ANATOMY

### I. **Growth disorders**

- Agenesis
- Hypoplasia
- Hyperplasia
- Neoplasia
- Hypotrophy
- Hypertrophy
- Myospasm
- Myofascial Pain Dysfunction Syndrome

### II. **Structural incompatibilities**

- *Deviation in form*
- Adherence
- *Adhesion*
- Ankylosis
- Subluxation
- Spontaneous Dislocation

### III. **Derangement of condyle- disk complex**

- Disc displacement
- Disk displacement with reduction
- Disk displacement without reduction

### IV. **Inflammatory joint disorders**

- Synovitis or capsulitis
- Retrodiscitis
- Osteoarthritis

### IV. **Syndromes associated**

- Costen syndrome
- Auriculocondylar Syndrome
- Treacher Collins Syndrome/Mandibulofacial Dysostosis

## AGE CHANGES OF THE TMJ

- With advancing age, degenerative changes like roughness, fissure, and erosion were seen on the condylar surface

### I. Articular layer

- Vascular at birth and becomes progressively fibrous

### II. Condyle

- Flattens with a decrease in convexity
- Decrease in condylar height
- Fibrous capsule becomes thicker
- Osteoporosis of underlying bone
- Resorption is more on lateral aspect compared to medial
- In extreme cases, there might be the disappearance of condyle
- Thinning or absence of cartilaginous zone

- After 20 yrs, superior and anterior part of condyle and posteroinferior part of eminence retain the condylar cartilage. This is due to adaptation to functional stress

### III. Disc

- Initially flat and highly vascular
- With ageing, there is marked decrease in vascular supply
- Central part thins, with anterior and posterior parts becoming thicker
- Becomes fibrous
- Collagen fibres become coarse and dense and get arranged in a three-dimensional network
- Shows hyalinization and chondroid changes

### IV. Synovial fold

- Become fibrotic with thick basement membrane

### V. Blood vessels and nerves

- Walls of blood vessels thickened

- Nerves decrease in number
- These age changes lead to:
  - Decrease in the synovial fluid formation- loss of lubrication
  - Impairment of motion due to decrease in the disc and capsule extensibility
  - Decrease the resilience during mastication due to chondroid changes into collagenous elements
  - Dysfunction in older people

## PROSTHODONTIC IMPLICATIONS

- Neuromuscular harmony of facial and oral structures depends on structural harmony between occlusion and temporomandibular joint
- Most **common factors** affecting TMJ towards prosthodontic management
  - Occlusal discrepancies
  - Disharmony between occlusion and centric relation
  - Parafunctional habits like bruxism
  - Stress triggers the condyle and masticatory muscle especially in edentulous patients
  - Trauma
  - Defective crowns or restorations leads to occlusal interference triggering TMD and muscle hyperactivity
  - Degenerative diseases (Eg. Osteoarthritis)

### 1. Influence of Vertical dimension:

- It is the relationship between mandible to maxilla when teeth are in maximum intercuspsation
  - Determined by contracted length of elevator muscles
  - Limits the tooth eruption based on amount of jaw separation

### 2. Centric relation

- It is defined as relationship between mandible and maxilla when condylar disk assemblies are properly aligned and are in the most superior position against the eminence.
- Positioning of mandible into centric relation occurs in the following manner

Elevator muscles moves the condyle and disk assembly onto the posterior slopes of the articular eminence

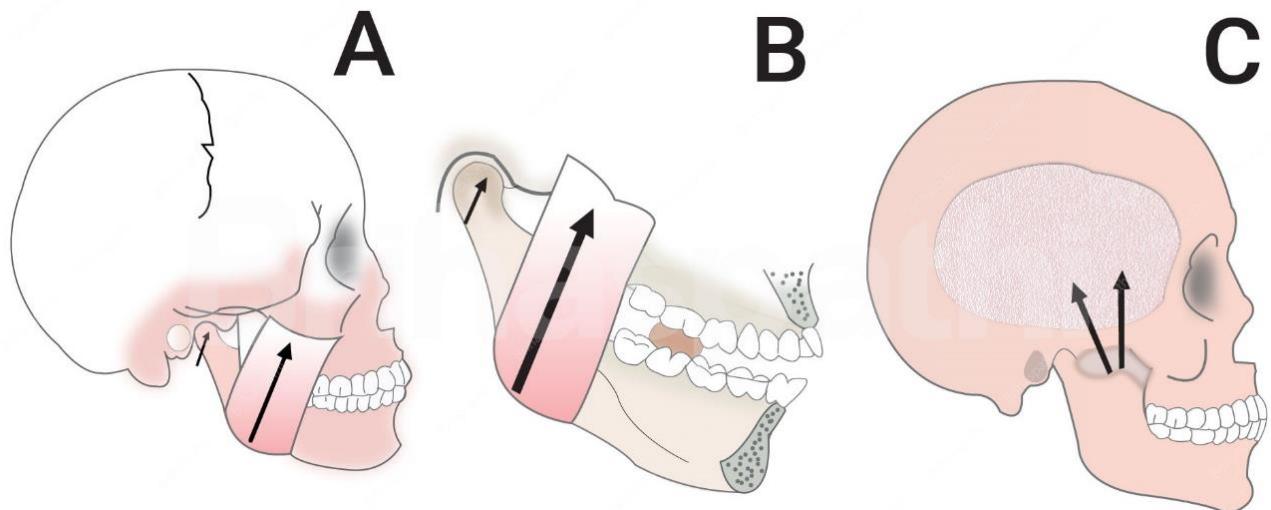
In this position lateral pterygoid relaxes and maintains the same throughout the closure

Seats condyle in the superior most position

Centric relation is achieved

### 3. Influence of muscles towards TMJ biomechanics

- *Superficial part of the masseter (A)* moves the condyle UP against the posterior slope
- *Medial pterygoid (B)* moves the condyle UP from lingual side of the mandible
- *Temporalis(C)* attached to the coronoid process keeps the condyle in UP position



#### 4. **Musculature pain during occlusion**

**Etiology:** Occlusal interference

In order to adjust to occlusal interference, TMJ displaces to achieve maximum intercuspatation

Lead to lack of muscle coordination

Causes pain due to hyperactivity of muscles

### Prosthodontic management of Temporomandibular joint disorders

#### 1. **Occlusal therapy**

Management of TMD with occlusal therapy is done to:

- Stabilize temporomandibular joint
- Prevent interference in posterior teeth
- Achieve harmony in anterior teeth with envelope of function

#### Treatment

- Modification of occlusal surfaces by
- Reshaping (enameloplasty), selective grinding
- Restoration by crowns, fixed bridges and implants

#### 2. **Occlusal splints**

Based on the severity of damage to TMJ and masticatory muscles, several occlusal splints are available in prosthodontic management.

Used to

- Stabilize the TMJ muscles
- Introduce optimum occlusal conditions to prevent hyperactivity of muscles
- To protect excessive wear of teeth or trauma

Examples: Night guards, mouth guards, permissive splints (muscle deprogrammer) etc

#### 3. **Orthodontic management**

#### 4. **Orthognathic surgery**

### CONCLUSION

- Temporomandibular joint is associated with mandibular movements and oral functions.
- Hence proper examination and assessment regarding anatomy and functioning of TMJ is important prior to treatment planning for a successful prosthodontic treatment

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*Please Give Your Feedback on this Answer*

**Q. 02: Trigeminal nerve and its course. (10M), (7M)**

**CONTENTS/SYNOPSIS**

- Introduction
- Trigeminal nerve
  - Gross anatomy
    - Preganglionic
    - Postganglionic
    - Motor roots
    - Sensory roots
    - Semilunar ganglion
  - Branches of trigeminal nerve
- Ophthalmic nerve
  - Branches
    - Lacrimal nerve
    - Frontal nerve
    - Nasociliary nerve
- Maxillary nerve
  - Course
  - Branches
    - Branch given off on the cranium
    - Branches in the pterygopalatine fossa
    - Branches in the Infraorbital canal
    - Branches on the face
- Mandibular nerve
  - Branches from the undivided nerve
  - Branches from the divided nerve
- Innervations of maxillary teeth
- Innervations of mandibular teeth
- Innervation of supporting tissues
- Clinical considerations
  - Trigeminal neuralgia
  - Auriculotemporal syndrome/ frey's syndrome
- Conclusion
- References

## INTRODUCTION

- Trigeminal nerve consists of both sensory and motor components controlling the ipsilateral sensation of facial and masticatory muscles and their movements.

## TRIGEMINAL NERVE

- It is a fifth cranial nerve and largest of all cranial nerves
- It is a mixed nerve

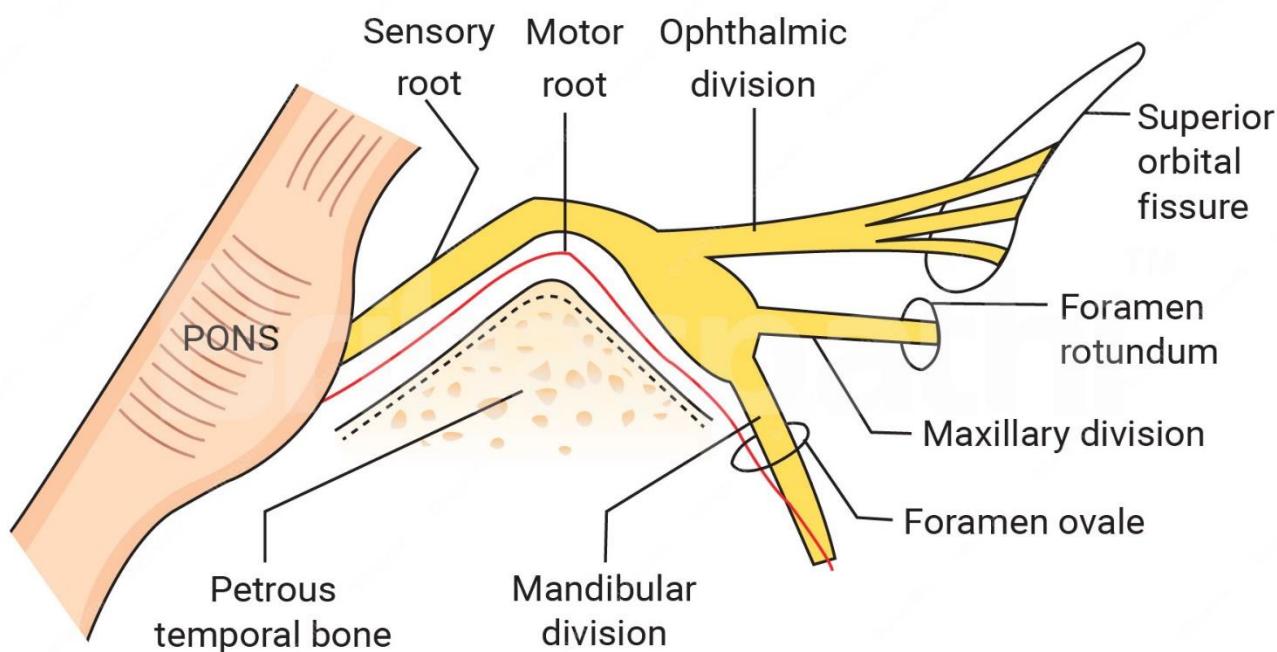
## Gross anatomy

### 1. Preganglionic

- Trigeminal ganglion is present within the Meckel's cavity with cavernous sinus posterolaterally and sphenoid bone on either side.
- Meckel's cavity also consists of internal carotid artery and motor root of trigeminal nerve

### 2. Postganglionic

- Trigeminal nerve exits the brain as a large sensory and small motor root through pons at its junction with middle cerebral peduncle



<b>3. Motor root</b>	<b>4. Sensory root</b>
<ul style="list-style-type: none"> <li>The motor root arises separately from the sensory root originating in the motor nucleus within the pons and medulla oblongata</li> <li>Its fibers forming a small nerve root travel anteriorly along with but entirely separate from the larger sensory root to the region of the semilunar ganglion</li> <li>At the semilunar ganglion, the motor root passes in a lateral and inferior direction under the ganglion towards the foramen ovale through which it leaves the middle cranial fossa along with the third division of the sensory root</li> <li>Just after leaving the skull, the motor root unites with the sensory root of the mandibular division to form a single nerve trunk</li> <li>Motor fibers of the trigeminal nerve supply the following muscles: <ul style="list-style-type: none"> <li>Masseter</li> <li>Temporalis</li> <li>Pterygoideus medialis</li> <li>Pterygoideus lateralis</li> <li>Mylohyoid</li> <li>Anterior belly of the digastric</li> <li>Tensor tympani</li> <li>Tensor veli palatini</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Sensory root fibers of the trigeminal nerve comprise the central processes of ganglion cells located in the trigeminal ganglion</li> <li>On entering the pons, divide into upper and lower roots</li> <li>The upper root ends in nucleus situated in the pons lateral to the lower motor nucleus</li> <li>The lower root descends through the pons and medulla oblongata</li> <li>Lower root is sometimes named the spinal root of the nerve</li> <li>The 3 branches of the sensory root supply: <ul style="list-style-type: none"> <li>Skin of the entire face</li> <li>Mucous membrane of the cranial viscera</li> <li>The mucous membrane of the oral cavity and teeth, except for the pharynx and base of the tongue</li> </ul> </li> </ul>

## 5. Semilunar ganglion

- Occupies a cavity in the dura mater covering the trigeminal impression near the apex of the petrous part of the temporal bone

- It is in relation with the internal carotid artery and the posterior part of the cavernous sinus
- It gives off minute branches to the tentorium cerebelli & to the dura mater in the middle fossa of the cranium
- The ganglia are flat and crescent shaped, their convexities facing anteriorly and downward and they measure approximately 1 x 2 cm
- Sensory root fibers enter the concave portion of each crescent and the three sensory divisions of the trigeminal nerve exit from the convexity
  - Ophthalmic
  - Maxillary
  - Mandibular
- Trigeminal nerve is associated with three divisions and four ganglia

### **Ganglia**

1. Ciliary ganglion associated with ophthalmic nerve
2. Sphenopalatine ganglion associated with maxillary nerve
3. Optic ganglion and
4. Sub maxillary ganglion associated with mandibular nerve

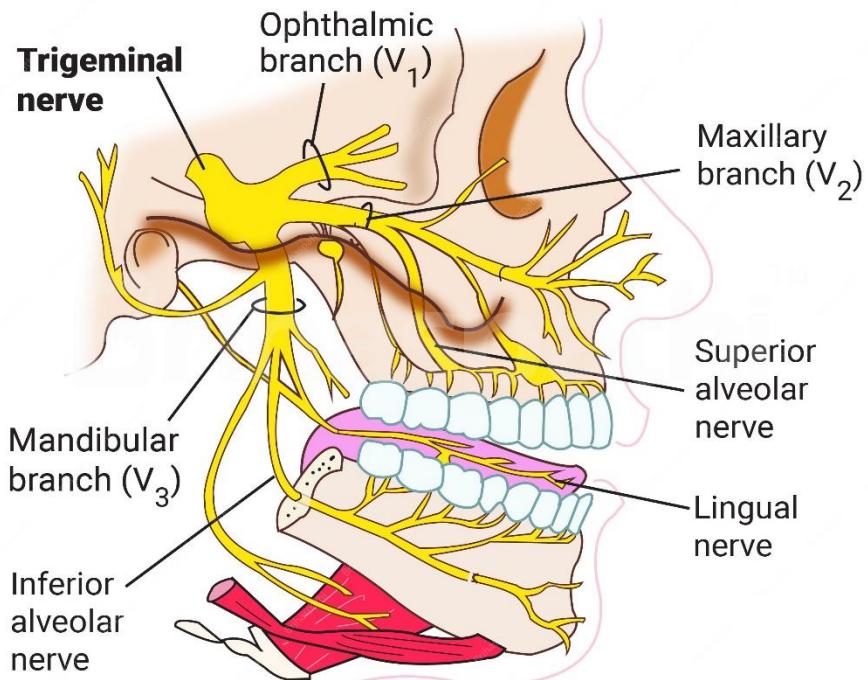
They receive

- Sensory filaments from the trigeminal nerve
- Motor and sympathetic filaments from various sources
- These filaments are called as ROOTS OF GANGLION

### **Branches of trigeminal nerve**

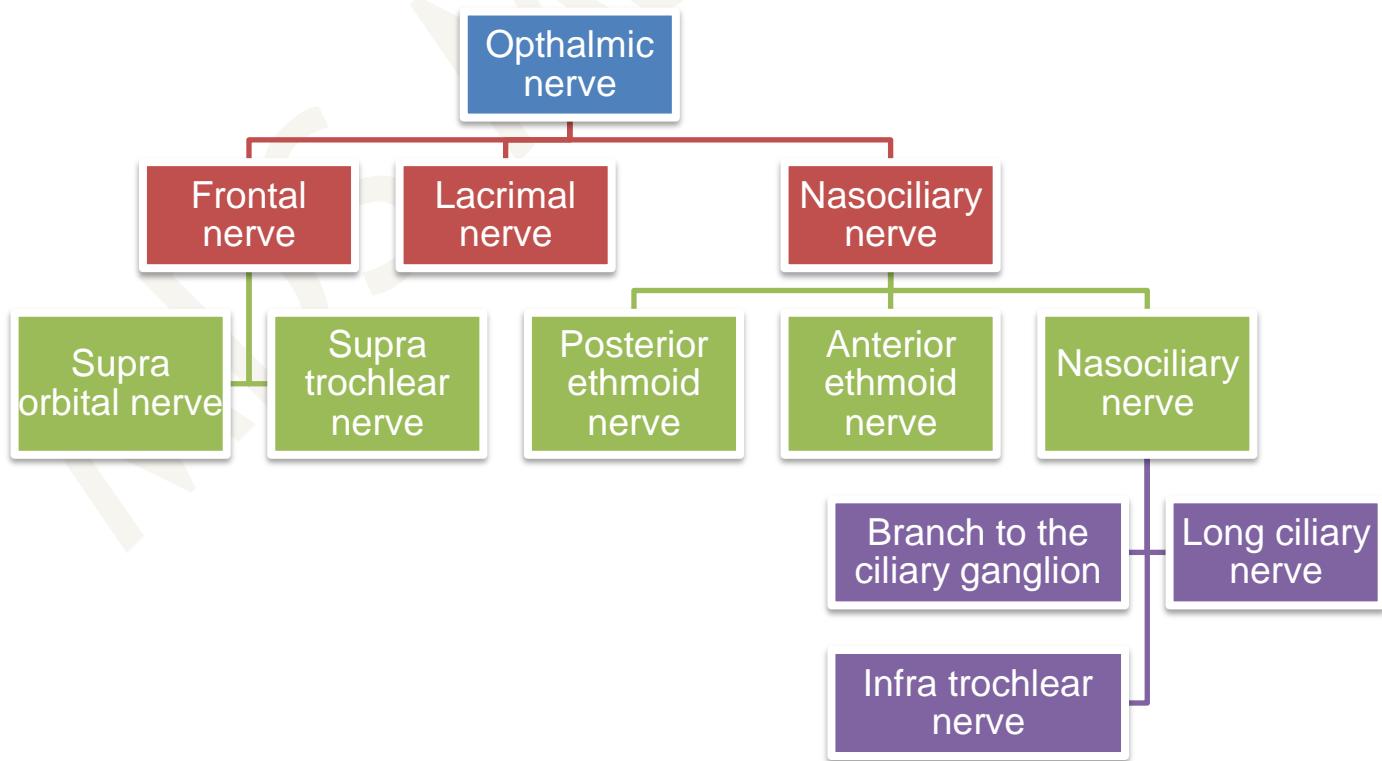
- There are three branches of trigeminal nerve

<b>Branch</b>	<b>Foramina</b>
• Ophthalmic nerve	• Superior orbital fissure
• Maxillary nerve	• Foramen rotundum
• Mandibular nerve	• Foramen ovale



## OPHTHALMIC NERVE (V<sub>1</sub>)

- It is the smallest and superior branch of trigeminal nerve
- Sensory nerve
- Recurrent branch of ophthalmic nerve supplies to anterior cranial fossa and tentorium cerebella. It is divided into three branches



## Branches

### 1. *Frontal nerve*

It travels through the orbit and branches into

i. *Supra orbital nerve* which supplies to forehead, scalp, mucous membrane of frontal sinus and pericranium

ii. *Supra trochlear nerve* which is placed more medially supplies to skin of the upper eyelid and lower part of the forehead

### 2. *Lacrimal nerve*: Passes lateral to the orbit.

Supplies to lacrimal gland, conjunctiva and skin of the lateral part of the upper eye lid

### 3. *Nasociliary nerve*

- It runs deeper and is intermediate in size. Branches are divided into as follows

#### i. *Branches in the orbit*

- Long root of ciliary ganglion: Sensory branch and passes through ganglion without forming a synapse, supplies to eye ball
- Long ciliary nerve: Supplies to iris and cornea
- Posterior ethmoid nerve: Supplies to lining of ethmoid and sphenoidal sinuses
- Anterior ethmoid nerve: Supplies to lining of anterior ethmoid and frontal paranasal sinuses. It further branches into *internal nasal* and *external nasal* branches supplying to septal membranes, nasal conchae, anterior nasal wall, skin on the tip and ala of the nose

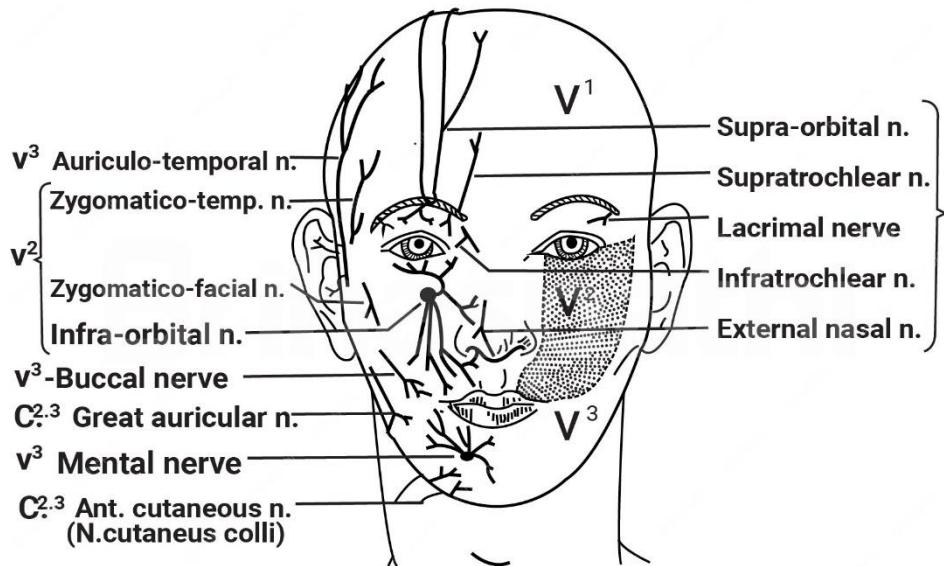
#### ii. *Branches in the nasal cavity*

- Supply to the mucosa of nasal cavity

#### iii. *Terminal branches*

- Supply sensory nerves to medial parts of both eyelids, lacrimal sac, skin of the bridge of the nose

## Branches of ophthalmic and maxillary divisions



### MAXILLARY DIVISION (V<sub>2</sub>)

- This is second and intermediate division of fifth cranial nerve
- It is a sensory nerve

#### Course:

Begins at middle of trigeminal ganglion

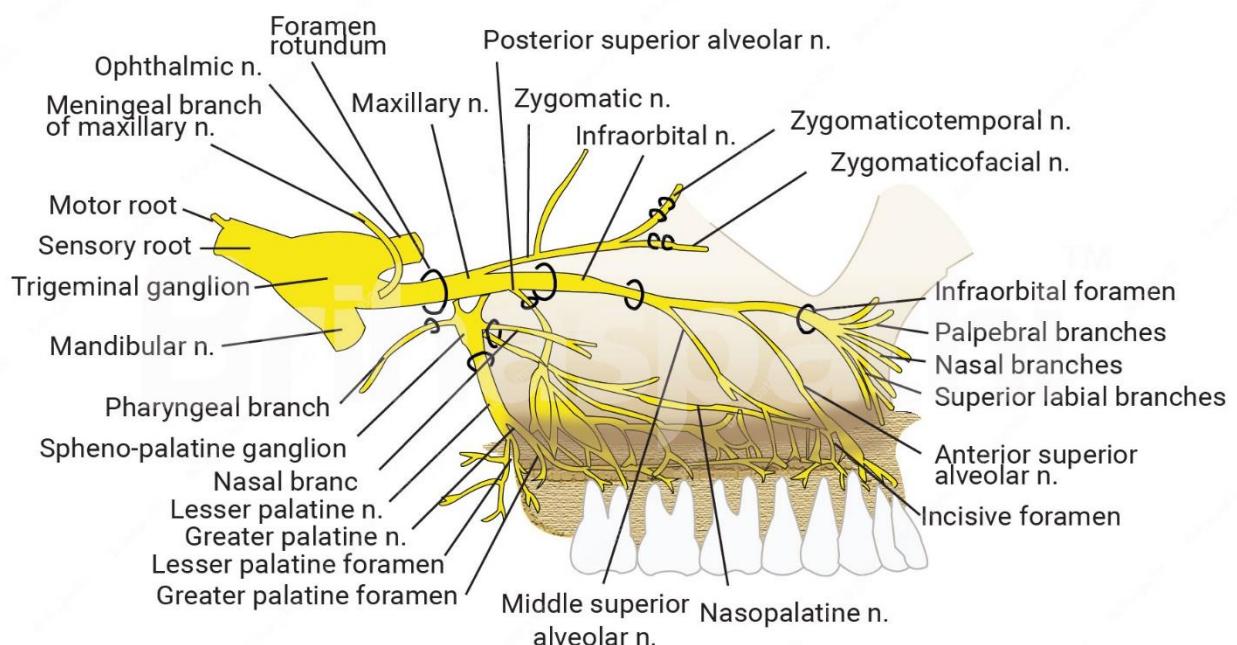
Passes horizontally forwards along later wall of cavernous sinus

Exits the skull through foramen rotundum

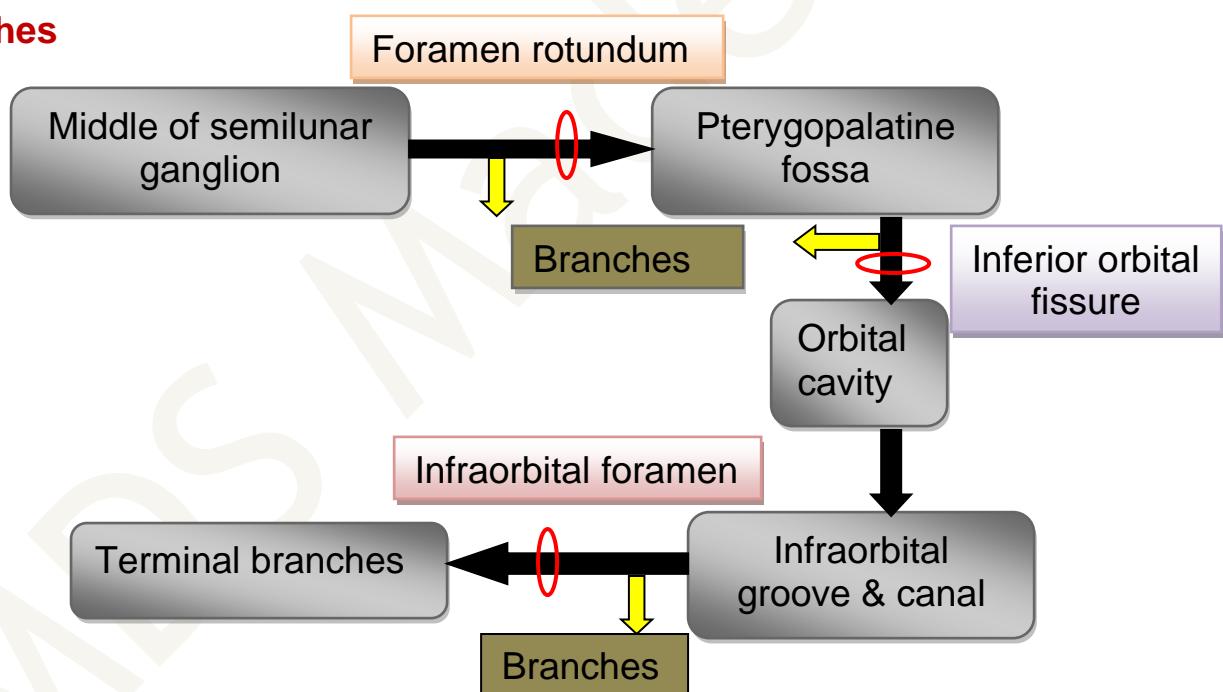
Crosses the upper part of pterygopalatine fossa

Inclines onto the posterior part of the orbital process of maxilla laterally and enters the orbit through orbital fissure

Passes through infraorbital canal in the floor of orbit and exits through infra orbital foramen and supplies to the face



## Branches



**Branch given off on the cranium****Meningeal branch**

- Given off near the foramen rotundum.
- The recurrent branch supplies the middle cranial fossa and duramater of anterior part of cranial fossa.

**Branches in the pterygopalatine fossa**

1. Ganglionic branches	2. Zygomatic nerve	3. Posterior superior alveolar nerve
<ul style="list-style-type: none"> <li>Connects the maxillary branch to pterygopalatine ganglion.</li> <li>Consists of secretomotor fibers to lacrimal gland.</li> <li>Supplies sensory fibers to periosteum of orbit and mucosa of nose, palate and pharynx</li> </ul>	<ul style="list-style-type: none"> <li>Arises from pterygopalatine fossa and passes anteriorly. enters through inferior orbital fissure.</li> <li>Divided into 2 branches: <ul style="list-style-type: none"> <li><b>Zygomaticofacial</b> supplying the skin over zygomatic bone</li> <li><b>Zygomaticotemporal</b> perforates the temporal surface of zygomatic and pierces the temporalis fascia, supplying skin over the anterior temporal fossa</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Begins in pterygopalatine fossa and divides into three branches through pterygomaxillary fissure.</li> <li>Supplies the maxillary tuberosity and sides of maxilla to the molars except mesiobuccal root of first molar, buccinator and adjoining part of gingiva and cheek</li> </ul>

#### 4. Pterygopalatine branches

- Enters the nasal cavity (posterior part) by sphenopalatine foramen

##### Nasal branches:

- Supplies to mucosa of superior and middle nasal conchae, posterior ethmoidal cells and septum (posterior part)

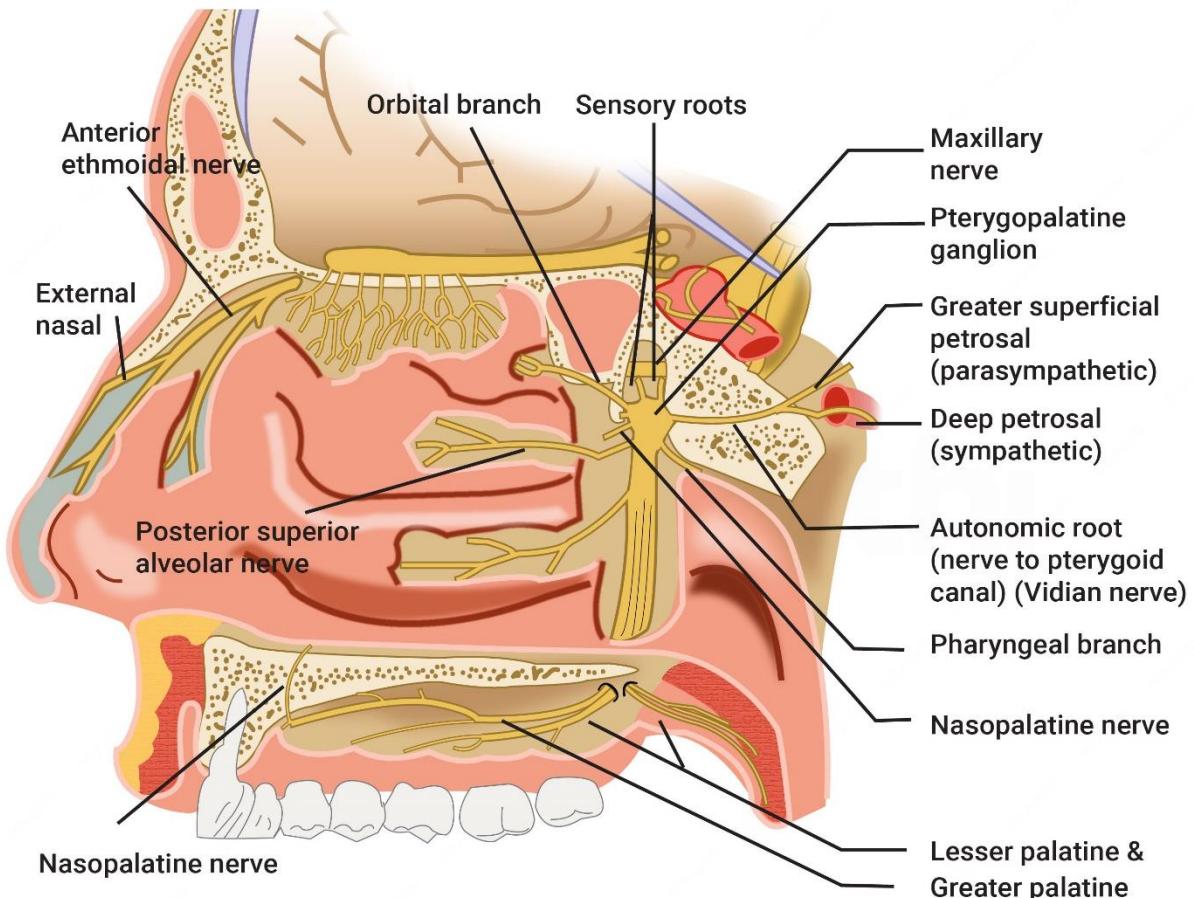
##### Nasopalatine nerve

- Travels through roof of nasal cavity below the opening of sphenoid sinus and reaches septum
- Then runs downward and forward between periosteum and mucous membrane of lower septum
- Descends to roof of mouth through incisive canal and communicates with anterior palatine nerve

Greater palatine nerves	Lesser palatine nerves	
Anterior palatine nerve	Middle palatine nerve	Posterior palatine nerve
<ul style="list-style-type: none"> <li>Emerges through greater palatine foramen onto the hard palate and travels anteriorly nearer to incisors</li> <li>Supplies to gums, mucous membrane of hard palate glands</li> </ul>	<ul style="list-style-type: none"> <li>Exists through minor palatine canals</li> <li>Supplies to uvula, tonsil and soft palate</li> </ul>	<ul style="list-style-type: none"> <li>Supplies to soft palate, tonsils, uvula</li> </ul>

##### Pharyngeal branch

- Supplies to mucous membrane of nasal part of pharynx



### Branches in the Infraorbital canal

#### Middle superior alveolar nerve

It travels through along the lateral wall of the maxillary sinus and supplies to maxillary premolars and mesiobuccal root of first molar

#### Anterior superior alveolar nerve

Travels through anterior wall of maxillary antrum and runs inferiorly supplying canine and incisors, mucosa of anterior part of lateral wall and floor of nasal cavity, nasal septum

### Branches on the face

**Inferior palpebral branch:** Supplies to skin and conjunctiva of lower eyelid

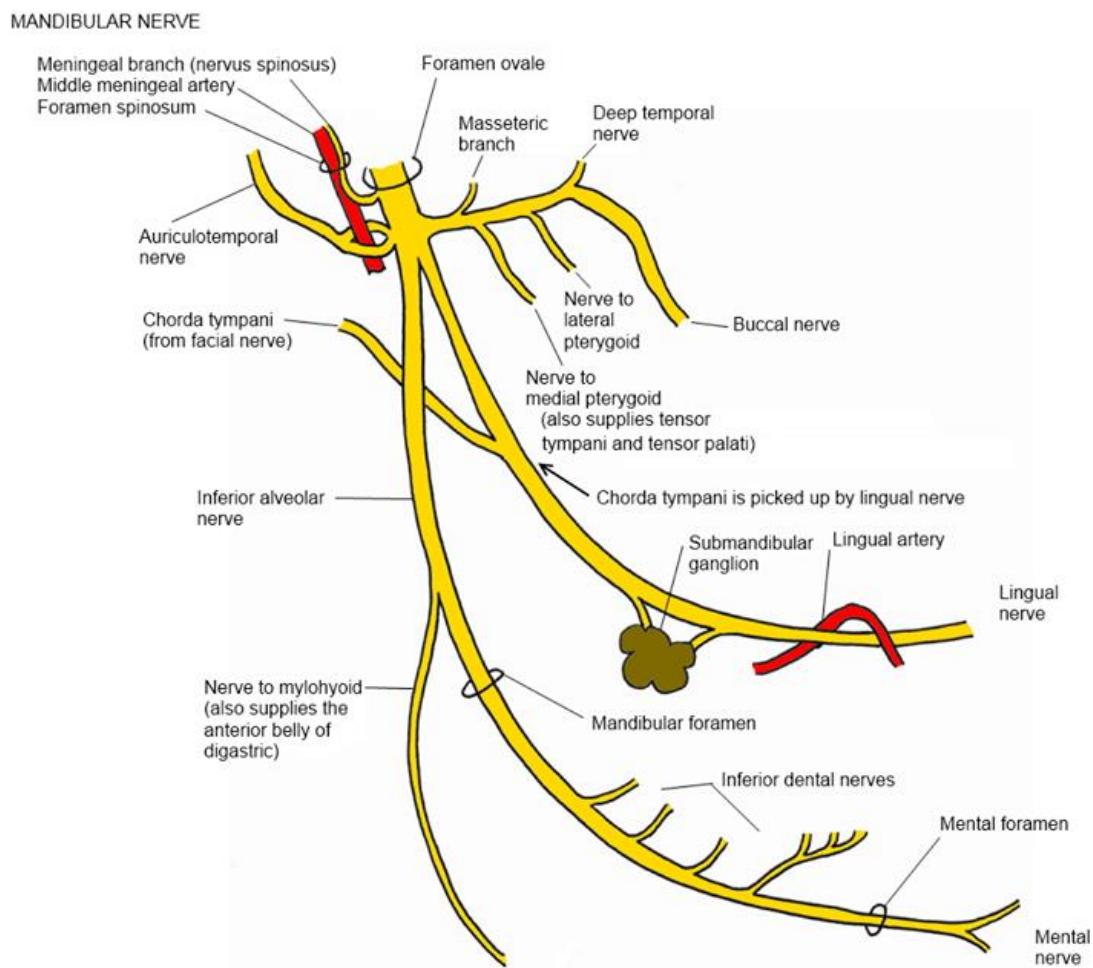
**External nasal branch:** Supplies to skin of the side of the nose and septum

**Superior labial branch:** Supplies to skin of upper lip, mucosa of mouth and labial glands

## MANDIBULAR NERVE ( $V_3$ )

- The mandibular nerve is the third division (branch) of the trigeminal nerve
- It passes through the foramen ovale and into the infratemporal fossa
- The mandibular nerve is largely sensory but it also receives the motor fibers (axons) from the motor root of cranial nerve V that mainly supply the muscles of mastication.
- In general, it supplies to:
  - Mandibular teeth and gums
  - Skin on temporal region
  - Auricula
  - Lower lip
  - Lower part of the face
  - Muscles of mastication
  - Mucosa of anterior two thirds of tongue

## Branches



**Branches from the undivided nerve**

1. Nervous spinosus	2. Nerve to Internal Pterygoid Muscle
<ul style="list-style-type: none"> <li>After exiting the skull, it passes into middle cranial fossa and supplies the dura mater and mastoid cells</li> </ul>	<ul style="list-style-type: none"> <li>Innervates the tensor veli palatini and tensor tympani muscles</li> </ul>

**Branches from the divided nerve**

1. Anterior division	
<i>i. Nerve to lateral pterygoid muscle</i>	<i>ii. Nerve to masseter muscle</i>
<ul style="list-style-type: none"> <li>Pterygoid nerve enters the lateral pterygoid muscle on its mesial side and provides motor supply to it</li> </ul>	<ul style="list-style-type: none"> <li>Masseter nerve passes above the lateral pterygoid and transverses the mandibular notch</li> </ul>
<i>iii. Nerve to temporalis muscles</i>	
<ul style="list-style-type: none"> <li>Anterior deep temporal nerve supplies the deep part of temporalis and in the anterior portion</li> </ul>	<ul style="list-style-type: none"> <li>Posterior deep temporal nerve passes up to the deep temporalis muscle</li> </ul>
<i>iv. Long buccal nerve</i>	
<ul style="list-style-type: none"> <li>It travels downward, anteriorly and laterally between the two heads of lateral pterygoid muscle.</li> <li>Supplies to buccinator and mucous membrane of cheek</li> </ul>	

2. Posterior division
<ul style="list-style-type: none"> <li>Mainly sensory with few motor components</li> </ul>
<i>i. Auriculotemporal nerve</i>
<ul style="list-style-type: none"> <li>Travels along with middle meningeal artery and unties just before foramen spinosum</li> <li>Passes upwards and divides. Supplies to tragus of the pinna of external ear, scalp, skull vertex</li> </ul>
<i>ii. Lingual nerve</i>
<ul style="list-style-type: none"> <li>Travels medially to lateral pterygoid muscle and descends between internal pterygoid and ramus of mandible.</li> <li>Nerve lies parallel to inferior alveolar nerve and then enters the base of the tongue</li> </ul>

**iii. Inferior alveolar nerve**

- Largest branch of posterior division
- Descends with inferior alveolar artery beneath pterygoid plexus
- Travels between sphenomandibular ligament and ramus of the mandible
- Enters mandibular foramen and passes forward into the mandibular canal till mental foramen (Before entering mandibular canal, nerve branches into mylohyoid nerve which supplies mylohyoid muscle and anterior belly of the digastric and its dental branches supplies to molar and premolar mandibular teeth)
- Divided into two terminal branches: Incisive and mental
- Incisive nerve supplies to canine and incisor teeth, mental nerve supplies to skin of the chin, skin and lower mucous membrane of lower lip

**INNERVATIONS OF TEETH****I. Maxillary Teeth:**

- Anterior superior alveolar nerve: upper incisors and canines ( $V_2$ )
- Middle superior alveolar nerve: upper premolars and the mesio-buccal root of the maxillary first molar ( $V_2$ )
- Posterior superior alveolar nerve: upper molars except the mesio-buccal root of the maxillary first molar ( $V_2$ )

**II. Mandibular Teeth:**

- Inferior alveolar nerve: mandibular teeth, gingiva and lower lip unilaterally ( $V_3$ )
- Lingual nerve: anterior 2/3 of tongue and mucosa of the floor of the mouth ( $V_3$ )
- Buccal nerve: gingiva on the buccal side of posterior teeth ( $V_3$ )
- The upper parts of the oral cavity, including the palate and the upper teeth, are innervated by branches of the maxillary nerve ( $V_2$ )
- The lower parts, including the teeth and oral part of the tongue, are innervated by branches of the mandibular nerve ( $V_3$ )

### III. Innervation of supporting tissues

- Gingiva associated with the upper teeth is innervated by branches derived from the maxillary nerve ( $V_2$ ) and lower teeth are innervated by mandibular nerve ( $V_3$ )
- The gingiva associated with the buccal side of the mandibular incisor, canine, and premolar teeth is innervated by the mental branch of the inferior alveolar nerve
- Gingiva on the buccal side of the mandibular molar teeth is innervated by the buccal nerve, which originates from the mandibular nerve ( $V_3$ )

## CLINICAL CONSIDERATIONS

- Knowledge of anatomy of the branches of the trigeminal nerve is of utmost importance in administering local anesthesia for oral surgical procedures
- During placement of preauricular incision, and during parotid surgeries, there is chance of damage to the auriculotemporal nerve, that may cause frey's syndrome
- Branches of trigeminal nerve like infraorbital nerve and mental nerve are to be preserved during treatment of fractures
- Damage to the complete nerve may lead to
  - Unilateral anesthesia on the auricle
  - Unilateral anesthesia of the mucous membrane of mouth
  - Unilateral anesthesia of the mucous membrane of nose
  - Unilateral anesthesia of the anterior 2/3 of the tongue
  - Unilateral paralysis of muscles of mastication
- Trigeminal neuralgia affects one or more of the divisions of the trigeminal nerve causing severe pain
- Carcinoma of the tongue which affects the lingual nerve may refer pain to the distribution of the auriculotemporal nerve, causing earache

## Trigeminal neuralgia

- Trigeminal neuralgia or tic douloureux is sometimes described as the most excruciating pain known to humanity.

<b>Prevalence and Incidence</b>	<b>Clinical features</b>
<ul style="list-style-type: none"> <li>Advanced age is a major risk factor for trigeminal neuralgia, rarely affects anyone younger than age 50</li> <li>Most common in women than in men</li> </ul>	<ul style="list-style-type: none"> <li>It is an intense, stabbing, electric shock-like pain is caused due to irritation of the trigeminal nerve</li> <li>Initially starts as short and mild attacks, but can progress into longer and frequent bouts of searing pain</li> </ul>
<b>Trigger factors</b>	<b>Treatment</b>
<ul style="list-style-type: none"> <li>It is generally provoked by trigger factors like <ul style="list-style-type: none"> <li>Shaving</li> <li>Stroking your face</li> <li>Eating</li> <li>Drinking</li> <li>Brushing your teeth</li> <li>Talking</li> <li>Putting on makeup</li> <li>Encountering a breeze</li> <li>Smiling</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Anticonvulsive medications are the first treatment choice</li> <li>Patient should be educated about the trigger factors to minimise the episodes of pain</li> </ul>

## Auriculotemporal syndrome/ Frey's syndrome/ Gustatory sweating

<b>Etiology</b>	<b>Clinical features</b>	<b>Treatment</b>
<ul style="list-style-type: none"> <li>It results from damage to the Auriculotemporal nerve.</li> <li>The syndrome usually follows some surgical operation.</li> </ul>	<ul style="list-style-type: none"> <li>Flushing and sweating of the involved side of the face</li> </ul>	<ul style="list-style-type: none"> <li>Injection: Botulinum toxin</li> <li>Surgical transection of nerve fibre</li> </ul>

## CONCLUSION

- Comprehensive understanding of the nerve pathway and the nerve supply to the various sites of the oral cavity is essential for the dentist.
- It helps in the diagnosis and treatment of pain involving the oral and paraoral structures.

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*Please Give Your Feedback on this Answer*

## Vitamin and its function (7M)

### CONTENTS/SYNOPSIS

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- Water soluble vitamins
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## INTRODUCTION

- Vitamins may be regarded as organic compounds required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth and health of the organism

## CLASSIFICATION OF VITAMINS

Based on solubility:

<b>I. Fat-soluble vitamins</b>	<b>II. Water-soluble vitamins</b>		
Vitamins soluble in fats or fat solvents	Vitamins that are not stored in the body & are easily excreted		
Vitamin A	Non-B complex	Vitamin B-complex	
Vitamin D	Vitamin C	Energy releasing	Hematopoietic
Vitamin E		Thiamin B1 Riboflavin B2 Niacin B3 Pantothenic acid B5 Pyridoxine B6 Biotin B7	Folic acid Cyanocobalamin (vitaminB12)
Vitamin K			

## WATER SOLUBLE VITAMINS

Heterogeneous group of compounds: differ chemically

- Common character: solubility in water
- Easily absorbed
- Not stored in the body except for Vitamin B12
- Readily excreted in urine
- Form coenzymes: biochemical reactions

### I. Vitamin C (Ascorbic Acid)

- In 1933, Vitamin C was named ascorbic acid owing its ant scorbustic properties

#### 1. Sources

- Abundantly seen in citrus fruits, gooseberries, guava, melons, sprouting seeds, leafy vegetables, spinach, cauliflower, cabbage, tomatoes and drumstick

## 2. RDA

- Infants: 35 mg
- Children: 40mg
- Adults: 45mg
- Pregnant women: 60mg
- Lactating Women: 80mg

## 3. Biochemical functions

- Reversible oxidation
- Plays an important role in collagen formation: collagen protein requires vitamin C for hydroxylation
- Thereby facilitating cross linkage of collagen fibers and increases its strength
- Helps in bone formation
- Plays a role in iron and hemoglobin metabolism
- Takes part in the metabolic reactions of tryptophan, tyrosine, folic acid and cholesterol
- Enhances the synthesis of immunoglobulins and increases their phagocytic action
- Also acts as a strong biological antioxidant

## 4. Biosynthesis and metabolism

- Many animals can synthesize ascorbic acid from glucose via uronic acid pathway
- Humans cannot synthesize ascorbic acid due to the deficiency of a single enzyme namely L-Gulono-Lactoneoxidase
- Oxidation of ascorbic acid is rapid in the presence of copper. Hence vitamin C becomes inactive if the foods are prepared in copper vessels

## 5. Deficiency manifestations (General)

- Leads to scurvy, characterized by spongy and sore gums, loose teeth, swollen joints, anemia, fragile blood vessels, delayed wound healing, hemorrhage, osteoporosis etc.
- Defective collagen synthesis
- “Cork screw” hair pattern with tiny bleeding points around the orifice of a hair follicle
- “Woody legs” with large spontaneous bruises in lower extremities

- “Tummer field zone” is the classic histological picture of bone in scurvy

### 6. Oral manifestations

- Affects the gingival and periodontal tissues
- Interdental and marginal gingiva is swollen, bright red, with a smooth and shiny surface
- Pathognomonic sign is the swollen and spongy gums, particularly the interdental papillae are involved producing the appearance of scurvy buds
- In fully developed scurvy, the gingiva becomes boggy, ulcerates and bleeds. The color changes to a violaceous red
- In severe cases, hemorrhages to periodontal membranes followed by loss of bone and loosening of teeth occurs

### 7. Hypervitaminosis C

- Ascorbic acid is generally not toxic. But, dehydroascorbic acid (oxidized form of ascorbic acid) is toxic
- Oxalate is a major metabolite of vitamin C and oxalates have been implicated in the formation of kidney stones
- Mega doses of vitamin C are used in common cold, wound healing trauma etc. & potential toxic effects of mega doses of vitamin C cannot be ignored

## II. Vitamin B-Complex

- Comprise a large number of water-soluble vitamins which are nutritional essentials for all forms of life
- They also form essential co enzymes to certain important intracellular enzyme systems
- There are about individual components, most of them are synthesized by the microbial flora
- Types of vitamin B complex are
  - Thiamine: Vitamin B1
  - Riboflavin: Vitamin B2
  - Niacin: Vitamin B3
  - Pantothenic acid: Vitamin B5
  - Pyridoxine: Vitamin B6
  - Biotin: Vitamin B7

- Folic acid group
- Cyanocobalamin: Vitamin B12

### **1. *Thiamine (Vitamin B1, anti-beriberi, antineuritic vitamin)***

- Free thiamin is basic and heat stable including acid medium
- Thiamine is practically present in all plants and animal tissues commonly used as food & is destroyed with improper cooking
- It has a specific coenzyme, thiamine pyrophosphate (TPP), which is mostly associated with carbohydrate metabolism
- Readily soluble in water
- Can be destroyed when autoclaved at 120°C for 30min, at room temperature in an alkaline medium

#### *i. Dietary sources*

- Cereals, pulses, oil seeds, nut and yeast are good sources.
- Thiamine is mostly concentrated in the outer layer (bran) of cereals.
- Also present in animal foods like pork, liver, heart, kidney, milk etc

#### *ii. RDA*

- Infants - 0.3-0.5 mg
- Children – 0.7-1.2mg
- Adults – Males – 1.2-1.5mg, Females – 1.0-1.1mg
- Pregnant women – 1.3-1.5mg
- Lactating Women – 1.3-1.5mg

#### *iii. Biochemical functions*

- The enzyme thiamine pyrophosphate or cocarboxylase is intimately connected with the energy releasing reactions in the carbohydrate metabolism
- TPP also plays an important role in the transmission of nerve impulse- required for acetylcholine synthesis and the ion translocation of neural tissue

#### *iv. Deficiency manifestations*

- B1 deficiency is seen in populations consuming polished rice as staple food
- B1 deficiency is called beriberi
- The early symptoms of thiamine deficiency are loss of appetite (anorexia), weakness, constipation, nausea, mental depression, peripheral neuropathy, irritability

- In adults, two types of beriberi, namely wet and dry beriberi are seen. Infantile type of beriberi is also seen.

Wet beriberi	Dry beriberi	Infantile beriberi
<ul style="list-style-type: none"> <li>• <u>Cardiovascular manifestations</u> including edema of legs, face, trunk and serous cavities, with breathlessness and palpitations, along with increase in systolic and decrease in diastolic blood pressure</li> </ul>	<ul style="list-style-type: none"> <li>• <u>Neurological manifestations</u> resulting in peripheral neuritis, with progressive weakening in muscles &amp; difficulty to walk</li> </ul>	<ul style="list-style-type: none"> <li>• Seen in infants born to mothers suffering from thiamine deficiency, characterized by sleeplessness, restlessness, vomiting, convulsions and bouts of screaming, these are due to cardiac dilatation</li> </ul>

## 2. Riboflavin (Vitamin B2)

- Riboflavin through its coenzymes flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) takes part in a variety of cellular oxidation-reduction reactions
- Involved in carbohydrate, lipid, protein and purine metabolisms, besides electron transport chain
- Enzymes that use flavin coenzymes are called flavoproteins
- Many flavoproteins contain metal atoms and hence known as metalloflavoproteins

i. Dietary sources	ii. RDA
<ul style="list-style-type: none"> <li>• Milk and milk products, meat, eggs, liver, kidney are rich sources.</li> <li>• Cereals, fruits, vegetables and fish are moderate sources.</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 0.4-0.6 mg</li> <li>• Children: 0.8-1.2mg</li> <li>• Adults: Males 1.5 - 1.8mg, Females 1.1-1.4mg</li> <li>• Pregnant women: 1.4-1.7mg</li> <li>• Lactating Women: 1.6-1.9mg</li> </ul>

### iii. Deficiency manifestations

- Includes cheilitis, glossitis, and dermatitis
- Riboflavin deficiency as such is uncommon, but seen along with other vitamin deficiencies
- Chronic alcoholics are more susceptible to this vitamin deficiency

- Nasolabial seborrhea
- Vascularization of cornea
- Scrotal dermatitis

*iv. Oral manifestations*

- Glossitis: filiform papillae become atrophic while the fungiform papillae become engorged and mushroom shaped, resulting in magenta colored tongue
- Cheilosis. ocular lesions

**3. Niacin (Vitamin B3, Nicotinic acid)**

- Also known as the pellagra preventive factor of Goldberg
- The coenzymes of niacin are synthesized by the essential amino acid, tryptophan
- These coenzymes NAD<sup>+</sup> and NADP<sup>+</sup> are involved in a variety of oxidation-reduction reactions
- The essential amino acid tryptophan can serve as a precursor for the synthesis of nicotinamide coenzymes

<i>i. Dietary sources</i>	<i>ii. RDA</i>
<ul style="list-style-type: none"> <li>• The rich natural sources of niacin include liver, yeast, whole grains, pulses like beans and peanuts</li> <li>• Milk, fish, eggs and vegetables are moderate sources</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 0.4 - 0.6 mg</li> <li>• Children: 0.8 - 1.2mg</li> <li>• Adults: Males 1.5 - 1.8mg, Females 1.1-1.4mg</li> <li>• Pregnant women: 1.4 - 1.7mg</li> <li>• Lactating Women: 1.6 - 1.9mg</li> </ul>

*iii. Deficiency manifestations*

- Niacin deficiency results in a condition called as pellagra
- Pellagra involves skin, gastrointestinal tract and central nervous system
- Symptoms are commonly referred to as three D's. Disease also progresses in the order Dermatitis, Diarrhea, Dementia, and if not treated may rarely lead to death
- The symptoms of dementia include anxiety, irritability, poor memory, insomnia etc.

**iv. Oral manifestations**

- Bald tongue
- Raw beefy tongue
- The mucosa becomes fiery red and painful
- Salivation becomes profuse

**4. Pantothenic acid (Vitamin B5)**

- Pantothenic acid, also known as chick anti-dermatitis factor or filtrate factor
- The functions of pantothenic acid are exerted through coenzyme A or CoA
- CoA is the central molecule involved in all the metabolisms (carbohydrate, lipid and protein), acting as the carrier of activated acetyl or acyl groups

<i>i. Dietary sources</i>	<i>ii. RDA</i>
<ul style="list-style-type: none"> <li>• Widely distributed in plants and animals.</li> <li>• Rich sources are egg, liver, meat, yeast, milk etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 0.4 - 0.6 mg</li> <li>• Children: 0.8 - 1.2mg</li> <li>• Adults: Males 1.5-1.8mg, Females 1.1-1.4mg</li> <li>• Pregnant women: 1.4 - 1.7mg</li> <li>• Lactating Women: 1.6 - 1.9mg</li> </ul>

**iii. Deficiency manifestations**

- Burning feet syndrome: pain and numbness in toes, sleeplessness and fatigue are features

**5. Pyridoxine (Vitamin B6)**

- Vitamin B6 collectively represent the three compounds: pyridoxine, pyridoxal and pyridoxamine
- The active form of vitamin B6 is the coenzyme pyridoxal phosphate (PLP)
- PLP is closely associated with the metabolism of amino acids
- The synthesis of certain specialized products like serotonin, histamine, niacin coenzymes from amino acids are dependent on pyridoxine
- PLP participates in reactions like transamination, decarboxylation, deamination, transsulfuration, condensation etc.
- Intestinal Bacteria can also produce Vitamin B6
- Isoniazid: drug used in the treatment of TB is antagonist to vitamin B6-Pyridoxin

<i>i. Dietary sources</i>	<i>ii. RDA</i>
<ul style="list-style-type: none"> <li>Animal sources such as egg yolk, fish, milk, meat are rich in B6</li> <li>Wheat, corn, cabbage, roots and tubers are good vegetable sources</li> </ul>	<ul style="list-style-type: none"> <li>Infants: 0.3 mg</li> <li>Children: 0.6 - 1.2mg</li> <li>Adults: Males 1.6 - 2.0mg, Females 1.6 - 2.0mg</li> <li>Pregnant women: 2.5mg</li> <li>Lactating Women: 2.5mg</li> </ul>

*iii. Deficiency manifestations*

- Pyridoxine deficiency is associated with neurological symptoms such as depression, irritability, nervousness and mental confusion
- Convulsions and peripheral neuropathy** are observed in severe deficiency
- These symptoms are related to the decrease in the synthesis of biogenic amines like serotonin, nor epinephrine and epinephrine
- Demyelination of neurons is also observed
- Decrease in hemoglobin levels, associated with hypochromic microcytic anemia, is seen in B6 deficiency, this is due to the decrease in heme production

**6. Biotin (Vitamin B7)**

- Biotin is an anti-egg white injury factor, vitamin B7 or vitamin H, is a sulfur containing B-complex vitamin
- Acts as a carrier of CO<sub>2</sub> in carboxylation reactions
- Biotin deficiency is uncommon since it is well distributed in food and also supplied by the intestinal bacteria

<i>i. Dietary sources</i>	<i>ii. RDA</i>
<ul style="list-style-type: none"> <li>Biotin is widely distributed in both animal and plant foods</li> <li>The rich sources are liver, kidney, egg yolk, milk, tomatoes, grains</li> </ul>	<ul style="list-style-type: none"> <li>100-300 mg for adults, but this vitamin is abundantly synthesized by the intestinal bacteria</li> </ul>

*iii. Deficiency manifestations*

- Symptoms include anemia, loss of appetite, nausea, dermatitis, glossitis etc.
- Biotin deficiency is not common
- Distributed in foods and also supplied by the intestinal bacteria

## 7. Folic acid

- Important for one carbon metabolism and is required for the synthesis of certain amino acids, purines and the pyrimidine-thymine
- Tetrahydrofolate (THF or FH4), the coenzyme of folic acid is actively involved in the carbon metabolism
- THF serves as an acceptor or donor of carbon units in a variety of reactions involving amino acid and nucleotide metabolism

<i>i. Dietary sources</i>	<i>ii. RDA</i>
<ul style="list-style-type: none"> <li>The rich sources are green leafy vegetables, whole grains, cereals, liver, kidney, yeast and eggs</li> </ul>	<ul style="list-style-type: none"> <li>Infants: 50µg</li> <li>Children: 100 - 300µg</li> <li>Adults: Males 400 µg, Females 400 µg</li> <li>Pregnant women: 800µg</li> <li>Lactating Women: 600 µg</li> </ul>

### *iii. Deficiency manifestations*

- Decreased production of purines and dTMP is observed, which impairs DNA synthesis
- Due to block in DNA synthesis, the maturation of erythrocytes is slowed down leading to macrocytic RBC
- Aminopterin and methotrexate are structural analogues of folic acid used in treatment of many cancer including leukemia, these drugs blocks the formation of THF and hence DNA synthesis is impaired

### *iv. Oral manifestation*

- Glossitis
  - The filiform papillae disappears first
  - But in advanced cases the fungiform papillae are lost and the tongue becomes smooth and fiery red in colour

## 8. Cyanocobalamin (Vitamin B12)

- Vitamin B12 is also known as anti-pernicious anemia vitamin and extrinsic factor of Castle
- Derived the names of cobalamin and Cyanocobalamin due to the presence of cobalt and cyanide groups

- Helps in the formation of labile methyl groups, for the synthesis of thymine and therefore for synthesis of nucleic acids, and along with folic acid for the normal Hemopoiesis
- Synthesis of methionine from homocysteine
- Isomerization of methylmalonyl CoA to succinyl CoA
- Bacterial synthesis of cobalamin occurs in the human colon but it is not absorbed.
- The only source of cobalamin in nature is via synthesis by microorganisms in soil, water and the animal intestine

<i>i. Dietary sources</i>	<i>ii. RDA</i>
<ul style="list-style-type: none"> <li>• Not seen in plant foods.</li> <li>• Animal sources are liver, kidney, eggs, milk, and meat</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 0.3µg</li> <li>• Children: 1 - 2µg</li> <li>• Adults: Males 3.0µg, Females 3.0µg</li> <li>• Pregnant women: 4.0µg</li> <li>• Lactating Women: 4.0µg</li> </ul>

### *iii. Deficiency manifestations*

- Most important is pernicious anemia
- Characterized by low hemoglobin levels
- Decreased number of erythrocytes
- Neurological manifestations
- Degeneration of myelin sheath and peripheral nerves also occurs

### *iv. Oral manifestation*

- Beefy red tongue – with glossopyrosis, glossitis and glossodynia
- Hunter's glossitis or Moeller's glossitis – which is similar to “bald tongue of sandwich seen in pellagra”
- The B-complex vitamins, such as niacin, thiamin, riboflavin, folic acid, and B12, are co-factors in energy metabolism and needed in DNA and RNA synthesis.
- This makes them indispensable for tissue maintenance and the production of new cells during development and healing

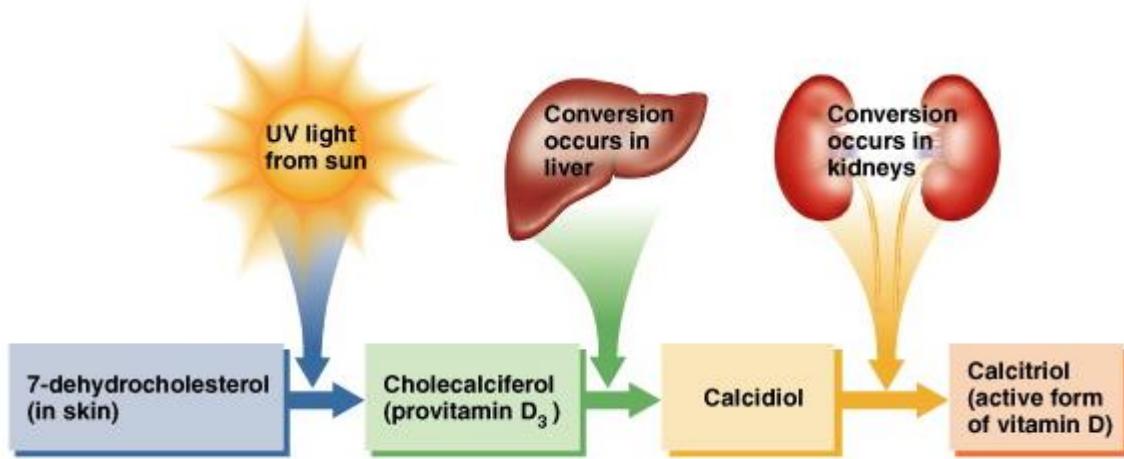
## FAT SOLUBLE VITAMINS

### I. Vitamin D

- Also called as cholecalciferol
- It is also known as “Sunshine Vitamin”
- Though it is a vitamin but still can be called as a hormone as it is synthesized by the skin when exposed to sunlight
- However, it is still a vitamin as it is first detected and isolated in dietary product and when there is insufficient exposure to sunlight, it has to be taken in diet thus it is a vitamin.

#### 1. Sources

- Mainly formed by action of UV rays on 7-DHC in SKIN
- First hydroxylated in Liver to 2-5 HCC which is main storage and circulatory form of vitamin D
- Later hydroxylated again in Kidney to 1,25 DHCC (calcitriol)
- Ergocalciferol (D<sub>2</sub>) is found mainly in plants
- Fish and poultry – cod liver oil, shark liver oil & egg yolk
- Fats and edible oils: ghee and Butter



#### 2. Requirement

- Adults: 2.5 $\mu$ g
- Lactating mother, pregnancy, adolescent and infants: 5 $\mu$ g
- 1 $\mu$ g = 40 I.U

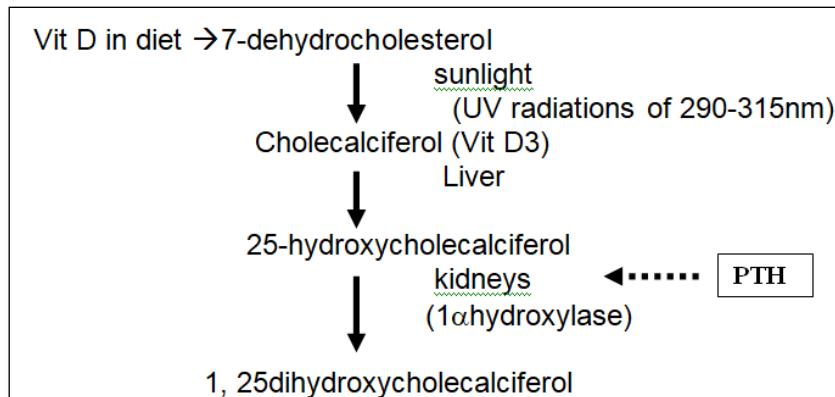
#### 3. Two major forms of vitamin D

- Vitamin D<sub>2</sub> : Ergocalciferol
- Vitamin D<sub>3</sub> : Cholecalciferol

Other forms:

- Vitamin D<sub>1</sub> : Ergocalciferol with Lumisterol
- Vitamin D<sub>4</sub> : 22- Dihydroergocalciferol
- Vitamin D<sub>5</sub> : Sitocalciferol

#### 4. Production & its metabolism



#### 5. Action of vitamin D

- Main action of vitamin D is to increase the plasma level of calcium
- It has 3 target sites:

Intestine	Kidney	Bone
<ul style="list-style-type: none"> <li>• Increases calcium absorption by acting over the mucosal cells to form messenger RNA</li> <li>• This mRNA then forms calcium binding proteins resulting into increase calcium absorption</li> </ul>	<ul style="list-style-type: none"> <li>• It is a weaker site of action of vitamin D.</li> <li>• Vitamin D increases renal reabsorption of calcium</li> </ul>	<ul style="list-style-type: none"> <li>• Vitamin D receptors are present on osteoblast cells and not on osteoclast cells.</li> <li>• However, vitamin D in sufficient amount increases resorption of bone by stimulating recruitment and fusion of cells precursor to active osteoblasts.</li> <li>• Thus, vitamin D increases bone resorption</li> </ul>

#### Absorption

- Bile is necessary for absorption in jejunum
- Transported in lymph chylomicrons

- Excreted mainly in faeces with aid of bile salts

## 6. Vitamin D deficiency

i. Vitamin D deficiency in children	ii. Vitamin D deficiency in adults
<ul style="list-style-type: none"> <li>It causes <u>Rickets</u> affecting the long bone in the body</li> <li>It occurs due to failure in mineralization because of lack of calcium levels</li> <li>Thus, cartilaginous form of bone persist</li> <li><u>Craniotabes</u>: Localized area of thinning, finger pressure causing indentation</li> <li>Extremities: <u>Short stature and bowing of legs</u></li> <li>Head: <u>Frontal bossing</u> and squared appearance</li> <li><u>Ricketic Rosary</u>: Over growth of cartilage or osteoid tissue at costochondral junction</li> <li><u>Pigeon Breast</u>: Weakened ribs bend inwards due to pull of respiratory muscles creating anterior protrusion of sternum</li> </ul>	<ul style="list-style-type: none"> <li>It causes <u>osteomalacia</u></li> <li>It mainly affects the flat bones of the body</li> <li>It occurs due to decrease dietary intake of calcium or decreased exposure to sunlight</li> <li><u>Bone pain and muscle weakness</u></li> <li>Increased fracture tendency, waddling gait, tetany</li> <li>Increased <u>incidence of periodontitis</u> (Taylor and Day et al)</li> <li><u>Pseudofracture</u>: Partial or complete fracture at right angles without displacement</li> <li><u>Lamina Dura</u>: Thin or may be absent</li> </ul>

### Oral manifestations

- Enamel hypoplasia (may be mottled and yellowish-gray in colour), delayed eruption
- Delayed eruption
- Misalignment of teeth
- Increased caries index
- Wide predentin zone and more interglobular dentin
- Large, high pulp horns & delayed closure of apices

## II. Vitamin A

- Vitamin A is essential nutrient required for small amount for normal functioning of the visual system, maintenance of cell function for growth, red blood cell production & epithelial integrity

1. Different forms	2. Sources
<ul style="list-style-type: none"> <li>Active forms: Retinol, Retinal, Retinoic acid</li> <li>Beta Carotene and other carotenoids are precursors or provitamins</li> <li>Beta Carotene yields two molecules of vitamin A</li> </ul>	<ul style="list-style-type: none"> <li>Retinol is found in foods of animal origin, while carotene is found in both plant and animal sources.</li> <li>Cereals and pulses: Red gram, soya beans</li> <li>Vegetables: Carrots, green leafy vegetables and spinach</li> <li>Fruits: Papaya, tomato, mango and raspberries</li> <li>Animal sources: Sheep liver, cow's milk, fish liver oils</li> <li>Fats and edible oils: Butter, hydrogenated oil and ghee</li> </ul>

### 3. Functions

- Epithelium*: Maintains the integrity of skin and mucosa
- Structural integrity*: Maintains normal permeability of cell membrane and organelles
- Bone and teeth*: Accelerates normal formation
- Vision*: Has important role in forming rhodopsin in Wald's visual cycle
- Oxygenation*: Increases permeability of capillaries
- Aging*: Prevents premature aging
- Synthesis*: Essential for synthesis of glucocorticoids and cholesterol

### 4. Role of vitamin a in oral diseases

- Vitamin A plays an important role in measles, oral leukoplakia, oral submucous fibrosis, growth promotion and wound healing in oral cavity
- Vitamin A deficiency induces epithelial proliferation and maturation defects
- Formation of hyperkeratotic white patches in oral lesions
- Have a role in xerostomia, gingivitis & periodontitis

- Retinol deficiency can decrease the production of mucin that leads to salivary flow leading to weakened tooth integrity and increase in risk for caries
- It deficiency leads to irregular tubular dentin formation and decreased taste sensitivity
- Teeth: odontogenic epithelium fails to undergo normal differentiation causing hypoplasia
- Increased rate of cell proliferation causes epithelial invasion of pulp
- Distortion of shapes of incisors and molars
- Gingiva becomes hyperplastic and shows keratinization
- Periodontal Tissue: Easily invaded by bacteria causing microabcesses formation
- Salivary Gland: Shows keratinizing metaplasia
- Bone: Retarded rate of formation

### 5. *Hypervitaminosis A* results in,

- Vacuoles and hemorrhages in the dental pulp with deposits of calcium
- Degeneration and disorganization of the odontoblasts with amorphous mineralization of the dentine
- In the incisor teeth, only dentine formation is affected
- Interfibrillar cementing substance is normally reduced
- Atrophy of Lingual odontoblasts

### III. Vitamin E

- It is also known as “Tocopherol”
- Anti- aging factor and anti-oxidant
- Least toxic of all vitamins
- Destroyed by UV light

#### 1. Sources

- Vegetable oils: wheat germ, sunflower, safflower and soyabean oils
- Whole grain cereals
- Animal meat and eggs

#### 2. Daily requirements

- Men: 8-10 mg
- Women: 5-8 mg

### 3. Functions

- **Anti-oxidant**: prevents free radical damage & maintains cell membrane structure mainly RBC
- Reproduction: **prevents sterility**
- Electric transport system: **acts as a cofactor**
- Healing: prevents excessive scar formation
- Prevents Vitamin A from destruction
- Anti-inflammatory
- Immune mediation

### 4. Deficiency

- Sterility in males and abortion of fetus in females
- Muscle atrophy and pain
- Neuropathies
- Necrosis and fibrosis of heart muscles

### 5. Oral manifestations

- Loss of pigmentation, enamel hypoplasia

## IV. Vitamin K

- It is also known as phyloquinone
- Anti hemorrhagic vitamin
- Destroyed by strong acids and alkalis

1. Forms	2. Sources	3. Requirements
<ul style="list-style-type: none"> <li>• K 1: plants</li> <li>• K 2 : bacteria in human intestine</li> </ul>	<ul style="list-style-type: none"> <li>• Green vegetables like turnip, spinach, broccoli, cabbage</li> <li>• Produced by bacterial flora in gut</li> </ul>	<ul style="list-style-type: none"> <li>• Adults: 70-140 mcg</li> <li>• Children: 35 - 75 mcg</li> </ul>

### 4. Functions

- Synthesis - Necessary for hepatic synthesis of coagulation factors 2, 7, 9, 10
- Oxidative phosphorylation: Cofactor
- Deficiency
- Tendency to bleed profusely
- Oral : Gingival bleeding

## ROLE OF VITAMINS IN ORAL TISSUES (SUMMARY)

### I. Vitamin A

- Teeth: odontogenic epithelium fails to undergo normal differentiation causing hypoplasia
- Increased rate of cell proliferation causes epithelial invasion of pulp
- Distortion of shapes of incisors and molars
- Increased caries susceptibility and delayed eruption
- Gingiva becomes hyperplastic and shows keratinization
- Periodontal Tissue: Easily invaded by bacteria causing microabcesses formation
- Salivary Gland: Shows keratinizing metaplasia
- Bone: Retarded rate of formation

**Hypervitaminosis A** in oral tissues results in,

- Vacuoles and hemorrhages in the dental pulp with deposits of calcium
- Degeneration and disorganization of the odontoblasts with amorphous mineralization of the dentine
- In the incisor teeth, only dentine formation is affected
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- Atrophy of Lingual odontoblasts

### II. Vitamin D

- Enamel hypoplasia (may be mottled and yellowish-gray in colour), delayed eruption
- Delayed eruption
- Misalignment of teeth
- Increased caries index
- Wide predentin zone and more interglobular dentin
- Large, high pulp horns & delayed closure of apices

**Hypervitaminosis D** on oral tissues results in,

- Decreased incisor growth
- Occurrence of pulpal stone
- Hypercementosis
- Ankylosis due to thickened cementoid
- Alterations in pulpal dentin
- Hemorrhage in periodontal membrane
- Atrophy of enamel organ

### III. Vitamin C

- Mainly affects gingiva and periodontium
- Interdental and marginal gingiva is bright red, swollen
- In fully developed, it becomes boggy, ulcerated and bleeds easily
- Loss of periodontal attachment and alveolar bone leads to loosening of teeth
- Fetid Odor

### IV. Vitamin E (Tocopherol)

- Loss of pigmentation
- Enamel hypoplasia

### V. Vitamin B12 (Cyanocobalamin)

- Painful tongue, fiery red
- Hunter's or Moeller's glossitis
- Shallow ulcers with atrophy of papillae
- Discomfort in wearing dentures

### VI. Vitamin B9 (Folic Acid)

- Atrophied filiform papillae
- Ulcerative stomatitis
- Swelling and redness of lips

### VII. Vitamin B3 (Niacin)

- Mucosa becomes fiery red and painful
- Filiform papillae disappears, fungiform papillae may enlarge (Bald tongue of Sandwith)
- Tongue becomes red, swollen and beefy
- Angular cheilitis
- Tenderness, pain and ulceration begin at interdental papillae
- Superimposed ANUG or Vincent's infection

### VIII. Vitamin B2 (Riboflavin)

- Glossitis, atrophic filiform papillae, engorged fungiform papillae & Magenta colored tongue
- Lips - Angular cheilitis

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3. R. Murray, Peter A. Mayes, Victor W. Rodwell and Daryl K. Harper's biochemistry 25th edition. McGraw-Hill, Health Profession Division, New York, 225.
4. Ghosh A, Pallavi SK, Nagpal B, Hegde U, Archana S, Nagpal J. Role of vitamins in oral health & disease: an overview. Indian journal of applied research 2015;5(12):292-5
5. Shaik PS, Pachava S. The role of vitamins and trace elements on oral health: A systematic review. Int J Med Rev 2017;4(1):22-31

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*Please Give Your Feedback on this Answer*

**Role of vitamin D in metabolism (10M)**

**Role of calcium in elderly patients (20M)**

**Calcium and phosphate metabolism (7M)**

**Calcium metabolism and prosthodontic complications (7M)**

**Calcium metabolism (20M)**

**Role of vitamin D in controlling plasma calcium coordination (10M)**

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  - Phosphate
- Daily requirements
- Dietary sources
- Functions of calcium
- Functions of phosphate
- Factors effecting absorption of calcium and phosphate
  - Factors affecting mucosa cells:
  - Factors influencing calcium absorption in the gut
- Concept of calcium balance
- Hormonal control of calcium and phosphate metabolism
  - Vitamin D
  - PTH
  - Calcitonin
- Other hormones affecting calcium metabolism
  - Growth Hormone
  - Insulin:
  - Testosterone
  - Estrogen
  - Osteoporosis
  - Placental lactogen and prolactane
  - Thyroid hormone:

- Clinical implications:
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MDS Made Easy

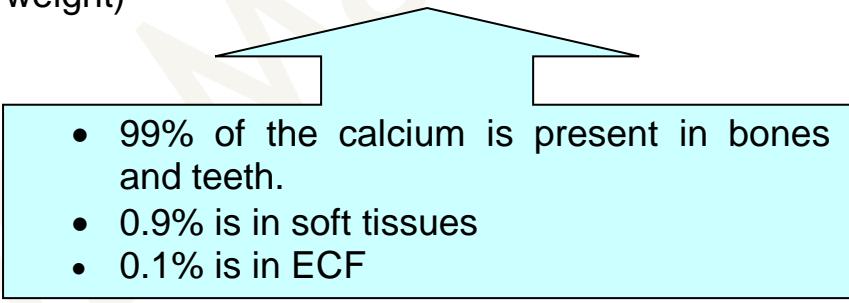
## INTRODUCTION

- Minerals are necessary for the normal growth of human body. Depending upon their daily requirements they are classified into
  - Macro elements: Required amount is greater than 100 mg.
  - Micro elements (Trace elements): Required amount is less than 100mg.
- Both calcium and phosphate are macro elements as they are required in an amount greater than 100mg
- The minerals in foods do not contribute directly to energy needs but are important as body regulators and as essential constituents in many vital substances within the body
- Calcium and phosphate individually have their own functions and together they are required for the formation of hydroxyapatite and physical strength of the skeletal tissue

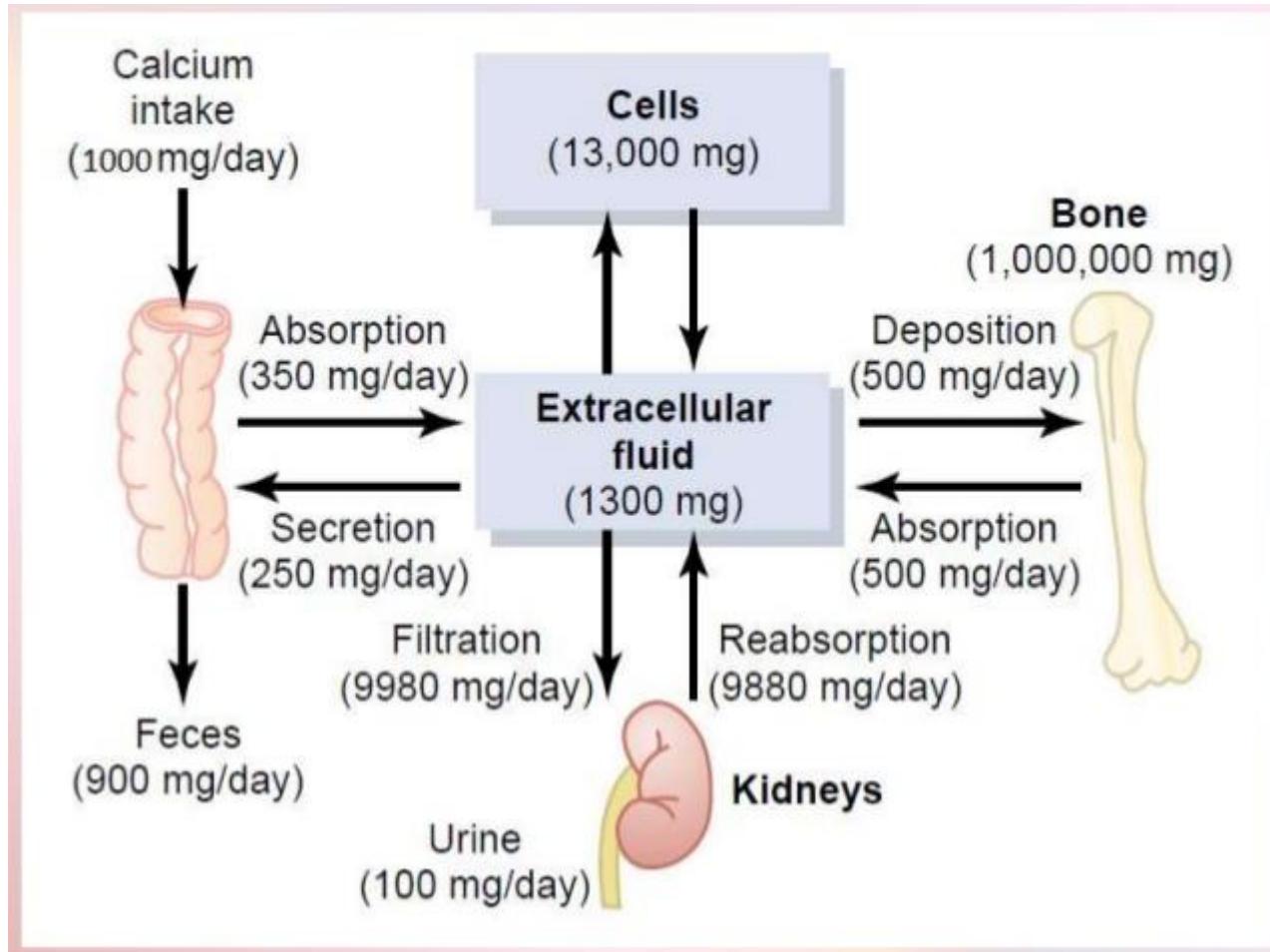
## DISTRIBUTION

### I. Calcium

- Total amount of calcium present in the body : 1100 to 1200 grams (about 1.5% of the total body weight)

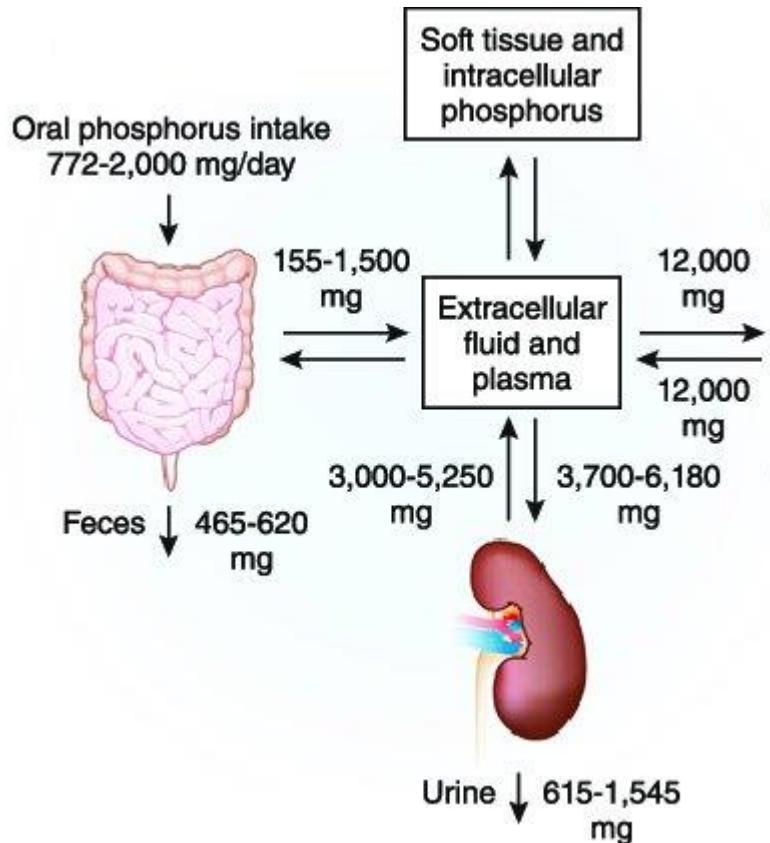
- 
- 99% of the calcium is present in bones and teeth.
  - 0.9% is in soft tissues
  - 0.1% is in ECF

- The serum level of calcium is closely regulated with normal total calcium of 9-10.5 mg/dL and normal ionized calcium of 4.5-5.6 mg/dL
- It is present in ionized and non-ionized form.
- Ionized calcium is a diffusible form of calcium, biologically active and is about 5mg/dL in concentration
- Non-ionizable calcium is about 4.5mg/dL and is bounded to plasma proteins i.e. albumin 4.0mg /dL, Globulin 0.5mg/dL. It is the biologically inactive form



## Phosphate

- Total amount of phosphate present in the body is about 500-800mg
  - 85% of this is present in bones and teeth
  - 15% is present in liver, pancreas and brain
- Plasma level of phosphate is 2.5-4.5mg /dL -
  - Organic form(phospholipids, glycerophosphates)
  - Inorganic form (hydroxyapatite)
- Calcium: Phosphate ratio normally is 2:1.
- Increase in plasma calcium levels causes corresponding decrease in absorption of Phosphate
- This ratio is always constant



## DAILY REQUIREMENTS

	Calcium	Phosphate
<b>Infants</b>	360 mg/day	240 mg/day
<b>Adolescents</b>	-	1200mg/day
<b>Adults</b>	500 - 800 mg/day	500 - 800 mg/ day
<b>Lactating mother</b>	2000 mg/ day	1200 mg/ day
<b>Pregnancy</b>	1500mg/ day	1200mg/ day
<b>Children</b>	800 mg/ day	

## DIETARY SOURCES

- The richest dietary source is the milk and milk products
- Other dietary sources include – Egg, fish, Vegetables, fruits (orange), Fortified bread, hard water, nuts
- Dietary source of phosphate is similar to calcium
- However, they are present in greater amount in cereals and pulses and are absent in hard water

## FUNCTIONS OF CALCIUM & PHOSPHATE:

Calcium	Phosphate
<ul style="list-style-type: none"> <li>Contributes to <u>hardness of bone</u></li> <li>Major component of <u>microstructure of teeth</u></li> <li>Stabilizing <u>cell membrane and permeability</u></li> <li>Maintains <u>excitability of nerves and muscles</u></li> <li>SA node of heart depends upon calcium for its pacemaker potential</li> <li>Acts as a <u>secondary messenger</u></li> <li>Neurotransmitter release</li> <li><u>Synthesis of nucleic acid and proteins</u></li> <li>Maintenance of <u>tight junctions</u> between cells</li> <li><u>Clotting of blood</u></li> <li>Production of milk</li> <li><u>Activation of enzymes</u> like – ATPase, succinate dehydrogenase, lipase</li> </ul>	<ul style="list-style-type: none"> <li><u>Formation of bone</u></li> <li>Important component of <u>microstructure of teeth</u></li> <li>Essential <u>constituent of all cells</u> (nucleoproteins, nucleus, phospholipids)</li> <li>Provides energy rich <u>bonds in ATP</u> and plays important role for muscle contraction</li> <li><u>Regulate pH</u> of blood and urine</li> <li>Form co-enzyme (pyridoxal phosphate)</li> <li><u>Important part of organic molecules</u> (DNA and RNA)</li> </ul>

## FACTORS AFFECTING ABSORPTION OF CALCIUM AND PHOSPHATE:

- The amount of calcium absorption is negligible as compared to the other components of diet as manufactures affect its absorption from the gut.
- These factors are classified as:

### 1. Factors affecting mucosa cells:

- Vitamin D
- Effect of previous calcium intake and calcium stores in the body
- Pregnancy and growth
- Parathyroid hormone (PTH)

**1. Vitamin D**

- Its active form 1, 25 DHCC acts on the mucosal cells and results into the formation of mRNA which in turn forms calcium binding proteins that absorbs calcium from the gut

**2. Previous dietary intake and calcium stores**

- Greater the dietary intake of calcium, greater the absorption
- He concluded that greater the body stores of calcium, lesser would be the calcium absorption from the gut

**3. Pregnancy and growth**

- During later stages of pregnancy, greater amount of calcium absorption is seen
- 50% of this calcium is used for the development of fetal skeleton and the rest is stored in the bones to act as a reserve for lactation
- This is due to the increased level of placental lactogen and estrogen which stimulates increased hydroxylation of vitamin D
- In growth there is an increased level of growth hormone. GH acts by increasing calcium absorption
- It also increases the renal excretion of calcium and phosphates. However the net effect is a positive calcium balance

**4. Para thyroid hormone**

- It does not act directly but indirectly by stimulating the formation of 1, 25 DHCC which in turn increases calcium absorption from the gut

**II. Factors influencing calcium absorption in the gut.**

- pH of intestine
- Amount of dietary calcium and phosphates
- Phytic acid and phytates
- Effect of oxalates
- Effect of fat
- Effect of proteins and amino acids
- Effect of carbohydrates
- Bile salts

<b>1. pH of intestine</b>	<ul style="list-style-type: none"> <li>• Acidic pH in the upper intestine (duodenum) increases calcium absorption by keeping calcium salts in a soluble state</li> <li>• In lower intestine since pH is more alkaline, calcium salts undergo precipitation</li> </ul>
<b>2. Amount of dietary calcium and phosphates</b>	<ul style="list-style-type: none"> <li>• Increased level of calcium and phosphate in diet increases their absorption however up to a certain limit</li> <li>• This is because the active process of their absorption can bear with certain amounts of load beyond which the excess would pass out into faeces</li> </ul>
<b>3. Phytic acid and phytates</b>	<ul style="list-style-type: none"> <li>• They are present in oatmeal, whole meat and cereals and are considered anti-calcifying factors as they combine with calcium in the diet thus forming insoluble salts of calcium</li> </ul>
<b>4. Oxalates</b>	<ul style="list-style-type: none"> <li>• They are present in spinach and rhubarb leaves</li> <li>• They form oxalate precipitates with calcium present in the diet thus decreasing their availability</li> </ul>
<b>5. Fats</b>	<ul style="list-style-type: none"> <li>• They combine with calcium and form insoluble calcium soaps, thus decreasing calcium absorption</li> </ul>
<b>6. Bile salts</b>	<ul style="list-style-type: none"> <li>• They increase calcium absorption by promoting metabolism of lipids</li> </ul>
<b>7. Protein and aminoacids</b>	<ul style="list-style-type: none"> <li>• High protein diet increases calcium absorption as protein forms soluble complexes with calcium and keeps calcium in a form that is easily absorbable</li> </ul>
<b>8. Carbohydrates</b>	<ul style="list-style-type: none"> <li>• Certain carbohydrates like lactose promotes calcium absorption by creating the acidity in the gut as they favour the growth of acid producing bacteria</li> </ul>

## CONCEPT OF CALCIUM BALANCE

- Net gain or loss of calcium from the body over a specified period of time is called calcium balance

Calculated by reducing the amount of calcium present in faeces and urine from the calcium present in the diet

- In growing children there is a positive calcium balance as calcium is stored in the body
- However, in aging individuals there is a negative calcium balance as calcium is lost from the body

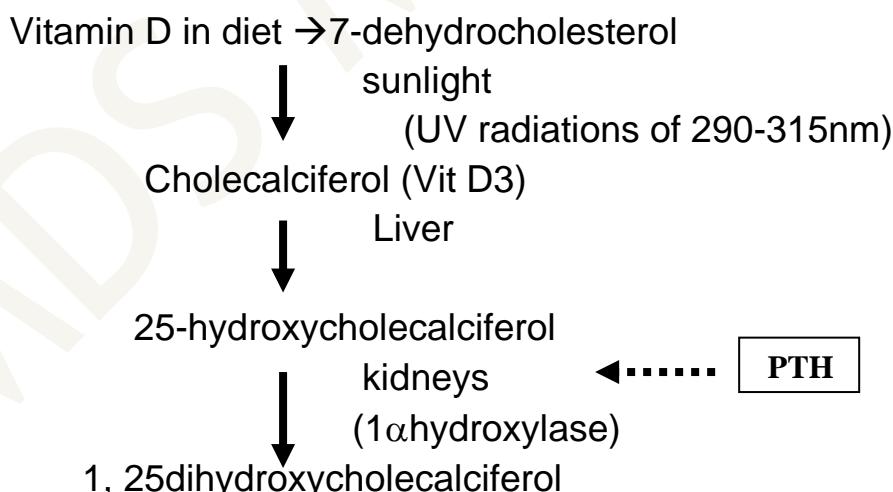
## HORMONAL CONTROL OF CALCIUM AND PHOSPHATE METABOLISM

Three hormones regulate the calcium and phosphate metabolism

1. Vitamin D.
  2. PTH
  3. Calcitonin – Minor regulators
- Major regulators

### I. Vitamin D:

- Also called as cholecalciferol
- Though it is a vitamin but still can be called as a hormone as it is synthesized by the skin when exposed to sunlight
- However, it is still a vitamin as it is first detected and isolated in dietary product and when there is insufficient exposure to sunlight, it has to be taken in diet thus it is a vitamin.



1. Requirement	2. Dietary source
<ul style="list-style-type: none"> <li>Adults: 2.5µg.</li> <li>Lactating mother, pregnancy, adolescent and infants: 5µg.</li> <li>1µg = 40 I.U.</li> </ul>	<ul style="list-style-type: none"> <li>Cod liver oil</li> <li>Fish (Salmon)</li> <li>Egg and liver</li> </ul>

### 3. Actions:

Main action is to increase the plasma level of calcium

3 target sites:

**Intestine:** increases calcium absorption by acting over the mucosal cells to form messenger RNA which then forms calcium binding proteins resulting into increase calcium absorption

**Kidney:** It is a weaker site of action of vitamin D and increases renal reabsorption of calcium

**Bone:** Vitamin D receptors are present on osteoblast cells and not on osteoclast cells. However, vitamin D in sufficient amount increases resorption of bone by stimulating recruitment and fusion of cells precursor to active osteoblasts. Thus, increasing bone resorption

## II. Para thyroid hormone (PTH)

- Secreted by parathyroid gland
- Histologically parathyroid gland contains 2 types of cells.
  - Chief cell forms PTH hormone.
  - Oxyphilic cells which replaces chief cells and also stores hormones

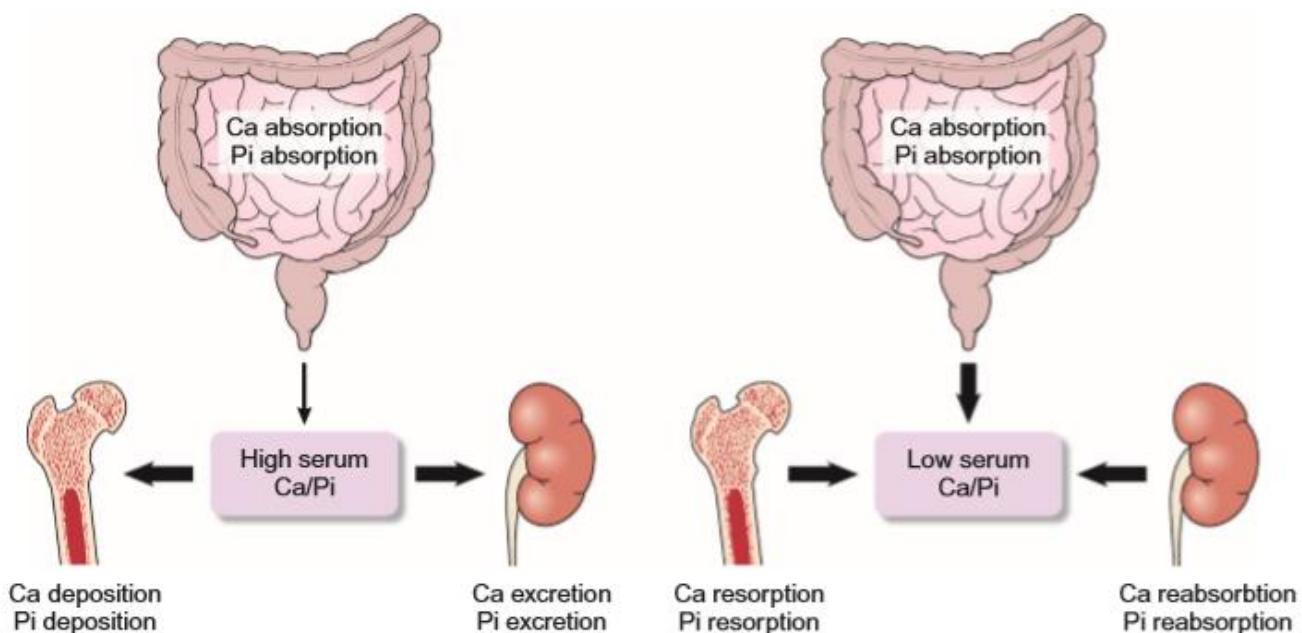
### 1. Action

- Increases plasma calcium level at its target sites:

**Bone**

PTH accelerates removal of calcium from bone by 2 process:

- Stimulating osteolysis** in which calcium ions travel from bone fluid to outer cell membrane to extracellular fluid (ECF). No release of phosphate takes place.
- It **stimulates osteoclast to resorb completely mineralized bone**, leads to release of both calcium and phosphates into ECF



### Kidney

- PTH increases the reabsorption calcium from the distal coronal tubule of the kidney
- It also inhibits the reabsorption of phosphate in proximal coronal tubule of the kidney causing increased phosphate excretion
- PTH also increases the synthesis of vitamin D (1, 25 DHCC) in kidney

### Intestine

- No direct effect of PTH on intestine. However, indirectly it acts by stimulating the formation of 1, 25 DHCC which in turn increases the calcium and phosphate absorption in the intestine
- The stimulatory effect for PTH secretion is the low calcium level in plasma
- The maximum secretion occurs when plasma calcium level falls below 7mg/ dL
- When plasma calcium level increases to 11mg/dL – it causes decrease in secretion of PTH as calcium influx suppresses the chief cell secretion

## OTHER HORMONES AFFECTING CALCIUM METABOLISM

### I. Growth Hormone:

- Increases absorption of calcium in the intestine and also increases excretion in urine. However, there is a positive calcium balance.
- Stimulates protein synthesis in bone by producing insulin like growth factor.
- It also forms stomatomedin C which acts on cartilage and increases the length of bone.

### II. Insulin

- It is an anabolic hormone that increases bone growth.

### III. Testosterone

- Acts on cartilage and results in the increased growth of bone.
- It also causes the appearance of secondary sex characters like thickening of supraorbital ridge, increased mandibular growth and prognathism

### IV. Estrogen

- There is a balance between calcium deposition and mobilization
- However, after menopause estrogen secretion decreases and thus this equilibrium shift towards mobilization and loss of calcium from bone leading to osteoporosis

### V. Osteoporosis

- It is a most common bone disorder in old age
- Characterized by parallel loss of minerals and organic matrix
- Thus, decreasing bone mass and increasing the incidence of fractures
- Caused by decreased physical activity and decreased calcium and vitamin D intake in the diet.
- Most commonly seen in menopausal women (ten times more than men)

### VI. Placental lactogen and prolactin

- Both placental lactogen (during later stages of pregnancy) and prolactin (during lactation) causes increase hydroxylation of vitamin D- increases plasma calcium and phosphate levels.

### VII. Thyroid hormone

- In infants it causes stimulation of bone growth.
- In adults – it causes increased bone metabolism thus favouring calcium mobilization resulting into hypercalcemia and hypercalciuria
- It may predispose to osteoporosis

## CLINICAL IMPLICATIONS

I. Hypercalcemia	II. Hypocalcemia
<ul style="list-style-type: none"> <li>It is the increased level of calcium in the blood.</li> <li>It can be caused by diseases like: <ul style="list-style-type: none"> <li>Hyperparathyroidism.</li> <li>Acute osteoporosis.</li> <li>Vitamin D intoxication.</li> <li>Thyrotoxicosis.</li> </ul> </li> </ul> <p><b>Symptoms</b></p> <ul style="list-style-type: none"> <li>Tiredness, loss of appetite, nausea, vomiting, polyuria, dehydration, loss of muscle tone, etc.</li> </ul>	<ul style="list-style-type: none"> <li>It is the decreased level of calcium in the blood (below 4mg is fatal).</li> <li>It may be caused by: <ul style="list-style-type: none"> <li>Insufficient calcium intake in diet.</li> <li>Hypoparathyroidism.</li> <li>Insufficient vitamin D intake.</li> <li>And increased level of calcitonin.</li> </ul> </li> </ul> <p><b>Symptoms</b></p> <ul style="list-style-type: none"> <li>Tetany (carpopedal spasm)</li> </ul>

### Chvostek's sign

- Contraction of ipsilateral facial muscles when facial nerve is tapped at the angle of the jaw.

### Trousseau sign

- The spasm of the muscles of the upper extremity causing flexion of wrist and thumb and extension of fingers.
- It may be produced clinically by applying sphygmomanometer cuff on the upper arm to more than the systolic blood pressure.

- Erbs sign:** Hyperexcitability of muscles to electrical stimulation

### III. Vitamin D deficiency:

- Vitamin D deficiency in children causes Ricketts – it affects the long bone in the body
- It occurs due to failure in mineralization because of lack of calcium levels
- Thus, cartilaginous form of bone persist

**Dental findings:**

- Developmental anomalies of enamel and dentin
- Delayed eruption
- Misalignment of teeth
- Increased caries index
- Wide predentin zone and more interglobular dentine

**Vitamin D deficiency in adults causes osteomalacia**

- It mainly affects the flat bones of the body.
- It occurs due to decrease dietary intake of calcium or decreased exposure to sunlight.

<b>IV. Hyperparathyroidism</b>	<b>V. Hypoparathyroidism</b>
<ul style="list-style-type: none"><li>• Increased level of PTH due to adenoma of the PT gland.</li></ul> <p><b>Clinical manifestations:</b> bone pain, joint stiffness, pathological fractures, increased incidence of urinary tract stones etc</p>	<ul style="list-style-type: none"><li>• It involves low levels of PTH may be caused by surgical excision of PT gland, atrophy of the gland due to thrombosis of the blood vessels supplying the gland or congenital abscess.</li><li>• It can be diagnosed by decreased level of calcium in plasma and increased level of phosphate level.</li></ul> <p><b>Clinical manifestations:</b> hyperactive reflexes, spontaneous muscular contraction, convulsions, and laryngeal spasm.</p>

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*Please Give Your Feedback on this Answer*

**Give a short account of degenerative changes that occur in mandible due to ageing (10M)**

## CONTENTS/SYNOPSIS

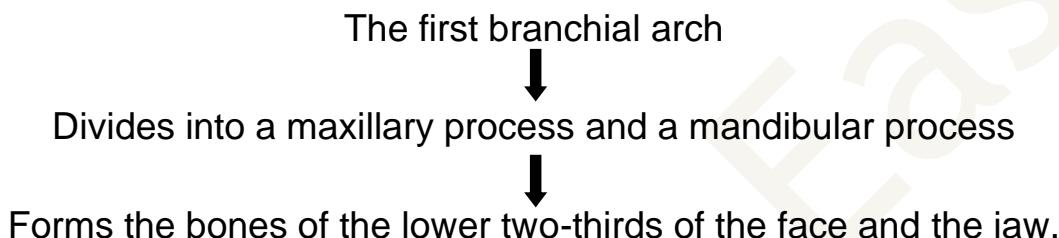
- Introduction
- Development of mandible
  - Meckel's cartilage
  - Development of Body
  - Development of Ramus
  - Fate of Meckel's cartilage
  - Further Development
    - Condylar cartilage
    - Coronoid cartilage
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  - Development of alveolar process
- Growth of mandible
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  - Development of the alveolar process
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- Clinical Considerations
  - Developmental disturbances
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## INTRODUCTION

- Mandible is the largest and strongest bone of the face, serves for the reception of the lower teeth.
- Parts of mandible: body which meets in midline at symphysis, 2 rami, 2 condylar heads, 2 coronoid processes.

## DEVELOPMENT OF MANDIBLE

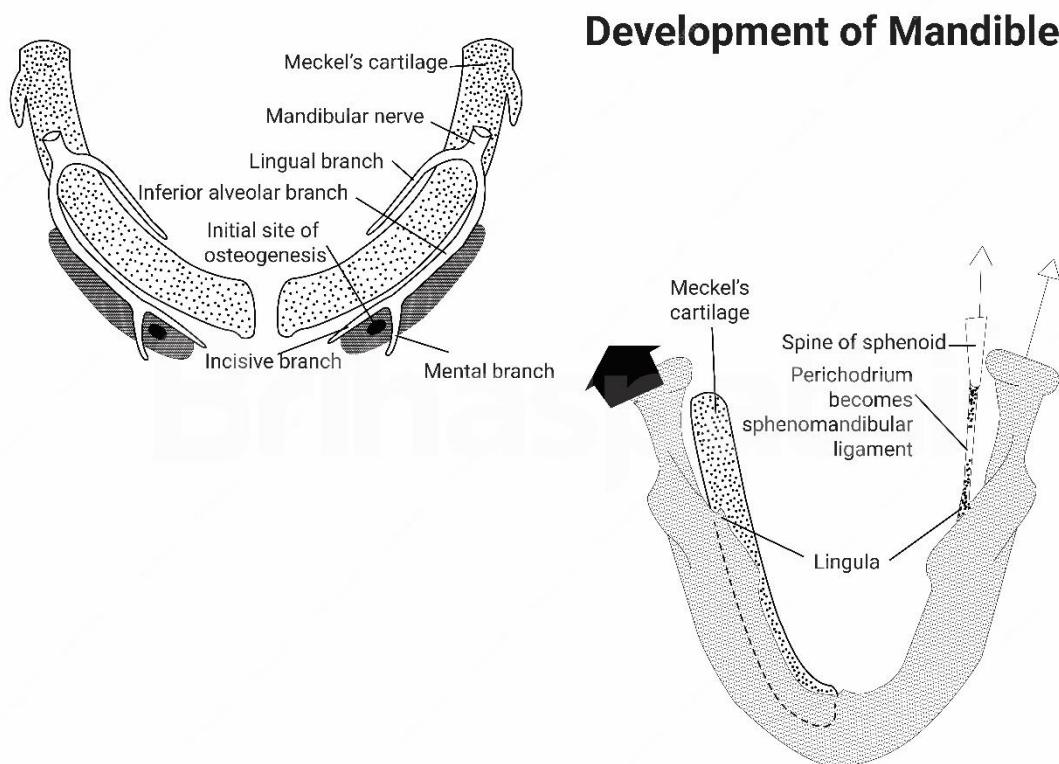
- About the fourth week of intrauterine life, the pharyngeal arches are laid down  
→ The first arch is called the mandibular arch.



- The maxillary process becomes the maxilla (or upper jaw), and palate while the mandibular process becomes the lower jaw.
- The first structure to develop in the primordium of the lower jaw is the mandibular division of trigeminal nerve.

### I. Meckel's cartilage:

- It has a close, relationship to the mandibular nerve → at the junction between posterior and middle thirds, where the mandibular nerve divides into the lingual and inferior dental nerve.
- The lingual nerve passes forward, on the medial side of the cartilage, while the inferior dental lies lateral to its upper margins & runs forward parallel to it and terminates by dividing into the mental and incisive branches.



## II. Development of Body:

- At 6 weeks of development, Meckel's cartilage extends as a solid hyaline cartilaginous rod surrounded by a fibrocellular capsule.
- Their proximal or cranial ends are connected with the ear capsules, and their distal extremities are joined to one another at the symphysis by mesodermal tissue.

### Ossification:

- On the lateral aspect of Meckel's cartilage, during the 6th week of embryonic development, a condensation of mesenchyme occurs in the angle formed by the division of inferior alveolar nerve and its incisor and mental branches.
- 7th week → ossification begins at this site
- From this centre of ossification, bone formation spreads rapidly anteriorly to the midline and posteriorly to the point

- Where the mandibular nerve divides into lingual and inferior alveolar branch.

- The new bone forms a trough that consist of medial and lateral plates that unite beneath the nerve.

- The trough is soon converted into a canal as bone forms over the nerve, joining the lateral and medial plates.

### III. Development of Ramus:

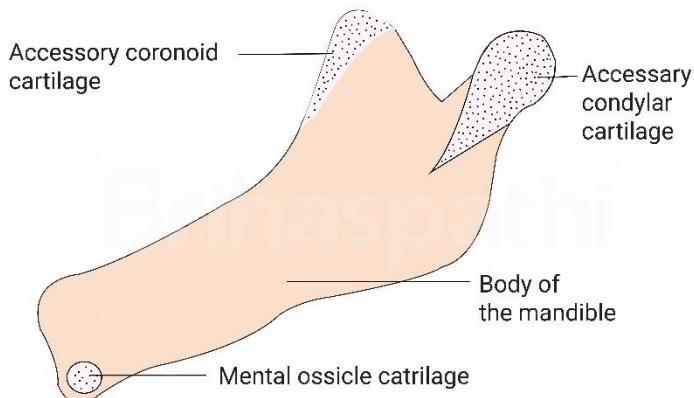
- The ramus of the mandible develops by a rapid spread of ossification backwards into the mesenchyme of the first branchial arch diverging away from Meckel's cartilage.
- This point of divergence is marked by the lingula in adult mandible, where the inferior alveolar nerve enters mandibular foramen.
- By 10 weeks: rudimentary mandible is formed almost entirely by intramembranous ossification.

### IV. Fate of Meckel's cartilage

- Its posterior end forms the malleus and incus of the inner ear and the sphenomalleolar ligament
- Its fibrocellular capsule persists to form the sphenomandibular ligament .
- From the lingula forward to the division of the alveolar nerve into its incisor and mental branches, Meckel's cartilage degenerates.

### V. Further development:

- Influenced by the appearance of 3 secondary cartilages:
  1. Condylar cartilage
  2. Coronoid cartilage
  3. Symphyseal cartilage



### 1. **Condylar cartilage**

- Carrot shaped cartilage
- Appears at 12 weeks of development in the region of the condyle and occupies most of the developing ramus.
- Converted to bone by endochondral ossification
- Develops into Condyle head and neck of the mandible.
- The posterior half of the ramus to the level of inferior dental foramen
- At 20 weeks a thin layer of cartilage remains in the condylar head.

### 2. **Coronoid cartilage**

- It is relatively transient growth cartilage centre
- Appears at 4th month of development
- Develops into Coronoid process and anterior half of the ramus to the level of inferior dental foramen
- Disappears long before birth

### 3. **Symphyseal cartilage**

- 2 in number, appear in the connective tissue between the 2 end of Meckel's cartilage
- They are obliterated within the 1st year after birth.

## VI. Development of alveolar process

Starts when the deciduous tooth germs reach the early bell stage.

Bone begins to grow on each side of the tooth germ

Tooth germs come to be in a trough or groove of bone, which also includes the alveolar nerves and blood vessels.

Septa of bone between the adjacent tooth germs develop

Keep each tooth separate in its bony crypt.

The mandibular canal is separated from the bony crypts by a horizontal plate of bone.

The alveolar processes grow at a rapid rate during the periods of tooth eruption.

## GROWTH OF THE MANDIBLE

Occurs in following ways:

- Growth by secondary cartilage
- Development of the alveolar process
- Subperiosteal bone apposition and bone resorption

### I. Growth by secondary cartilage (mainly condylar cartilage)

- Increase in height of the mandibular ramus
- Increase in the overall length of the mandible
- Increase of the inter condylar distance

### II. Development of the alveolar process

- Due to the increase in the space between the upper and lower jaws a space is created between the opposing teeth to erupt.
- At the same time bone apposition occurs at the crest of the alveolar process and the fundus of the alveolus.
- This means that bone deposition contributes to the growth of the body of the mandible in height.

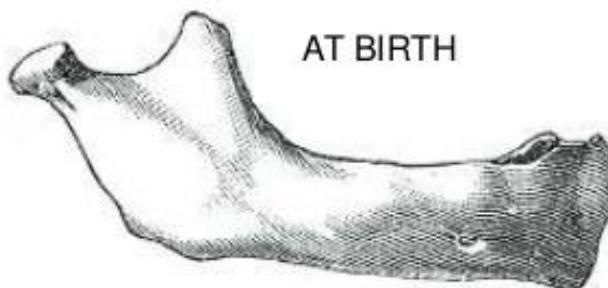
### III. Subperiosteal bone apposition and bone resorption

Bone deposition	Bone resorption	Result
• External surface of the mandible	• Inner surface of the mandible	• Increase the transverse dimension
• Posterior border of the ramus	• Anterior border of the ramus	• Adjust the thickness of the ramus
• Anterior border of the coronoid process	• Posterior border of the coronoid process	• Displacement of the coronoid process
• Chin region	-	• Modeling of the lower face

### AGE CHANGES IN THE MANDIBLE

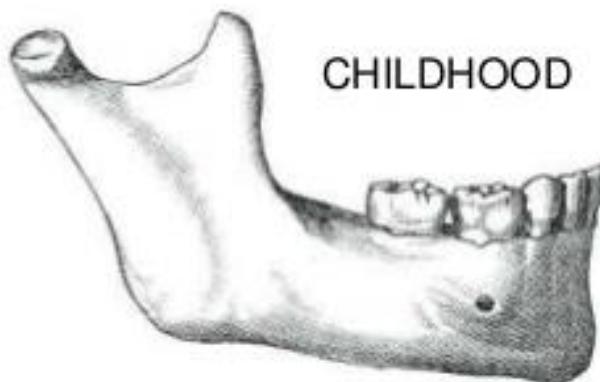
#### I. At birth

1. <b>Body</b>	• Body is a mere shell consisting of sockets of deciduous teeth, partitioned imperfectly
2. <b>Mandibular canal</b>	• Large in size, runs near lower border of the mandible
3. <b>Mental foramen</b>	• Mental foramen opens beneath the socket of the first deciduous molar tooth. • Lies near lower border
4. <b>Angle</b>	• Angle is obtuse ( $175^\circ$ ), and the condyloid portion is nearly in line with the body.
5. <b>Coronoid and condylar process</b>	• Coronoid process is of comparatively large size, and projects above the level of the condyle. • Condyle is in line with the body
6. <b>Symphysis menti</b>	• Present and 2 halves are united by fibrous band



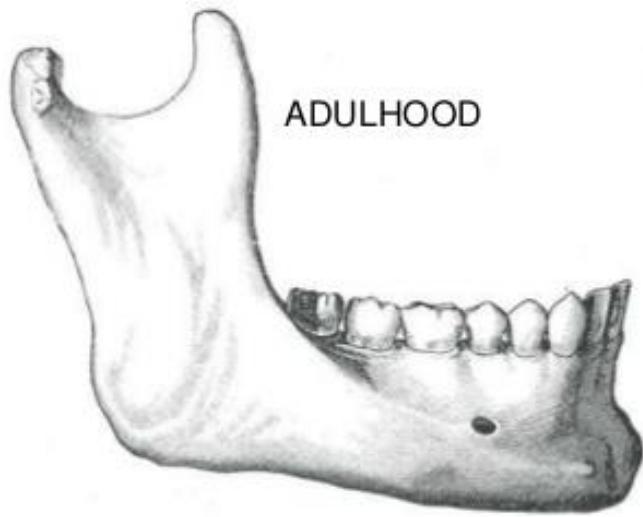
## II. At Childhood

<b>1. Body</b>	<ul style="list-style-type: none"> <li>Body becomes longer especially behind mental foramen, area of fusion of symphysis from below upward</li> </ul>
<b>2. Mandibular canal</b>	<ul style="list-style-type: none"> <li>After the permanent dentition it lies just above the level of mylohyoid line</li> </ul>
<b>3. Mental foramen</b>	<ul style="list-style-type: none"> <li>Opens midway between upper and lower borders of the mandible</li> </ul>
<b>4. Angle</b>	<ul style="list-style-type: none"> <li>Less obtuse due to separation of the jaws by the teeth, <math>140^\circ</math></li> </ul>



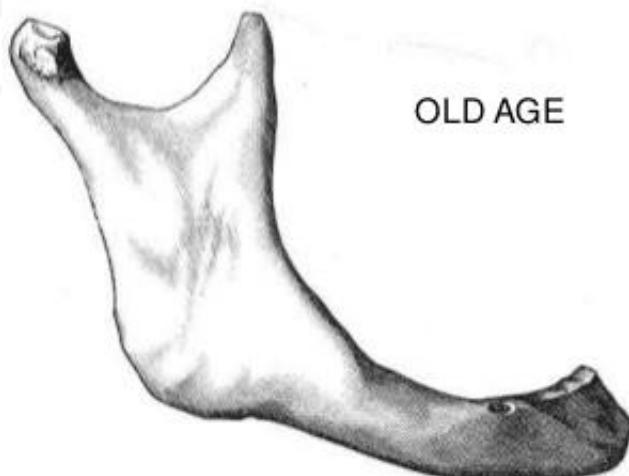
## III. Adulthood

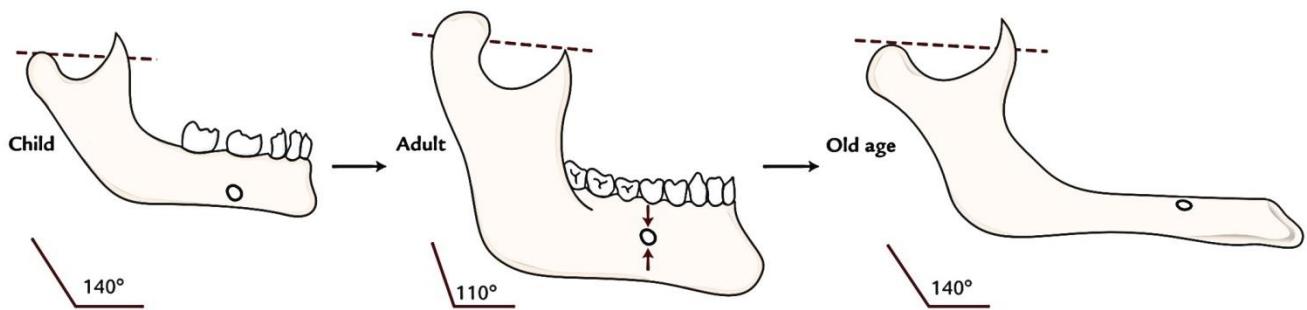
<b>1. Body</b>	<ul style="list-style-type: none"> <li>Body has equal portions of alveolar and sub dental areas</li> </ul>
<b>2. Mandibular canal</b>	<ul style="list-style-type: none"> <li>Parallel to mylohyoid line</li> </ul>
<b>3. Mental foramen</b>	<ul style="list-style-type: none"> <li>Opens at middle of the bone between upper and lower borders of mandible</li> </ul>
<b>4. Angle</b>	<ul style="list-style-type: none"> <li>Almost vertical in direction with an angle <math>110^\circ - 120^\circ</math></li> </ul>
<b>5. Coronoid and condylar process</b>	<ul style="list-style-type: none"> <li>Condyle is above coronoid</li> </ul>
<b>6. Symphysis menti</b>	<ul style="list-style-type: none"> <li>Present as a faint ridge only on upper part</li> </ul>



#### IV. Old age

<b>1. Body</b>	<ul style="list-style-type: none"> <li>Body reduces size greatly.</li> <li>With loss of teeth the alveolar process is absorbed and reduces the height of the mandible</li> </ul>
<b>2. Mandibular canal</b>	<ul style="list-style-type: none"> <li>Run closer to upper border</li> </ul>
<b>3. Mental foramen</b>	<ul style="list-style-type: none"> <li>Near upper border</li> </ul>
<b>4. Angle</b>	<ul style="list-style-type: none"> <li>Oblique in direction (Obtuse) with an angle of <math>140^{\circ}</math></li> </ul>
<b>5. Coronoid and condylar process</b>	<ul style="list-style-type: none"> <li>Condyle is above coronoid</li> </ul>
<b>6. Symphysis menti</b>	<ul style="list-style-type: none"> <li>Absent or not recognizable</li> </ul>





## CLINICAL CONSIDERATIONS

### Developmental disturbances

<b>1. Agnathia</b>	<ul style="list-style-type: none"> <li>• Hypoplasia or absence of mandible</li> <li>• The entire mandible or one side may be missing or only the condyle or the entire ramus.</li> </ul>
<b>2. Micrognathia</b>	<ul style="list-style-type: none"> <li>• Means small jaw</li> <li>• Can be due to small jaw or to an abnormal positioning or abnormal relation of one jaw to another.</li> </ul>
<b>3. Macrognathia</b>	<ul style="list-style-type: none"> <li>• Abnormally large jaws</li> </ul>
<b>4. Facial hemihypertrophy</b>	<ul style="list-style-type: none"> <li>• Exhibits an enlargement which is confined to one side of the body, unilateral macroglossia, and premature development, and eruption as well as increased size of dentition.</li> </ul>
<b>5. Facial hemiatrophy</b>	<ul style="list-style-type: none"> <li>• Progressive wasting of subcutaneous fat accompanied by atrophy of skin, cartilage, bone and muscle.</li> </ul>

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*Please Give Your Feedback on this Answer*

## Oral mucosa (10M)

### Geriatric changes in oral mucosa (10M)

### Microanatomy of oral mucosa (7M)

### Histology of oral mucosa (7M) (6M)

### CONTENTS/SYNOPSIS

- Introduction
- Functions of oral mucosa
- Classification of oral mucosa
  - Based on primary function
  - Based on keratinization
  - Based on location
- Development of oral mucosa
- Structure of oral mucosa
  - Epithelium
    - Structure of ortho keratinized oral epithelium
      - ✓ Stratum basale
      - ✓ Stratum germinatum
      - ✓ Stratum spinosum
      - ✓ Stratum granulosum
      - ✓ Stratum corneum
    - Structure of Para keratinized oral epithelium
    - Structure of non keratinized oral epithelium
  - Lamina propria
  - Submucosa
- Functional type of oral mucosa
  - Masticatory mucosa
  - Lining mucosa
  - Specialized mucosa
- Effects of aging on the oral mucosa
- Prosthetic considerations
  - Oral mucosa under stress
  - Tissue responses

- Changes in the oral mucosa due to prosthesis
- References

MDS Made Easy

## INTRODUCTION

- Oral cavity is the most important part of the human body
- It is lined with an uninterrupted mucosa and continuous anteriorly with the skin near vermillion border of the lips and pharyngeal mucosa posteriorly.

## FUNCTIONS OF ORAL MUCOSA

<b>I. Protection</b>	<ul style="list-style-type: none"> <li>• Acts as a barrier for mechanical trauma and microbial organisms</li> </ul>
<b>II. Sensation</b>	<ul style="list-style-type: none"> <li>• Responds to senses like heat, cold temperatures, touch and pain</li> <li>• Reflexes like swallowing, gagging and salivation are present</li> </ul>
<b>III. Absorption</b>	<ul style="list-style-type: none"> <li>• Sublingually nitrates are absorbed</li> </ul>
<b>IV. Secretion</b>	<ul style="list-style-type: none"> <li>• Consists of minor salivary glands which creates a moist oral environment and helps in mastication, speech, swallowing and in taste perception</li> </ul>
<b>V. Excretion</b>	<ul style="list-style-type: none"> <li>• Helps in excretion of certain metabolites</li> </ul>
<b>VI. Esthetics</b>	<ul style="list-style-type: none"> <li>• Thickness of mucosa enhances lips and gingiva, provides for facial esthetics</li> </ul>

## CLASSIFICATION OF ORAL MUCOSA

### I. Based on primary function

- Masticatory mucosa
- Lining mucosa
- Specialized mucosa

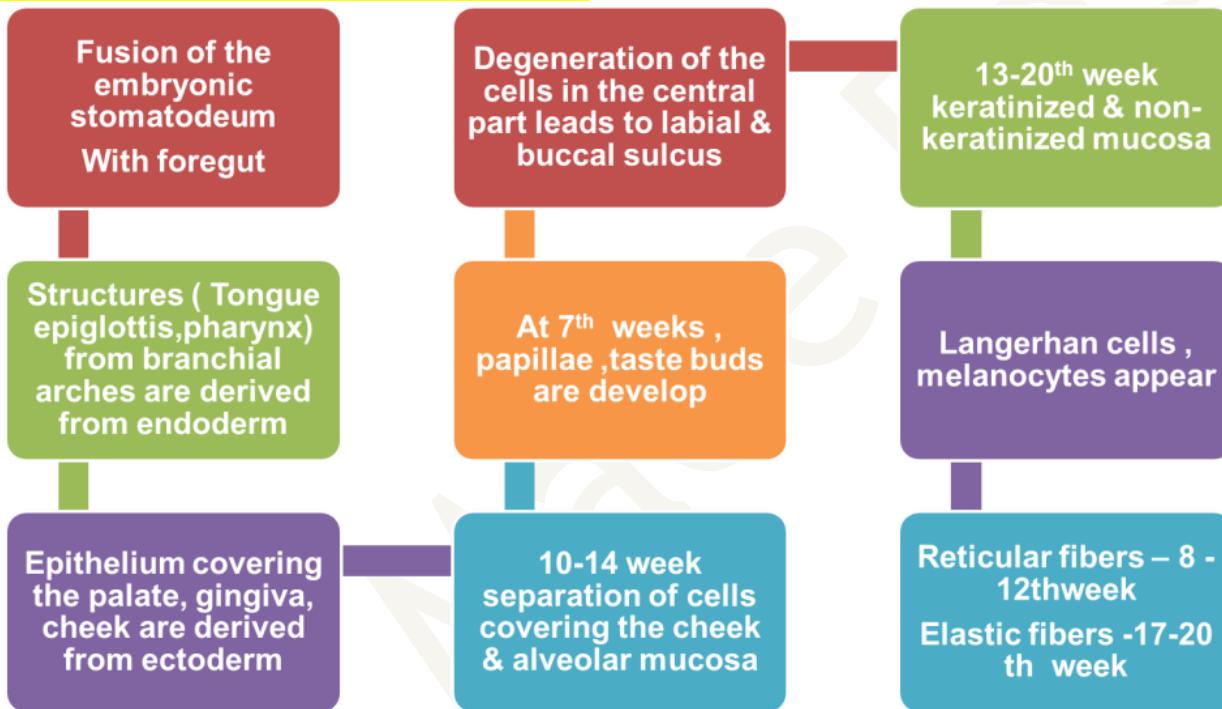
### II. Based on keratinization

- Keratinized
  - Ortho keratinized
  - Para keratinized
- Non keratinized

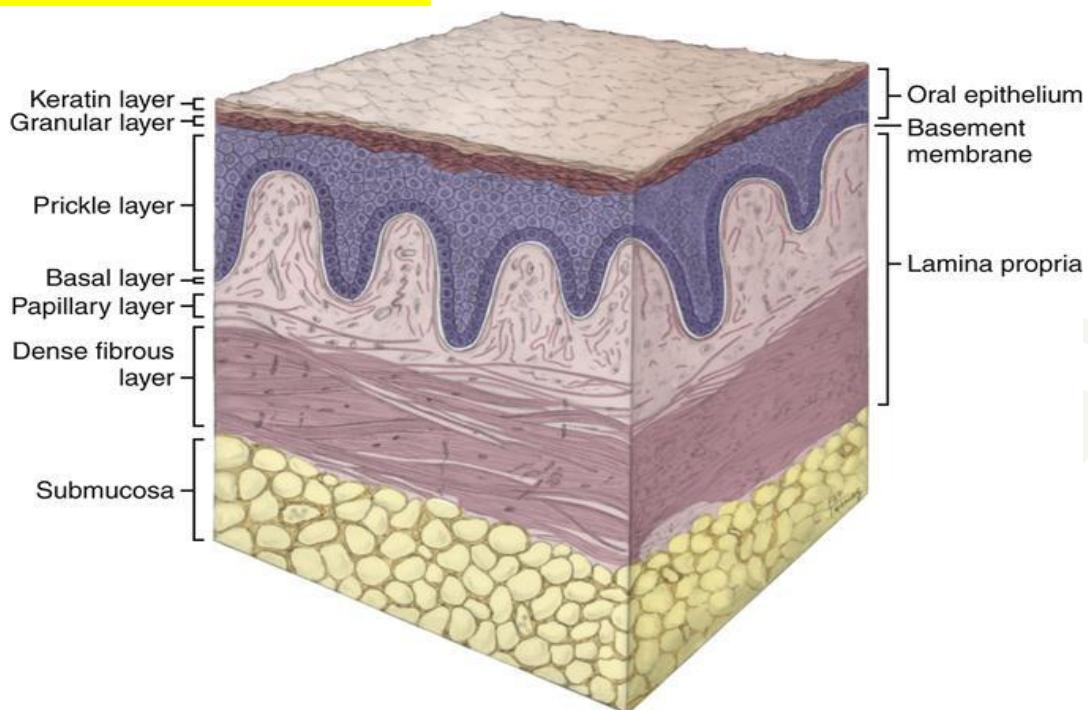
### III. Based on location

- Buccal mucosa
- Lingual mucosa
- Palatal mucosa
- Labial mucosa
- Alveolar mucosa

## DEVELOPMENT OF ORAL MUCOSA



## STRUCTURE OF ORAL MUCOSA



### I. Epithelium

- Consists of two population of cells

Progenitor population

Stem cells & Amplifying cells: Divides and provide new cells

Maturing population

Forms a protective layer by constantly undergoing maturation

#### Turnover time:

- Skin: 52 - 75 days
- GIT: 4 - 14 days
- Gingiva: 41 - 57 days
- Cheek: 25 days
- Junctional epithelium: 5 - 6 days

- The oral epithelium is either keratinized or non-keratinized.

Keratinization:

- It is the process in which the cytoplasm of the outermost cells of the mammalian mucosa is replaced by a structural protein called keratin
- It takes place in stratum corneum layer

Physiology of keratinization:

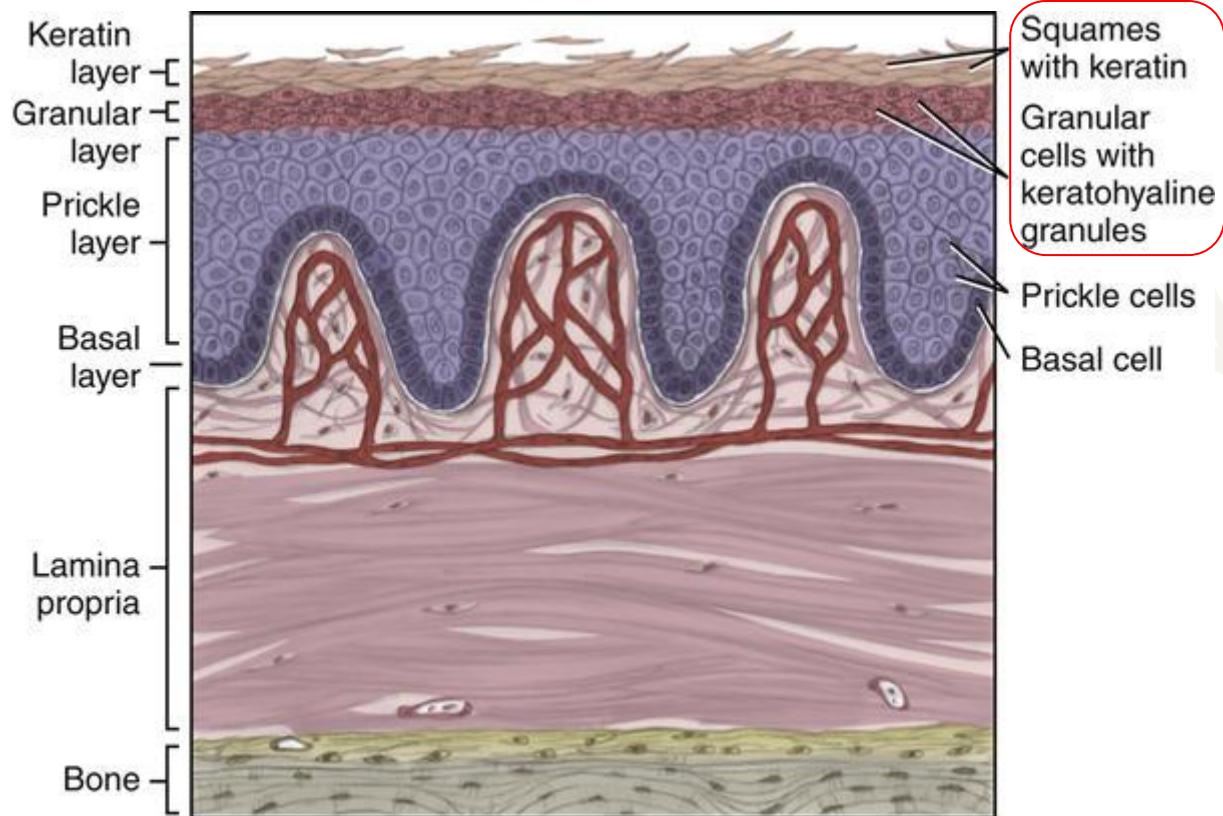
- Keratinization is also called as cornification
- It is a process of cytodifferentiation of keratinocytes
- These hardened cells filled with protein are called keratin
- Keratinized epithelium can be further classified into:
  - Ortho keratinized
  - Para keratinized

**1. Structure of ortho-keratinized oral epithelium**

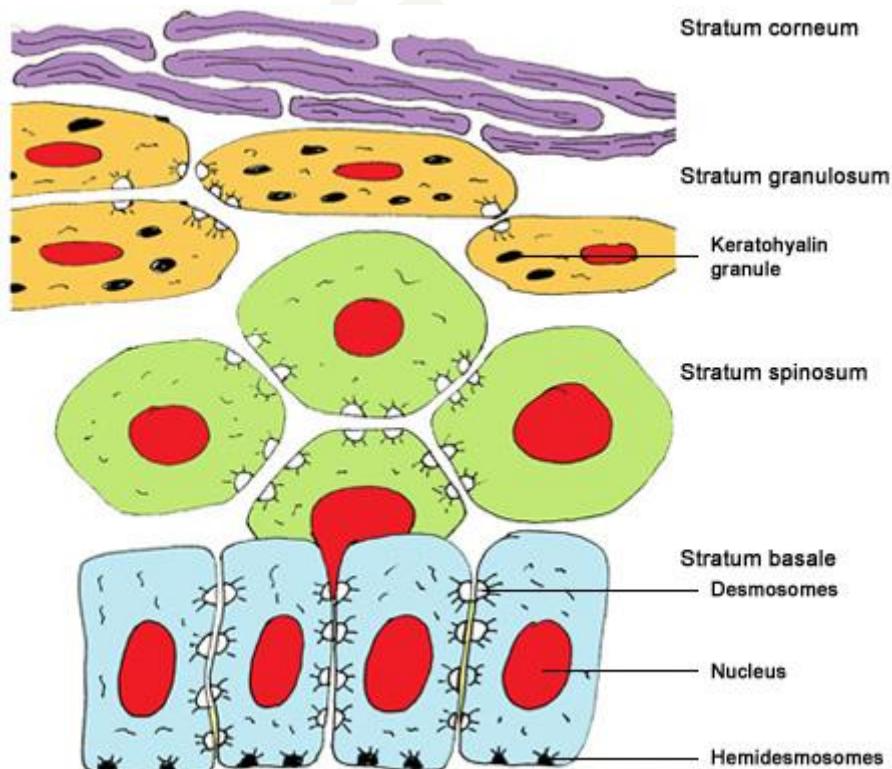
- The ortho keratinized epithelium is divided into 5 layers:

<i>i. Stratum basale</i>	<ul style="list-style-type: none"> <li>• It is the first layer and also called as <u>basal layer</u></li> <li>• Lies adjacent to the basement membrane and contains layers of the <u>cuboidal or columnar cells</u>.</li> <li>• The cells contain RER, Golgi complex and ribosomes.</li> <li>• The cytoplasmic processes are <u>rich in hemidesmosomes</u> and have well developed filament bundles.</li> <li>• Provides <u>anchorage to the connective tissue</u>.</li> </ul>
<i>ii. Stratum germinatum</i>	<ul style="list-style-type: none"> <li>• Also called <u>proliferative layer</u> and the cells germinate, divide and proliferate.</li> <li>• It is actually a part of the basal layer and its use describes the cells in the basal region that are capable of division.</li> <li>• They are <u>irregular or polyhedral cells</u>.</li> <li>• They are joined together by inter cellular bridges <u>made up of tonofilaments and desmosomes</u> which provides tensile support to the epithelium.</li> <li>• The intercellular spaces contain glycoproteins, glycosaminoglycans and fibronectin.</li> </ul>
<i>iii. Stratum spinosum</i>	<ul style="list-style-type: none"> <li>• Also called <u>prickle cell layer / spinous layer</u>.</li> <li>• They are several rows of <u>larger elliptical / spherical cells</u> called so after the histological appearance where they frequently shrink away from each other remaining in</li> </ul>

	<p>contact only at points known as intercellular bridges.</p> <ul style="list-style-type: none"><li>• This point of attachment resembles a spine ending at desmosomes.</li><li>• This layer is active in protein synthesis i.e., they produce additional proteins rather than produced from basal layer.</li><li>• This <u>indicates their biochemical commitment to keratinization</u></li></ul>
iv. <i>Stratum granulosum</i>	<ul style="list-style-type: none"><li>• Also called as <u>granular cell layer</u></li><li>• They contain <u>larger flattened cells with keratohyalin granules</u>.</li><li>• They also <u>contain lamellar granules</u>, a small organelle (also known as keratinosomes, odland bodies, membrane-coating granules).</li><li>• This granule discharge their content in to the intercellular space forming a permeability barrier which prevent escape of water or water soluble substances.</li><li>• During the same time the inner unit of cell membrane thickens to form a cornfied cell envelope, which is a dense band of highly insoluble protein material formed by cross linking of involucrin, loricrin, filagrin, desmoplakin, cysteine, glutamine and lysine.</li></ul>
v. <i>Stratum corneum</i>	<ul style="list-style-type: none"><li>• Also called as <u>Keratinized layer/ Cornified layer / Horny layer</u>.</li><li>• This superficial layer is <u>composed of flat or squamous cells</u>.</li><li>• These cells do not contain nuclei.</li><li>• All keratohyalin granules, other cell organelles have disappeared and it only contains densely packed filament developed from tonofilaments altered and coated by filagrin.</li><li>• These cells appear compact, dehydrated and cover a greater surface area than the basal cell from which it developed.</li></ul>

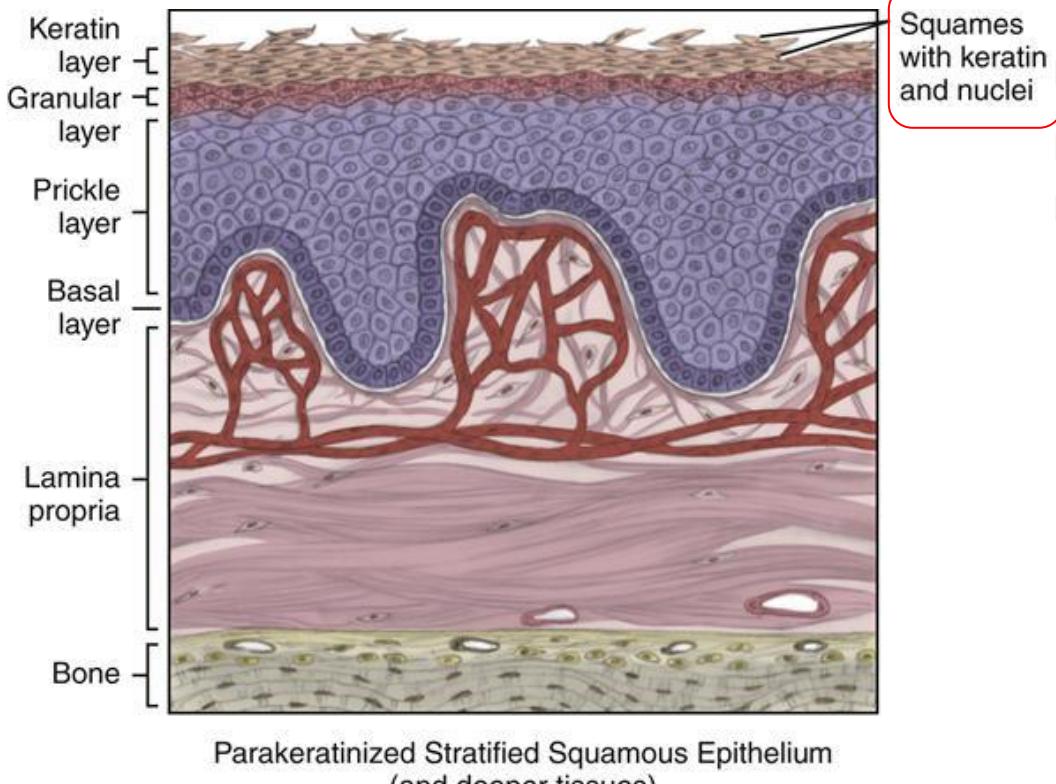


Orthokeratinized Stratified Squamous Epithelium  
(and deeper tissues)



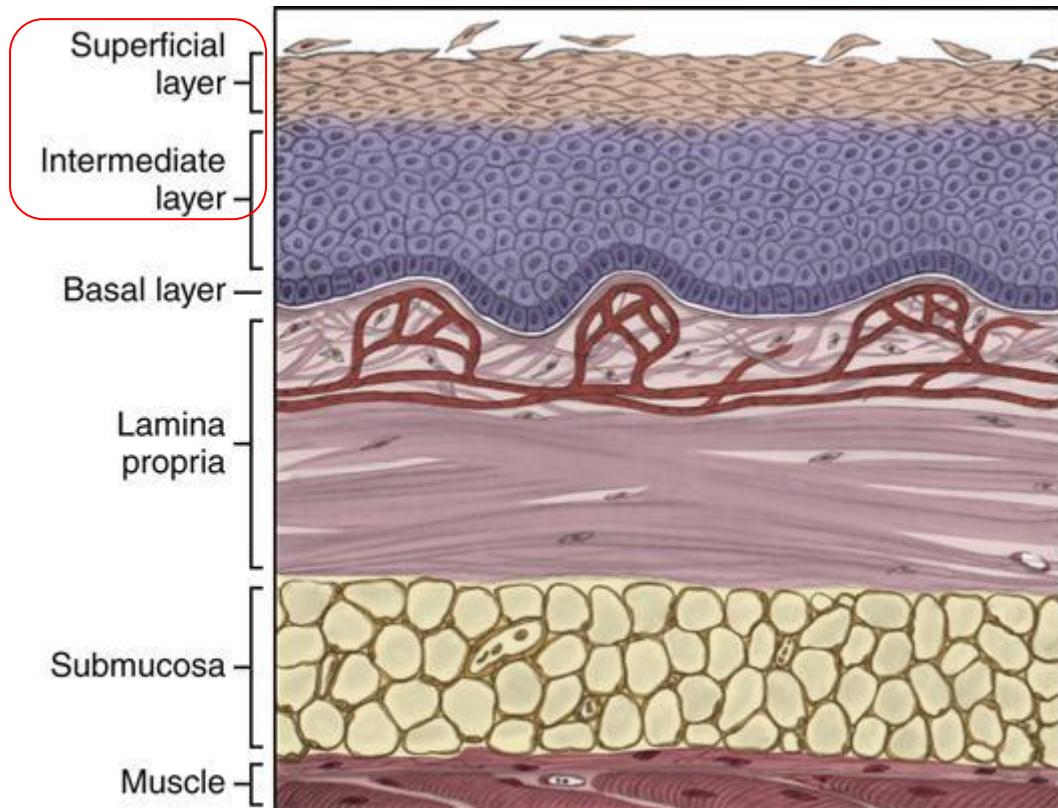
## 2. Structure of Para keratinized oral epithelium

- In Parakeratinized epithelia, the basic structure is same as Orthokeratinized epithelium except:
  - The stratum corneum retains pyknotic nuclei
  - The keratohyalin granules are dispersed, not giving rise to a stratum granulosum.



### 3. Structure of non keratinized oral epithelium

- The non-keratinized epithelium differs from the ortho keratinized epithelium in-
  - It does not have stratum granulosum and stratum corneum
  - The superficial cells have viable nuclei.



Nonkeratinized Stratified Squamous Epithelium  
(and deeper tissues)

<b>Keratinized epithelium</b>	<b>Non keratinized epithelium</b>
<ul style="list-style-type: none"> <li>Layers: Basal, spinosum, granular, cornified layer</li> <li>Produces cornified layer on the surface</li> <li>Prickly appearance</li> <li>Ortho keratinized: no nuclei, Para keratinized: pyknotic nuclei</li> <li>Consists of filagrin</li> <li>Several tonofilaments with keratohyaline granules</li> </ul>	<ul style="list-style-type: none"> <li>Layers: Basal, intermediate, surface layer</li> <li>Does not have a cornified layer</li> <li>No prickly appearance without any obvious intercellular spaces</li> <li>Consists of nucleated cells in stratum superficiale</li> <li>No filagrin, consists of involucrin</li> <li>Tonofilaments are less developed and dispersed, lack of keratohyaline granules</li> </ul>

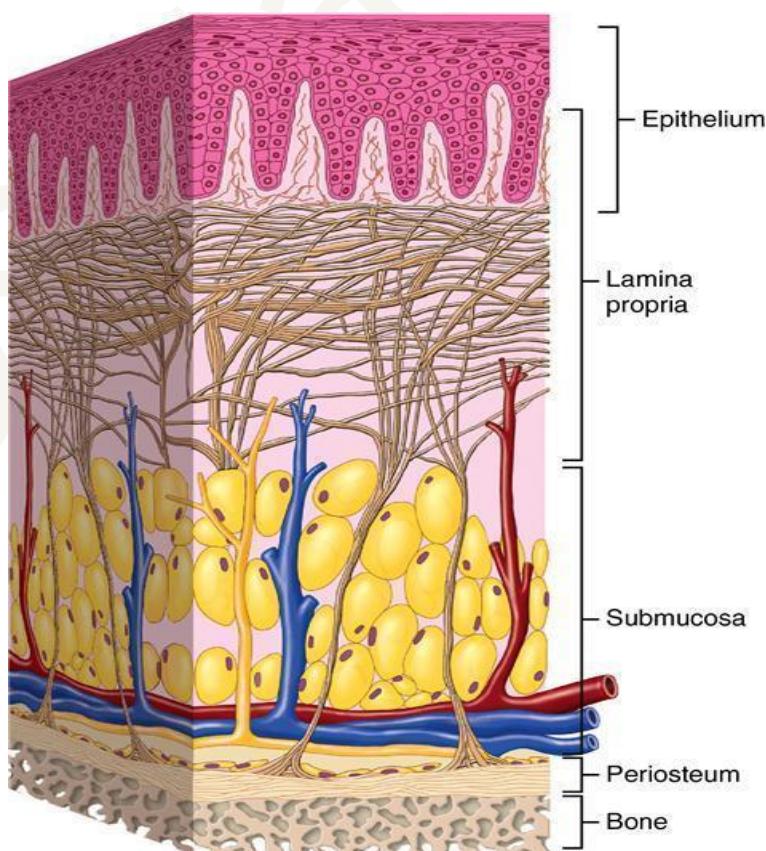
## II. Lamina propria

Consists of

- Papillary layer: close to epithelial ridges with loosely arranged cells
- Reticular layer: located parallel to epithelium with thick fibres
- Cells: Fibroblast, histiocytes, mast cells, macrophages, PMNs, lymphocytes, plasma cells, endothelial cells
- Blood vessels and neural elements
- Fibres
- Ground substance

## III. Submucosa

- It attaches the mucous membrane to the underlying substructures (Eg. bones and muscles)
- Attachment is either loose or firm
- Consists of glands, blood vessels, nerves and adipose tissues
- Thickness of connective tissue is varied



## Functional type of oral mucosa

- The oral mucosa shows considerable variation in structure not only at their epithelial surface but also at their junction and at the connective tissue level.
- The normal variants of oral mucosa are:
  - Masticatory mucosa: hard palate, gingiva.
  - Lining mucosa: ventral surface of tongue, inner layer of lips, cheeks, floor of the mouth and alveolar process.
  - Specialized mucosa: dorsum of tongue.

### 1. Masticatory mucosa

- Masticatory mucosa covers the gingiva and hard palate, supporting mucosa in edentulous patients
- It is the primary mucosa that comes in contact with food during mastication
- The junction between epithelium and underlying lamina propria is convoluted, and the numerous elongated papillae provide good mechanical attachment and prevent the epithelium from being stripped off under shear force.
- The lamina propria is thick, containing a dense network of collagen fibers in the form of large, closely packed bundles.

<i>i. Gingiva</i>	<i>ii. Hard palate</i>
<ul style="list-style-type: none"> <li>• Gingiva consists of either keratinized or para keratinized epithelium with no submucosal layer</li> <li>• Develops from the union of oral epithelium and reduced enamel epithelium</li> <li>• Consists of free gingiva, attached gingiva, interdental papilla</li> </ul>	<ul style="list-style-type: none"> <li>• Consist of masticatory mucosa in the visible parts of the oral cavity</li> <li>• Anterior part of the palate is called rugae</li> <li>• Posterolateral part consists of palatine glands</li> <li>• Midpalatine raphe does not contain submucosa</li> </ul>

### 2. Lining mucosa

- It covers all the soft tissues of the oral cavity except gingiva, hard palate and dorsal surface of the tongue
- The epithelium of lining mucosa is thicker than that of masticatory mucosa, sometimes exceeding 500  $\mu$  m in the cheek, and is non - keratinized.
- The surface is thus flexible and is able to withstand stretching.

- The interface with connective tissue is relatively smooth, although slender connective tissue papillae often penetrate into the epithelium.
- The lamina propria is generally thicker than in masticatory mucosa and contains fewer collagen fibers, which follow a more irregular course between anchoring points

i. <i>Lip</i>	<ul style="list-style-type: none"> <li>• Covered by lining mucosa</li> </ul>
ii. <i>Vermilion border</i>	<ul style="list-style-type: none"> <li>• It is the junction between skin and mucous membrane of the lip</li> </ul>
iii. <i>Floor of the mouth</i>	<ul style="list-style-type: none"> <li>• Consists of loosely attached underlying structures.</li> <li>• Submucosa consists of adipose tissue</li> </ul>
iv. <i>Ventral surface of the tongue</i>	<ul style="list-style-type: none"> <li>• Mucosa is thin and smooth</li> <li>• Attached to muscles of the tongue tightly</li> </ul>
v. <i>Cheek</i>	<ul style="list-style-type: none"> <li>• Consists of fat cells and mixed salivary glands in submucosa</li> </ul>

### 3. Specialized mucosa

- Covers the dorsal surface of the tongue
- Connective tissue binds the epithelium to the underlying skeletal muscle
- Epithelium is modified, keratinized, covered with papillae which is visible to naked eye
- Types of papillae found on the dorsal surface of the tongue are
  - Filiform papillae: keratinized
  - Fungiform papillae: Nonkeratinized
  - Circumvallate papillae
  - Foliate papillae

### EFFECTS OF AGING ON THE ORAL MUCOSA

- Thinning of epithelium
- Decrease in keratinization
- Rete pegs are less prominent
- Decrease in cellular proliferation
- Loss of submucosal elastic fibers and adipose cells
- Increase in fibrous connective tissue
- Degeneration of collagen

## PROSTHETIC CONSIDERATIONS

### Oral mucosa under stress

- Behaves in viscoelastic fashion
- Decrease in depth of epithelial ridges and connective tissue papillae
- Hence care should be taken while making impressions using minimal pressure techniques

### Tissue responses

<b>New dentures</b>	<b>Denture wearers &gt; 1 year</b>
<ul style="list-style-type: none"><li>• Inflammation</li><li>• Distortion of soft tissue</li><li>• Impingement of gingival margin</li><li>• Dental plaque accumulation</li></ul>	<ul style="list-style-type: none"><li>• Hyperkeratinization</li><li>• Scarring of tissues in borders</li><li>• Tissue distortion</li></ul>

### Changes in the oral mucosa due to prosthesis

- Soft tissue hyperplasia
- Fibrous hyperplasia
- Papillary hyperplasia
- Epulis fissuratum
- Inflammation under denture bases
- Denture stomatitis
- Candidiasis
- Ulcerative lesions
- Angular cheilitis

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*Please Give Your Feedback on this Answer*

## Discuss self protective features of human dentition (20M)

### Oral changes due to aging (7M).

#### CONTENTS/SYNOPSIS

- Introduction
- Age changes of enamel
  - Attrition
  - Abrasion
  - Erosion
  - Discoloration and increased translucency
  - Modification of surface layer
  - Reduced permeability
- Changes in dentin with aging
  - Primary dentin
  - Secondary dentin
  - Transparent dentin
  - Dead tracts
  - Reparative dentin
  - Atubular dentin
  - Vitality of dentin
- Cementum
  - Permeability
  - Thickness of cementum
  - Clinical consideration
- Age changes in the pulp
  - Vascular changes
  - Size and morphology
  - Pulpal fibrosis
  - Pulp calcifications
  - Clinical consideration
- Age changes in gingiva
- Aging in periodontal ligament
- Age changes in alveolar bone
- Effects of aging on the oral mucosa
- Age changes in tongue
- Age changes in salivary glands
- References

## INTRODUCTION

- Aging refers to irreversible and an inevitable change that occurs with time
- It is also a sum of all morphological and functional alteration of an organism leading to functional impairment

## AGE CHANGES OF ENAMEL

- Enamel is the hardest substance of our body with 4 % organic & 96 % inorganic content and consists of hydroxyapatite crystal
- Incapable of regeneration
  - Attrition
  - Erosion
  - Abrasion
- Discoloration and increased translucency
- Modification of surface layer
- Reduced permeability
- Increase hardness

### 1. Incapable of regeneration

<b>i. Attrition</b>	<ul style="list-style-type: none"> <li>• Attrition is tooth loss involving tooth to tooth contact</li> <li>• Occurs both occlusally and interproximally</li> <li>• In molars, <u>occlusal attrition is most commonly seen on the palatal surfaces of maxillary molars</u></li> </ul>
<b>ii. Abrasion</b>	<ul style="list-style-type: none"> <li>• Abrasion is tooth loss involving friction between the tooth and outside material</li> <li>• <u>Common cause is tooth brush abrasion</u> seen on the labial and buccal surfaces</li> </ul>
<b>iii. Erosion</b>	<ul style="list-style-type: none"> <li>• Erosion is tooth loss involving contact with acidic agents that may be extrinsic or intrinsic</li> <li>• In cases of <u>bulimia</u>, the erosion characteristically affects the palatal surfaces of the upper anterior teeth</li> </ul>

### 2. Discoloration and increased translucency

- Color is determined by differences in the translucency of enamel
  - Yellow color: dentin is visible
  - Grey color : opaque enamel

- Translucency increases with age causing teeth to be yellower
- Loss of enamel rods alters the light reflection of enamel and results in tooth color change
- Deepening of dentin color is seen through progressively thinning layer of enamel

### 3. Modification of surface layer

- Aging results in
  - Localized increase in fluoride and nitrogen content
  - Fluoride can beneficially be incorporated into surface enamel
  - This reduces the porosity and susceptibility to caries
  - Loss of perikymata

### 4. Reduced permeability

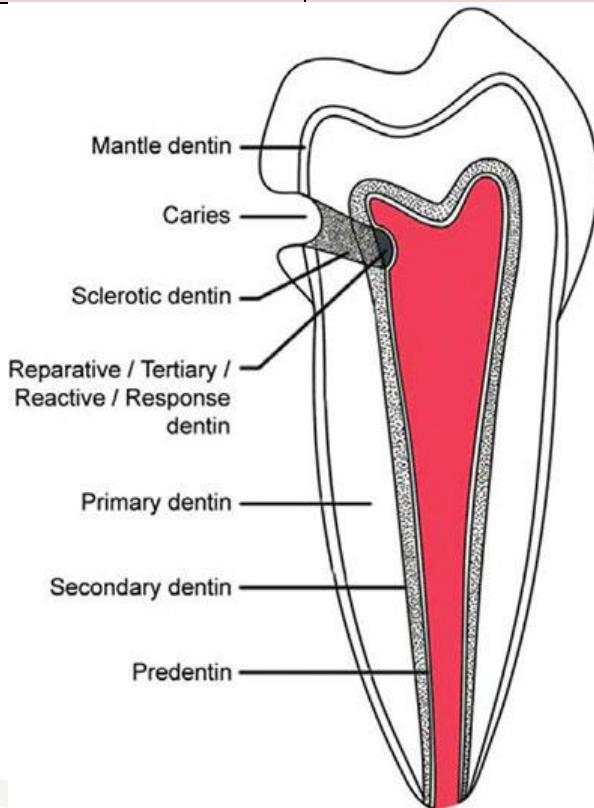
- Crystals in the enamel acquire ions (F, N) from the oral fluids
- Increase in the size of crystals
- Decrease in the pores between crystals
- Reduced permeability
- Normally enamel is semi permeable
- With age, there is reduction in permeability

### AGE CHANGES IN DENTIN

- Dentin is a hard tissue characterized with dentinal tubules throughout its thickness, with an increase in age there are both irreversible and inevitable changes
- Increase in sclerotic dentin
- Increase in number of dead tracts
- Increase in formation of reparative and reactive dentin
- Vitality of dentin

I. Primary dentin	II. Secondary dentin
<ul style="list-style-type: none"> <li>• It is the type of dentin <u>formed before root completion</u></li> <li>• As age increases, it may slowly undergo reduction in the diameter of the dentinal tubules due to continues peritubular dentin deposition</li> </ul>	<ul style="list-style-type: none"> <li>• Type of <u>dentin formed after root formation</u></li> <li>• Dentin formation takes place at a slower rate in entire life even after tooth eruption. This dentin is termed as regular or physiologic secondary dentin</li> </ul>

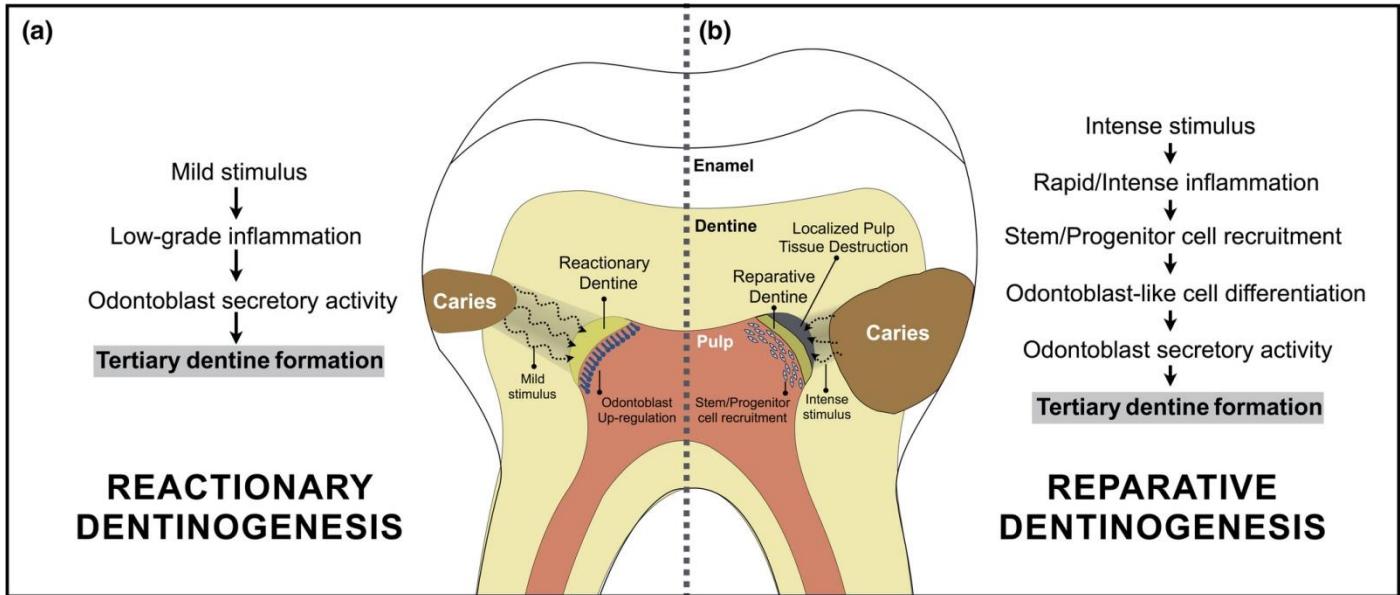
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|--|---|
| <ul style="list-style-type: none"> <li>• This results in decreased permeability &amp; sensitivity of dentin</li> </ul> | <ul style="list-style-type: none"> <li>• As ages, deposition of secondary dentin on the entire pulpal surface of the dentin at irregular rate</li> <li>• More prominent on the floor and roof of the pulpal chamber of posterior teeth</li> <li>• As a result, there is obliteration of pulp horn with reduced pulpal cavity</li> </ul> |
|--|---|



### III. Transparent dentin

- It is also called as sclerotic dentin
- It is due to regressive alteration in the primary dentin which is characterized by occlusion of the dentinal tubules by calcified materials
- Various stimuli like caries, attrition, abrasion, erosion or cavity preparation can activate the odontoblastic processes which forms collagen fibers and apatite crystals to appear in dentinal tubules
- Other reason can be due to that the odontoblastic processes undergo fatty degeneration and cause calcification
- If the sclerosis occurs due to aging process it is referred as physiological dentin sclerosis

- If it occurs due to external stimuli and it is termed as reactive dentin sclerosis
- Most commonly found in apical third of the root
- It is transparent in transmitted light and dark in reflected light
- Sclerotic dentin provides a defensive reaction to dentin and helps in pulpal vitality



#### IV. Dead tracts

- Due to severe injury or stimulation to dentin, odontoblastic processes undergo complete degeneration and the empty dentinal tubules are filled with air
- Dead tracts commonly found in primary dentin, especially in coronal part near to pulpal horns
- Dentinal areas with degenerated odontoblastic processes demonstrate decreased sensitivity.
- After sealing of reparative dentin at the affected tubules at their pulpal ends, tubules are filled with fluid or gaseous substances
- In ground sections, tubules entrapped with air appears black in transmitted light and white with reflected light

#### V. Reparative dentin

- Type of dentin formed in reaction to severe stimuli such as caries, operative procedures and erosion.
- Localized dentin formation on the pulpal dentin border
- Characterized by greater reduction of the tubules which runs in twisted course or irregular manner

- In these cases, odontoblastic processes are exposed and the cells are severely damaged and undergo degeneration

## VI. Atubular dentin

- It is reactionary dentin present either as a layer of the osteodentin type or as tubular or atubular orthodentin
- Degeneration of odontoblast cells stimulates the undifferentiated cells from the pulp and migrate these cells to the site of injured odontoblasts and differentiate into precursors that forms dentin
- Hence, the type of dentin formed is atypical without characteristic dentinal tubules is known as a tubular dentin

## VII. Vitality of dentin

- Normally, odontoblasts do not undergo degeneration, there is dentin deposition throughout the life
- After tooth eruption the functional dentinogenesis become slow and further dentin formation become more slower

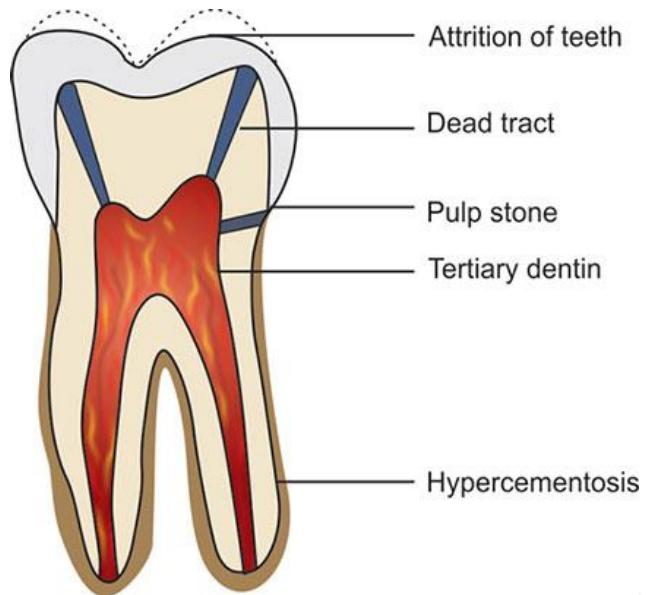
## CEMENTUM

- Cementum is the specialized, avascular, non- innervated, mineralized dental tissue covering the anatomic root of human teeth

<h3>I. Permeability</h3>	<ul style="list-style-type: none"> <li>• In <u>younger age groups, acellular &amp; cellular cementum are very permeable</u> and permits the diffusion of dyes from the pulp and external root surface</li> <li>• <u>With aging, permeability of cementum diminishes</u></li> <li>• Permeability from the periodontal side is lost except in recently formed layer of cementum and in the dentine side, it remains only in the apical region</li> </ul>
<h3>II. Thickness of cementum</h3>	<ul style="list-style-type: none"> <li>• <u>Increases with age particularly at the apex due to passive eruption</u>, except in areas where cementum is exposed due to gingival recession</li> <li>• Cementum triples its thickness from 10 to 75 years</li> <li>• Increased deposition in lingual surface as compared to other surface</li> <li>• Degeneration of cementocytes</li> <li>• Hence, cementum becomes acellular with increase in age (except at apex)</li> </ul>

**Clinical consideration**

<i>i. Hypercementosis</i>	<ul style="list-style-type: none"> <li>It is abnormal thickening of cementum</li> <li>Excementosis: knob like projection found in localized area of hypoplastic cementum hypercementosis is associated with large number of neoplastic and non-neoplastic diseases</li> <li>Generalized thickening is seen in <u>paget's disease</u></li> <li>Localized thickening seen in <u>benign cementoblastoma, acromegaly</u></li> </ul>
<i>ii. Localized hypercementosis</i>	<ul style="list-style-type: none"> <li>Observed in areas where enamel drops have developed on the dentin</li> <li>Hyperplastic cementum covers the enamel drops &amp; are irregular</li> <li>Sometimes, they contain round body which might be calcified epithelial cells</li> </ul>
<i>iii. Localized hypertrophy</i>	<ul style="list-style-type: none"> <li>A spur or prong like extension of cementum may be formed</li> <li><u>Occurs in conditions of excessive stress</u></li> <li>This provides large surface area for attaching fibres creating firmer anchorage</li> </ul>
<i>iv. Excementosis</i>	<ul style="list-style-type: none"> <li>They are knob like projections of cementum</li> <li>They develop around degenerated epithelial rests</li> <li>Found in localized area of hyperplastic cementum</li> </ul>
<i>v. Extensive spike like hyperplasia</i>	<ul style="list-style-type: none"> <li>It is <u>formed during healing of cemental tear</u></li> <li>Calcification of Sharpey's fibers occurs accompanied by numerous cementicles</li> <li>Observed in sequela of injury to cementum</li> </ul>



### AGE CHANGES IN THE PULP

- The age-related changes of the dental pulp are difficult to separate from physiologic defensive changes
  - Compromised circulation and innervations
  - Size and morphology
  - Fat droplet deposition
  - Odontoblastic vacuolization
  - Reticular atrophy
  - Pulpal fibrosis
  - Hyaline degeneration
  - Calcifications.

<b>I. Vascular Changes</b>	<ul style="list-style-type: none"> <li>• Atherosclerotic plaques may appear in pulpal vessels</li> <li>• Outer diameter of vessel walls become greater as collagen fibers increase in the medial and adventitial layers</li> <li>• <u>Calcification in the walls of blood vessels</u> is found most often in the region near the apical foramen</li> <li>• <u>Blood flow decreases with age</u></li> </ul>
<b>II. Size and morphology</b>	<ul style="list-style-type: none"> <li>• <u>Decrease in pulp size</u></li> <li>• <u>Less prominent pulp horns</u></li> <li>• More fibrous tissue with mature collagen</li> <li>• <u>Reduction in cellular components</u></li> <li>• Reduced ground substances &amp; size and number of</li> </ul>

	cytoplasmic organelles
<b>III. Pulpal fibrosis</b>	<ul style="list-style-type: none"> <li>In the aging pulp accumulations of both diffuse fibrillary components as well as bundles of collagen fibers usually appear</li> <li>Fiber bundles may appear arranged longitudinally in bundles in the radicular pulp and in a random more diffuse arrangement in the coronal area</li> </ul>
<b>IV. Pulp calcifications</b>	<ul style="list-style-type: none"> <li>Size might vary from microscopic particle to the stones that occlude the pulp chamber</li> <li>Composed of carbonated hydroxyapatite crystals</li> <li>Pulp calcifications can be <ul style="list-style-type: none"> <li>➤ Pulp stones/Denticles: <ul style="list-style-type: none"> <li>True/ False pulp stones</li> <li>Free/ Attached/ Embedded pulp stones</li> </ul> </li> <li>➤ Diffuse calcifications</li> <li>➤ Calcific metamorphosis</li> </ul> </li> </ul>

### Clinical consideration

#### i. Pulp stones

- Pulp stones are nodular, calcified masses appearing in either or both the coronal and root portions of the pulp

True denticles	False denticles
<ul style="list-style-type: none"> <li>Similar in structure to dentin in that they <u>have dental tubules</u> and contain the processes of the odontoblasts that formed them</li> <li>Usually <u>located close to the apical foramen</u></li> </ul>	<ul style="list-style-type: none"> <li><u>Do not exhibit dental tubules</u> but appear as concentric layers of calcified tissue</li> <li>They appear within a bundle of collagen fibers</li> <li>In the center of these concentric layers of calcified tissue, remnants of necrotic and calcification of thrombin in blood vessels, called phleboliths might be present</li> <li>This may also serve as node for the false denticles</li> </ul>

## ii. *Calcific Metamorphosis*

- Might result because of trauma
- Results in partial or complete obliteration of pulp chamber
- Teeth presents with yellowish hue

## AGE CHANGES IN GINGIVA

- Thinning of epithelium
- Decrease in keratinization
- Increases width of attached gingiva
- Increase in permeability of epithelium (Eg. bacteria)
- Decreased resistance to trauma
- Stippling is reduced
- Flattened rete pegs
- Decrease in collagen and its turnover
- Recession of gingiva

## AGING IN PERIODONTAL LIGAMENT

- Increase in number of elastic fibres
- Decreased vascularity
- Decrease in number of fibrous tissues
- Decrease in width of periodontal space
- Increase in pocket depth
- Decrease in chemotaxis and proliferation rate of periodontal ligament cells

## AGE CHANGES IN ALVEOLAR BONE

- Bone resorption is a major change in alveolar bone associated with aging
- Common site: Labial aspect of alveolar bone

### Features:

- Decrease in height and width of the jaw
- Jagged and uneven appearance of alveolar sockets

- Increased distance between the crest of the alveolar bone and cemento-enamel junction

## EFFECTS OF AGING ON THE ORAL MUCOSA

- Thinning of epithelium
- Decrease in keratinization
- Rete pegs are less prominent
- Decrease in cellular proliferation
- Loss of submucosal elastic fibers and adipose cells
- Increase in fibrous connective tissue
- Degeneration of collagen

## AGE CHANGES IN TONGUE

- Loss of taste buds
- Loss of filiform papilla on the dorsum surface
- Foliate papillae becomes more prominent
- Increase in fissures
- Dryness of mouth
- Caviar tongue: Presence of nodular enlargements in the ventral surface of the tongue
- Reduced epithelial thickness
- Decrease in muscle fibre diameter

## AGE CHANGES IN SALIVARY GLANDS

- Atrophy of acinar cells
- Dilatation of ducts
- Fatty infiltration
- Fibrosis
- Infiltration of inflammatory cells
- Callus formation in peri acinar cells
- Oncocytes: Non functional cells with swollen appearance, eosinophilic granules in cytoplasm and pyknotic nucleus

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**Q. 15: Abrasives and polishing agents for prosthesis (15M, 6M)**

**CONTENTS/SYNOPSIS**

Introduction

Rationale

Objectives

Principles of cutting, grinding, finishing, and polishing

Erosion

Abrasion

- Principle of abrasion
- Types of Abrasion
- Factors affecting rate of abrasion
- Abrasive instrument design
- Maintenance of the abrasives

Classification of abrasives

1. Bonded abrasives
2. Non - bonded abrasives
3. Coated abrasive disks and strips

Types of abrasives

1. Aluminium oxide/ Alumina
2. Arkansas stone
3. Chalk
4. Cuttle
5. Corundum
6. Emery
7. Garnet
8. Kieselguhr
9. Pumice
10. Quartz
11. Sand
12. Tripoli
13. Rouge
14. Silicon carbide
15. Tin oxide
16. Zirconium silicate
17. Natural diamonds
18. Synthetic diamonds

Polishing instruments

Recent advances

- Air particle abrasion technology
- Nanotechnology in abrasives

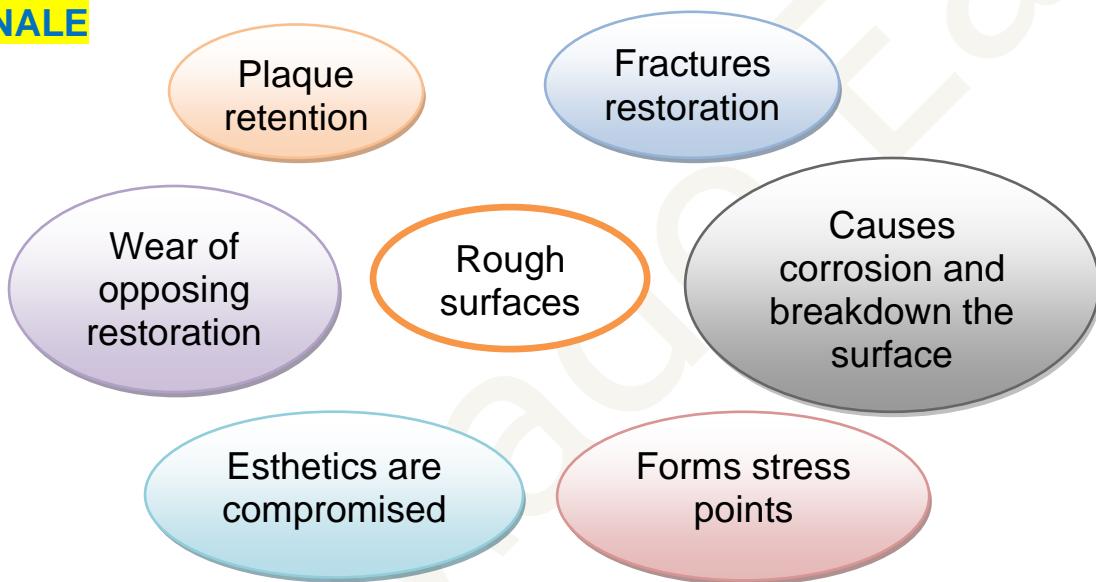
Conclusion

Reference

## INTRODUCTION

- According to Jines et al., a patient can sense a roughness lesser than 1  $\mu\text{m}$ , and a surface roughness greater than 1  $\mu\text{m}$  can cause bacterial adhesion, food deposit and staining. (*Research Brit Dent J*, 196:42-45, 2004).
- A properly finished and polished restoration provides the following four benefits
  1. Improves the health of gingiva
  2. Ability to chew efficiently
  3. Patient's comfort
  4. Better esthetics

## RATIONALE



## OBJECTIVES

To remove marginal irregularities

Anatomic contours can be defined

To smoothen the roughness on the restorations

Refine cavosurface margins

Form a translucent smooth enamel surface

## PRINCIPLES OF CUTTING, GRINDING, FINISHING, AND POLISHING

Cutting	Grinding	Polishing
<ul style="list-style-type: none"> <li>Any instrument with blade or blade like fashion can be used</li> <li>Blades are arranged regularly and removes large to smaller particles on the substrate</li> <li>Cutting pattern is unidirectional Eg., High speed tungsten carbides</li> </ul>	<ul style="list-style-type: none"> <li>Instruments with abrasives that are bonded or coated will be used</li> <li>Removes the small particles on the substrate</li> <li>Course of action is Unidirectional Eg., Diamond points</li> </ul>	<ul style="list-style-type: none"> <li>Acts on thin substrate surfaces</li> <li>Course of action is Multidirectional</li> </ul>

Bulk reduction	Contouring	Finishing	Polishing
<ul style="list-style-type: none"> <li>Removal of excessive material (cutting, grinding)</li> </ul>	<ul style="list-style-type: none"> <li>Commonly contouring can be done by bulk reduction</li> <li>To achieve</li> </ul>	<ul style="list-style-type: none"> <li>Removes deeper notches by introducing finer scratches</li> </ul>	<ul style="list-style-type: none"> <li>Provides a smooth and shiny surface on restoration without any</li> </ul>

<ul style="list-style-type: none"> <li>Instruments used: Diamonds points, carbide &amp; steel burs (8 - 12 fluted), abrasives (&gt; 100 <math>\mu\text{m}</math>) wheels, discs.</li> </ul>	<p>proper anatomy and margins - fine cutting instruments (12- 16 fluted burs) or abrasives (30 - 100 <math>\mu\text{m}</math>) are used</p>	<p>leading to a blemish free surface</p> <ul style="list-style-type: none"> <li>Carbide burs (18 -30 fluted burs), fine to super fine diamond points, abrasives (8 - 20 <math>\mu\text{m}</math>) can be used</li> </ul>	<p>scratches</p> <ul style="list-style-type: none"> <li>Abrasives of 20 <math>\mu\text{m}</math> are used</li> <li>Eg., Rubber points, fine discs and strips, polishing pastes</li> </ul>
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## EROSION

- Erosive wear is caused on the surface of the substrate when impacted by hard particles like a stream of liquid or air
- Eg., Sandblasting, acid etching

## ABRASION

- Abrasion** is a type of wear in which material is removed whenever two surfaces glide against each other.
- The surface material causing abrasion is called as **abrasive**
- The surface being abraded is called as **substrate**
- Eg., Diamond particles coated on the bur is Abrasive, Tooth surface is substrate

## Principle of abrasion



## Types of Abrasion

Two body wear	Three body wear
<ul style="list-style-type: none"> <li>Abrasives are coated or bonded to instruments and used to polish substrates</li> </ul> <p>Eg., Trimmers, burs etc.</p>	<ul style="list-style-type: none"> <li>Abrasive is a slurry consistency material used between substrate and polishing instrument like rubber cups, buffering wheels etc.,</li> <li>Lubricants like water, glycerine will be used</li> </ul> <p>Eg., Polishing pastes</p>



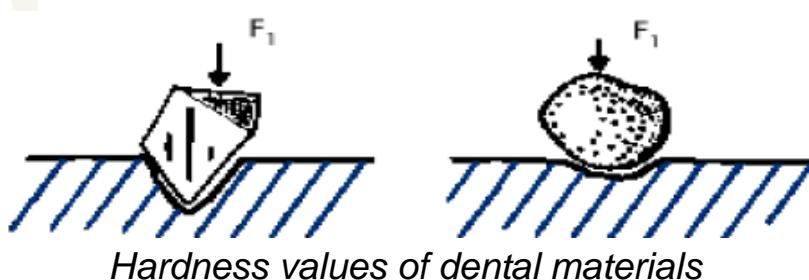
## Factors affecting Rate of Abrasion

### 1. Hardness

- Longevity of abrasives is related to the hardness of the particles
- Hardness is the measurement of the resistance of a material to be deformed either by scratching or indenting another material
- Abrasives should be harder than the substrate
- Tests used for hardness are Knoop and Vickers hardness test

### 2. Shape

- Irregular particles abrade deeper than round particles under equally applied force
- Cutting efficiency is enhanced by increasing number of cutting edges
- Rate of abrasion decreases with increase in use



Material	Moh's	Material	Moh's
Talc	1	Aluminium oxide	9
Gypsum	2	Silicon carbide	9-10
Chalk	3	Boron carbide	9-10
Rouge	5-6	Diamond	10
Pumice	6	<b>SUBSTRATES</b>	
Tripoli	6-7	Acrylic	2-3
Garnet	6.5-7	Pure gold	2.5-3
Tin oxide	6-7	Porcelain	6-7
Sand	7	Amalgam	4-5
Cuttle	7	Dentin	3-4
Tool steel		Enamel	5-6
Zirconium silicate	7-7.5	Glass	5-6
Tungsten carbide	9	Resin composite	5-7

### 3. Size

- Larger the size of the particle more rapid the surface is abraded
- Particles according to their size
  - Coarse: 100 - 500  $\mu\text{m}$
  - Medium: 10 - 100  $\mu\text{m}$
  - Fine: 0 - 10  $\mu\text{m}$



### 4. Speed

Faster the speed

Faster will be  
the rate of  
cutting

Higher the  
temperature

Greater  
chances of  
overcutting

## 5. Lubrication

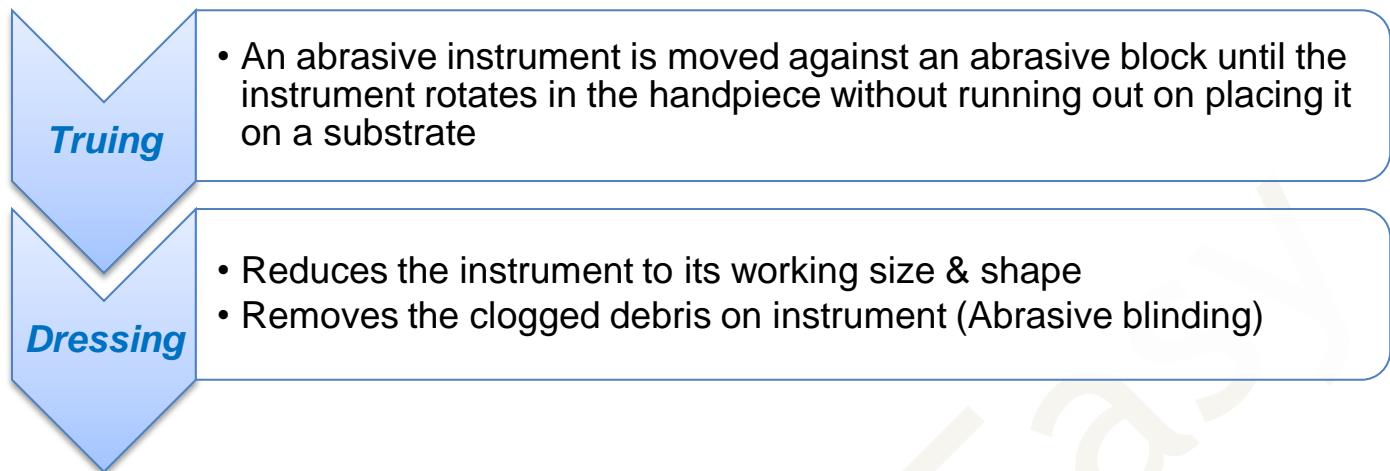
- Reduces heat accumulation and provides cooling
- Removes the debris
- Improves the process of abrasion
- Eg., Water, silicone

## Abrasive Instrument Design

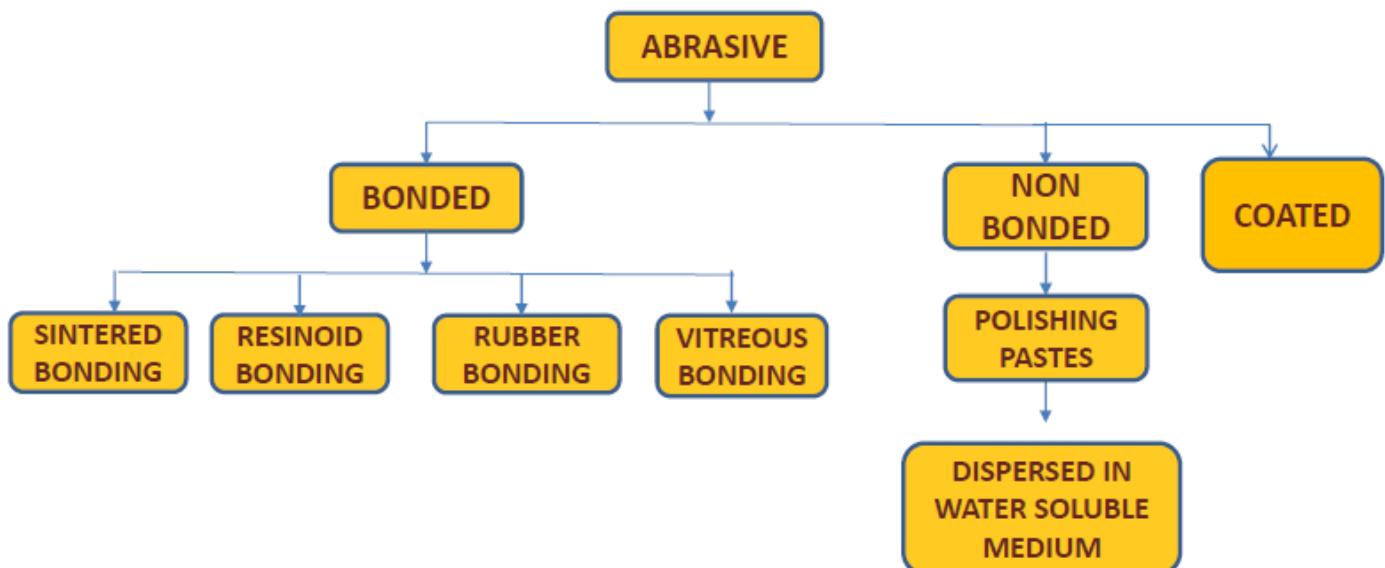
Abrasive motion	Abrasive grits
<p>Abrasive motions are classified as:</p> <ul style="list-style-type: none"> <li>• Rotary - burs</li> <li>• Planar - disk</li> <li>• Cyclic motion - Reciprocating handpieces</li> </ul>	<p>Abrasive grits are classified based on particle size:</p> <ul style="list-style-type: none"> <li>• Coarse</li> <li>• Medium coarse</li> <li>• Medium</li> <li>• Fine</li> <li>• Superfine</li> </ul>

Grit/Mesh (USA)	Aluminum Oxide, Silicon Carbide, and Garnet ( $\mu\text{m}$ )	Grade <sup>†</sup>	Coated Disc Diamond ( $\mu\text{m}$ )	Abrasive descriptions for Diamond Burs and Diamond Polishing Paste
120	142	Coarse	142	Supercoarse–coarse
150	122		122	Coarse–regular
180	70–86		86	Coarse–regular
240	54–63		60	Fine
320	29–32	Medium	52	Fine
400	20–23		40	Fine–superfine–coarse finishing
600	12–17	Fine	14	Superfine–medium finishing
800	9–12		8	Ultrafine–fine finishing
1200	2–5	Superfine	6	Milling pastes
1500	1–2		4	Polishing pastes (2–5 $\mu\text{m}$ )
2000	1		2	Polishing pastes (2–5 $\mu\text{m}$ )

## Maintenance of the Abrasives



## CLASSIFICATION OF ABRASIVES



Bonded abrasives	Non - bonded abrasives	Coated abrasive disks and strips
<ul style="list-style-type: none"> <li>Abrasives are incorporated to the grinding tool using a binder</li> <li>Particles are bonded using <ul style="list-style-type: none"> <li>Sintering</li> <li>Vitreous bonding</li> <li>Resinoid bonding</li> <li>Rubber bonding</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Three body wear</li> <li>Available in gel/paste forms</li> <li>Eg., Polishing pastes</li> <li>Applied to the substrate using rubber cups, muslin clothes, buffing wheel etc.,</li> </ul>	<ul style="list-style-type: none"> <li>Fabricated by placing abrasives to a flexible material</li> <li>Available in different diameters with thin backings</li> <li>Abrasive discs: Used for bulk reduction &amp; contouring, finishing &amp; polishing</li> <li>Abrasive strips: Used for interproximal polishing</li> </ul>

## TYPES OF ABRASIVES

Aluminium oxide/ Alumina	Arkansas stone	Chalk	Cuttle
<ul style="list-style-type: none"> <li>Synthetic abrasive, harder than natural abrasive</li> <li>Can be modified using reactants</li> <li>Used for fabrication of bonded &amp; coated abrasive, air propelled grits</li> </ul>	<ul style="list-style-type: none"> <li>It is a natural abrasive, semi translucent, light gray in colour</li> <li>It is dense &amp; hard, microcrystalline quartz with uniform texture</li> <li>Used for fine grinding of enamel &amp; alloys</li> </ul>	<ul style="list-style-type: none"> <li>It is a carbonate mineral form of calcite.</li> <li>Used as polishing paste for enamel, gold (foil), amalgam</li> </ul>	<ul style="list-style-type: none"> <li>It is a white calcareous powder, available as coated form of abrasive</li> <li>Used for polishing margins of metal and amalgam restorations</li> </ul>

Corundum	Emery	Garnet	Kieselguhr
<ul style="list-style-type: none"> <li>It is a white coloured aluminium oxide mineral form</li> <li>Physical properties are inferior to a <math>\text{Al}_2\text{O}_3</math></li> <li>Available as bonded form</li> <li>Used for grinding metal alloys</li> </ul>	<ul style="list-style-type: none"> <li>It is a gray to black coloured type of corundum</li> <li>Available as coated forms in discs in different grit sizes</li> <li>Used for metal and acrylic material finishing</li> </ul>	<ul style="list-style-type: none"> <li>It consists of different minerals (silicates of Al, Co, Fe, Mg, Mn) with similar physical and crystalline properties</li> <li>Dark red in colour, extremely hard, used for grinding metal &amp; acrylics</li> </ul>	<ul style="list-style-type: none"> <li>Consists of remnants of diatoms</li> <li>Coarse form - used as filler in dental materials</li> <li>used as mil abrasive, but with caution due to the chances of silicosis</li> </ul>

### Pumice

- Highly siliceous, volcanic origin
- Abrasive action is not very high
- Used for polishing enamel, gold (foil), amalgam restorations, acrylic resins

### Quartz

- Transparent, very hard
- Crystals are pulverized to form sharp and angulated particles
- Available as coated discs
- Used for grinding enamel and polish metal restorations

### Sand

- Comprises silica, rounded or angulated in shape
- Applied through air pressure (sandblasting)
- Available as coated paper discs
- Used for grinding metal and acrylic material

### Tripoli

- Obtained from light weight, siliceous rock
- It is ground and fabricated into bars with binders
- Colour - white/grey/yellow/pink/red
- Used for polishing metal and acrylic resins

<b>Rouge</b>	<ul style="list-style-type: none"> <li>• Consists of fine, red abrasive iron oxide</li> <li>• Blended into cake from using binders</li> <li>• Used for polishing high noble metal alloys</li> </ul>
<b>Silicon carbide</b>	<ul style="list-style-type: none"> <li>• 1st synthetic abrasive produced, hard, green and blue-black types are available (similar in properties)</li> <li>• Available in discs (coated), rubber bonded instruments.</li> <li>• Efficient in cutting metals, ceramics, acrylics</li> </ul>
<b>Tin oxide</b>	<ul style="list-style-type: none"> <li>• Extensively fine abrasive, but lesser than quartz</li> <li>• Used for polishing teeth, metallic restorations within the mouth.</li> <li>• Generally mixed with water or glycerine</li> </ul>
<b>Zirconium silicate</b>	<ul style="list-style-type: none"> <li>• Also called as zircon (<math>ZrSiO_4</math>)</li> <li>• Available in abrasive discs &amp; strips (coated)</li> <li>• Used as one of the components in dental prophylaxis paste</li> </ul>

<b>Natural Diamonds</b>	<b>Synthetic Diamonds</b>
<ul style="list-style-type: none"> <li>• Transparent, colourless, carbon mineral</li> <li>• Also called super abrasive, for its capacity to abrade any substrate</li> <li>• Available in <ul style="list-style-type: none"> <li>▪ Rotary instruments (bonded abrasive)</li> <li>▪ Flexible metal backed strips</li> <li>▪ Diamond polishing pastes</li> </ul> </li> <li>• Used for ceramics, composite restorations</li> </ul>	<ul style="list-style-type: none"> <li>• Merits of synthetic over natural diamonds is its consistent size and shape.</li> <li>• Bonded to either metal or resin. <ul style="list-style-type: none"> <li>▪ Resin bonded diamonds - sharp edges</li> <li>▪ Metal bonded diamonds - regular</li> </ul> </li> <li>• Used on tooth structure, ceramics, composite resins</li> </ul>

Bur type	Color	Grit size	ISO no
Supercoarse	■	Black ring	181µm
Coarse	■	Green ring	151µm
Medium		No ring	107-126µm
Fine	■	Red ring	40µm
Superfine	■	Yellow ring	20µm
Ultrafine	□	White ring	15µm

## POLISHING INSTRUMENTS

Rubber points

Fine particle coated discs and strips

Polishing pastes

Electrolyte polishing

## RECENT ADVANCES

### 1. Air particle abrasion technology

- It is an alternative for rotary instruments
- Alumina (Al<sub>2</sub>O<sub>3</sub>) particles of 25 - 30 µm are forced at high pressure

### Clinical Uses

1. Preparation of tooth cavities
2. Removal of damaged or defective restorations
3. To achieve endodontic access through metal ceramic crowns
4. Minimal tooth preparation for full coverage restoration
5. Removal of superficial stains

6. Roughening of internal surfaces of restoration to provide better cementation

## 2. Nanotechnology in abrasives

- Nano particles of 10 - 90 nm range, spherical shaped are used
- Polishing with nanoparticles improves polishing and minimizes surface roughness

## CONCLUSION

- The process of abrasion, finishing and polishing are important in preparing a clinically successful restoration

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*Please Give Your Feedback on this Answer*

**Q. 14: Denture adhesive components and its effects and ill effects (6M)**

**CONTENTS/SYNOPSIS**

- Introduction
- History of denture adhesives
- Composition of denture adhesives
- Mechanism of action of denture adhesives
- Ideal requirements of a denture adhesive
- Method of application
- Indications
- Contraindications
- Mode of application of denture adhesives
- Conclusion
- References

## INTRODUCTION

- Denture adhesive is defined as a material used to adhere a denture to the oral mucosa and its supporting tissues.
- Stability and retention of a prosthesis are the most common factors that creates satisfaction to the patients.
- Sometimes it is difficult to achieve superior results in prosthodontic management, especially complete dentures because of various factors that influence the prosthesis like
  - Psychological inhibition for first time denture wearers
  - Role of saliva
  - Arch size and form
  - Palatal depth
  - Extension of Posterior palatal seal
  - Thickness of mucosa
  - Frenal attachments etc
- To improve patient's psychological confidence, denture adhesives are prescribed as a supplement to enhance retention and stability.
- Guidelines are to be instructed to the patient about its application, use and removal.

## HISTORY OF DENTURE ADHESIVES

- Denture adhesives fixates were introduced in the age of modern dentistry/ late 18th century
- But there are no references about these materials till 19th century

19th Century	Denture adhesives were initially a mucilaginous material formulated from vegetable gums
1935	American Dental Association referred denture adhesives for the first time from the Accepted Dental Remedies, in which the council of Dental materials, instruments and equipment approved these products were nonmedical
1967	Kapur's conducted a study on 26 denture wearers which highlighted the used of denture adhesives to enhance retention and incisive ability

## COMPOSITION OF DENTURE ADHESIVES

- Based on main ingredients, denture adhesives are classified into three groups

### Group 1

Adhesive agents

- Tragacanth, gelatin, methyl cellulose, acacia, Hydroxyl methyl cellulose, karaya gum, sodium carboxyl methyl cellulose, pectin, synthetic polymers like acrylamides, acetic, polyvinyl and polyethylene oxide

### Group 2

Anti microbial agents

- Sodium tetraborate, ethanol, hexachlorphene, sodium borate

### Group 3

Others

- Plasticizers, flavouring agents like peppermint, oil of wintergreen and wetting agents

## MECHANISM OF ACTION

- Denture adhesives are available as paste, powder or cream

Denture adhesive on exposure to water



Absorbs the water and swells into a larger volume



Anions formed in adhesive reacts with cations of proteins in the oral mucosa



Increases the viscosity of adhesive in the presence of saliva, leading to an increased retention of denture

- Newer adhesives are stronger with bio-adhesive and cohesive forces.

- Components like methyl cellulose, sodium carboxyl methyl cellulose, hydroxyl methyl cellulose, poly methyl vinyl - ether maleic anhydride on hydration forms free carboxyl groups which forms electro covalent bonds leading to a sticky bio-adhesion.

Adhesive creams: They provide higher retention because of the increased viscosity which creates lateral spread excluding both air and saliva.

## IDEAL REQUIREMENTS OF DENTURE ADHESIVES

According to Adisman IK, the following are the required characteristics of denture adhesives

1. Biocompatible, nonirritant, non-toxic
2. No odor and taste
3. Ease of application
4. Be able to remove from denture surface
5. Prevent microbial growth
6. Retain adhesion upto 12 - 16 hours
7. Improve the comfort, retention and stability of denture

## INDICATIONS OF DENTURE ADHESIVES

1. To Stabilize the trial denture bases **during jaw relations and try in** procedure
2. Using adhesives during try in will increase the accuracy and **reduces the patient's apprehension** about the outcome of treatment
3. In **cases with poor denture bearing areas**, to improve the adaptation of new dentures and boost patient's confidence
4. **For Immediate dentures**, as they tend to lose retention and stability and needs relining or rebasing. Adhesives provide comfort during this interim period
5. In **conditions with ulcers, irritated tissues, inflamed denture bearing areas, excessive compression of oral mucosa due to dentures**
6. In **patients with xerostomia**, it is essential to use an adhesive due to lack of salivary secretion followed by drugs or radiotherapy
7. In **patients with neuromuscular disorders** like myasthenia gravis, Parkinson's and Alzheimer's disease to stabilize the dentures during the fabrication process and post-delivery of dentures
8. To provide **retention to maxillofacial prosthesis, radiation carriers, radiation protection**

## CONTRAINDICATIONS

1. Patients who are allergic to denture adhesives
2. Should not prescribe in cases with improper dentures with poor peripheral seals, denture base extensions, retention and stability
3. Severe bone resorption leading to changes in vertical dimension
4. Should not be used in fractured dentures
5. Patients who cannot maintain oral hygiene

## MODE OF APPLICATION

Removal of saliva, food debris on the tissue surface of the denture



Wet the dentures before using adhesive



Smaller quantities of adhesive powder or cream are applied onto the tissue surface of denture



Location: For maxillary arch apply onto the alveolar ridge, hard palate area, posterior palatal seal .

For mandible adhesive is applied on to the entire sulcus



Place the denture onto the tissues with firm pressure for a minimum of 5 - 10 seconds



Gauze is used to clean the adhesive

## CONCLUSION

- Denture adhesives are very beneficial in compromised cases to improve the physical and mechanical factors affecting the denture. It also provides psychological assurance to new denture wearers. But they should not be used to compensate the deficits of the dentures.

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*Please Give Your Feedback on this Answer*

**Q. 07: Alloys for RPD framework (6M).****Alloys for metal ceramic restorations (6M).****Age hardening of alloys (7M).****Noble metal alloys (10M, 6M)****CONTENTS/SYNOPSIS**

Introduction

History of metals in the field of dentistry

Desirable properties of casting alloys

Classification of dental casting alloys

- General classification
- Mechanical classification
- Classification based on specific use

Noble metals

- Gold for all metal restorations
  - Gold and gold alloys
- Heat treatment of gold alloys
  - Softening heat treatment
  - Hardening heat treatment
- Noble alloys for Metal ceramic restorations
  - Pd-Cu alloys (Palladium-copper)
  - Pd-Ag alloys (Palladium-silver)
  - Au-Pd-Ag alloys (Gold-palladium-silver)
  - Au-Pd alloys (Gold-palladium)
  - Au-Pt-Pd alloys (Gold- platinum-palladium)

Base metals

Classification of base metal alloys

Types of base metal alloys

- Nickel chromium (Ni - Cr) system
- Cobalt chromium (Co - Cr) alloys
- Titanium & Titanium Alloys

Guidelines for selection of alloys

Conclusion

References

## INTRODUCTION

- Dental casting alloys play an important role for the fabrication of prosthetic restorations.
- It has a combination of strength, elastic modulus, resistance to wear and biocompatibility for a long-term survival.
- Alloys have better physical properties on comparison with pure metals for the purpose of fabrication of prosthesis.
- They are designed for specific purposes like
  - Inlays
  - Onlays
  - Crowns and bridges
  - Partial dentures
  - Porcelain fused metal restorations

## HISTORY OF METALS IN THE FIELD OF DENTISTRY

2500	B.C gold bands and wires were used by Phoenicians
1746	Gold shell crowns were made by Mouton, patented by Beers in 1873
1885	Logan patented porcelain fused platinum post
1907	Lost-Wax Technique
1933	Replacement of gold with Co-Cr in RPDs
1950	Development of Resin Veneers for Gold Alloys
1959	Porcelain- Fused-to-Metal Technique
1968	Pd-Based Alloys as Alternative to Gold Alloys
1971	Ni-Based Alloys as Alternative to Gold Alloys
1980's	All-Ceramic Technologies
1999	Au Alloys instead of Pd-Based Alloys

## DESIRABLE PROPERTIES OF CASTING ALLOYS

Depending on the type of prosthesis the casting alloy is chosen

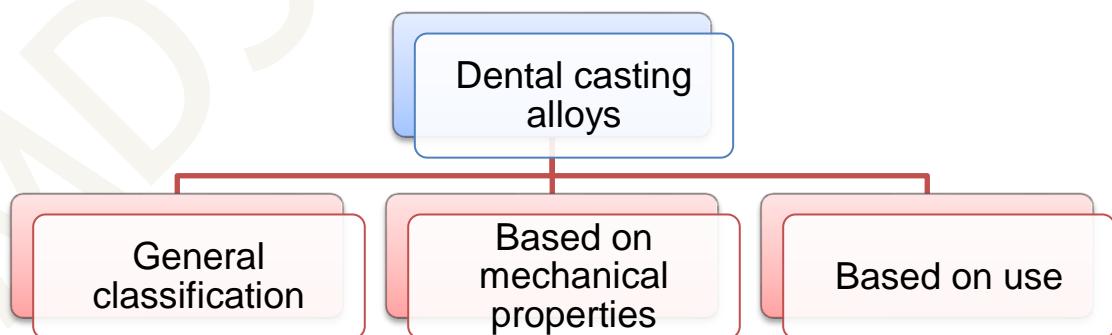
- **Biocompatibility:** Alloy should not react or leach metal ions with an exposure to oral environment
- **Non allergic:** Few patients might be allergic to metals; hence it is ideal to have a very detailed case history and decide the treatment planning for the prosthesis
- Ease of **fabrication**

- Ease of melting with a **minimum melting range** to form smooth surface on casting
- Reaction to mold (investment material) should be very minimum
- Alloys with **lower solidus temperature** are to be used to prevent shrinkage after cooling
- Alloy should be **hard enough to resist wear** by opposing natural tooth or restoration
- **Tarnish and corrosion resistance**
  - Tarnish is formation of thin film as a deposit or interacted layer over the metal surface. Commonly seen in silver and gold alloy which has higher silver content
  - Corrosion is formation of oxidized components leading to discoloration of natural teeth, veneers and soft tissues. They may also create galvanic shock leading to a metallic taste. Noble metals are resistant to corrosion
- **Thermal properties:** Alloys should have thermal expansion closer to porcelain to tolerate higher processing temperatures
- Should have the **ability to bond** to porcelain by creating an adherent oxide layer

### Elastic Modulus (GPa)

Cobalt chromium: 125-220	Nickle chromium: 145-190	Pure titanium: 117	Palladium based alloys: 110-135	Gold based alloys: 75-110
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### CLASSIFICATION



## I. General Classification (American Dental Association 1984)

### High noble alloys:

More than 40 wt% gold + 60wt% other noble metals.

### Noble alloys:

More than 25 wt% noble metals, i.e. no limit for gold content.

### Predominantly base metal alloy:

More than 75wt% base metal + less than 25wt% noble metals.

## II. Mechanical Classification

Types	Description	Yield strength (Minimum)	Percent elongation (Minimum)
Type 1: Low strength	For castings subjected to very slight stress (e.g., inlays)	(0.2% offset), 80 MPa	18 %
Type 2: Medium strength	For castings subjected to moderate stress (e.g., inlays, onlays, and full crowns),	(0.2% offset), 180 MPa	10 %
Type 3: High strength	For castings subjected to high stress (e.g., onlays, thin copings, pontics, crowns, and saddles)	(0.2% offset), 270 MPa	5 %
Type 4: Extra-high strength	For castings subjected to very high stress (e.g., saddles, bars, clasps, thimbles, certain single units, and partial denture frameworks)	(0.2% offset), 350 MPa	3 %

- Strength & hardness increases from type 4 - 1
- Ductility & % elongation decreases from type 1 - 4

## III. Classification based on specific use

1. Alloys used for All metal prostheses	2. Alloys used for Metal ceramic restorations	3. Alloys for RPD framework
<b>Noble metal alloys</b> <ul style="list-style-type: none"> <li>Gold based alloy: Type III, Type IV, low</li> </ul>	<b>Noble metal alloys</b> <ul style="list-style-type: none"> <li>Au - Pt - Pd alloy</li> <li>Au - Pd - Ag alloy</li> </ul>	<b>Noble metal alloys</b> <ul style="list-style-type: none"> <li>Type IV gold alloy</li> </ul>

<p>gold alloys</p> <ul style="list-style-type: none"> <li>Non gold based alloy: Ag - Pd alloy</li> </ul> <p><i>Base metal alloys</i></p> <ul style="list-style-type: none"> <li>Nickel based alloys</li> <li>Cobalt based alloys</li> </ul> <p><i>Others</i></p> <ul style="list-style-type: none"> <li>Copper - Zinc with Indium and Nickel</li> <li>Silver - indium with palladium</li> </ul>	<ul style="list-style-type: none"> <li>Au - Pd alloy</li> <li>Pd - Ag alloy</li> <li>High palladium alloy</li> </ul> <p><i>Base metal alloys</i></p> <ul style="list-style-type: none"> <li>Ni - Cr alloy</li> <li>Co - Cr alloy</li> </ul>	<p><i>Base metal alloys</i></p> <ul style="list-style-type: none"> <li>Co - Cr alloy</li> <li>Ni - Cr alloy</li> <li>Co - Cr - Ni alloy</li> <li>Ag - Pd alloy</li> <li>Al - bronze alloy</li> </ul>
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## NOBLE METAL ALLOYS

- Consists of eight noble metals
- Gold, Platinum, palladium, rhodium, ruthenium, iridium, osmium and silver
- Since silver is reactive in oral environment, it is not considered for prosthesis

### I. Gold for All metal restorations

- Direct restorations (pure gold)
- Indirect restorations (Gold alloy - dental cast noble alloy)

#### 1. Gold

##### Characteristics

- Ductile & malleable
- Weaker and softer
- Tarnish & corrosion resistance
- Yellowish in colour
- Melting point:  $1083^{\circ}\text{C}$
- Density:  $19 \text{ g/cm}^3$
- Coefficient of Thermal Expansion:  $14 \times 10^{-6}/^{\circ}\text{C}$

## 2. Gold Alloys

- According to ADA specification No 5 gold alloys are divided into

High gold alloys  
Type I, II, III, IV

Low gold alloys

White gold alloys

### i. High Gold Alloys

- Consists of  $\geq 70\%$  by weight gold, palladium and platinum

Type I (soft)	Type II (Medium)	Type III (Hard)	Type IV (Extra hard)
- Weaker, soft, high ductility burnished easily	- Harder, good strength, ductility like type I	- Used in areas under high stress	- Used in areas under very high stress
- Used in areas where occlusal stresses are lower	- Used in areas where stresses are moderate	- Eg. Crown and bridge	- Eg. Crowns & long span bridges.
- Eg. Inlays for class I, III, V cavities	- Eg. Inlays, onlays, three quarter crowns, pontics, full crowns	- Can be age hardened	- Most responsive to heat treatment, yield strength with lesser ductility
- Currently used very rarely			

### Composition

Au - 83%	Au - 77%	Au - 75%	Au - 56%
Ag - 10%	Ag - 14%	Ag - 11%	Ag - 25%
Cu - 6%	Cu - 7%	Cu - 9%	Cu - 14%
Pt - 0	Pt - 0	Pt - 0	Pt - 0
Pd - 0.5%	Pd - 1%	Pd - 3.5%	Pd - 4%
Zn & Ga - balance			

## Properties

Property	Type I	Type II	Type III	Type IV
Hardness (VHN)	50-90	90 - 120	120 - 150	150 - 200
Tensile strength	Low - 276 MPa	345 MPa	360 MPa	462 MPa
Yield strength	180 MPa	300 MPa	331 MPa	703 MPa
Linear casting shrinkage	1.56 %	1.37%	1.42%	2.30%
Ductility/ Elongation	46% (William O Brien) 18% (Anusavice)	40.5% (William O Brien) 10% (Anusavice)	39.4% (William O Brien) 5% (Anusavice)	17% (William O Brien) 3% (Anusavice)

## Heat treatment of Gold Alloys

- Heat treatment is done to alloys to improve or alter the mechanical properties.
- Gold alloys with enough copper content (Type III & IV) can be heat treated.
- There are two types of heat treatment
  - Softening heat treatment (Solution heat treatment)
  - Hardening heat treatment (Age hardening)

1. Softening heat treatment	2. Hardening heat treatment
<ul style="list-style-type: none"> <li>This treatment increases ductility, but decreases tensile strength, hardness and proportional limit.</li> </ul>	<ul style="list-style-type: none"> <li>This treatment increases strength, hardness and proportional limit, but reduces the ductility. Copper in the gold alloy helps in hardening process.</li> </ul>
<ul style="list-style-type: none"> <li><b>Indicated</b> for frameworks that are to be shaped or altered or cold worked in or outside the oral cavity</li> </ul>	<ul style="list-style-type: none"> <li><b>Indicated</b> for cast partial dentures, saddle pontics and bridges. Not used for smaller inlays.</li> </ul>

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li><b>Method:</b> Casting is placed in an electric furnace for 10 minutes at a temperature of <math>700^{\circ}\text{C}</math> followed by quenching. In this stage all the intermediate phases in the alloy are converted to solid solution which is disorderly in fashion. Rapid quenching is done to prevent ordering</li> </ul> | <ul style="list-style-type: none"> <li><b>Method:</b> it is performed by ageing or soaking the casting at a specific temperature base on the type of alloy (<math>200 - 450^{\circ}\text{C}</math>) for about 15 - 30 minutes followed by quenching. in this period the intermediate phases are changed into solid solution in an orderly fashion</li> </ul> |
|---|--|

Platinum	Palladium	Iridium, Ruthenium
<ul style="list-style-type: none"> <li>Increases corrosion resistance , strength, melting point</li> <li>Whitens the alloy</li> <li>Resuces the grain size</li> </ul>	<ul style="list-style-type: none"> <li>Similar to platinum</li> <li>Increases the hardness, fusion temperature</li> <li>Whitens the alloy</li> <li>Provides resistance to tarnish</li> <li>Less expensive than platinum</li> </ul>	<ul style="list-style-type: none"> <li>Decreases the grain size</li> </ul>

## ii. Low Gold Alloys

- They are also called as economy gold, as they were developed due to increased prices in gold
- Used for crown and bridge alloys with gold content less than 60% (42 - 55%), with gold as major element
- Disadvantage:** Due to decrease in gold content there is an increase in tarnish and corrosion on comparison with high gold alloys.
- This drawback can be overcome by adding palladium which makes the silver in the alloy resistant to tarnish (For every 3% silver, 1% palladium is required)

## iii. White Gold Alloys

- These alloys are introduced in 1930's
- Composition: Gold (30%), palladium (10 - 35%), silver (35 - 65%) and copper (6-25%)

The characteristic feature of white colour in this alloy is due to the addition of palladium, which acts as a potent whitener and also absorbs the gases produced during melting of alloy that may lead to porosity in castings

## II. Noble metal alloys For Metal-Ceramic Restorations

- Chronologically the alloys developed for ceramic-metal restorations were Au-Pt-Pd, Ni-Cr, Co-Cr, Au-Pd-Ag, Pd-Ag, Au-Pd, Pd-Cu, and Ti

### 1. Au-Pt-Pd alloys (Gold- platinum-palladium)

- It is the oldest alloy system used for metal ceramic restorations. Currently they are not widely used as they are very expensive

#### Composition

Gold: 75 - 88%  
Palladium: 11%  
Platinum: 8%  
Silver: 5%  
Trace elements like Indium, Iron and Tin

Advantages	Disadvantages
<ol style="list-style-type: none"><li>Castability is excellent</li><li>Porcelain bonding is good</li><li>Finishing and adjustments are at ease</li><li>Nobility level is high</li><li>Resistance to corrosion and tarnish is excellent</li><li>Biocompatible</li><li>Yellowish in colour</li><li>Can be burnishes</li><li>Easy to fabricate</li></ol>	<ol style="list-style-type: none"><li>Cost is expensive</li><li>Sag resistance is poor, not indicated for long span FPDs</li><li>Hardness is less, hence higher wear</li><li>Density is high</li></ol>

## 2. Au-Pd alloys (Gold-Palladium)

- This is developed to improve the Au-Pt-Pd system and Au-Pd-Ag systems

### Composition

Gold: 44 - 55%

Gallium: 5%

Palladium: 33 - 45%

Indium and Tin: 8 - 12%

Indium, Gallium and Tin are responsible for porcelain bonding

Advantages	Disadvantages
<ol style="list-style-type: none"><li>1. Effective Castability</li><li>2. Bond strength is good</li><li>3. Resistant to corrosion and tarnish</li><li>4. Hardness and strength are improves</li><li>5. Density is less</li></ol>	<ol style="list-style-type: none"><li>1. No compatible with high expansion porcelain</li><li>2. Higher cost</li></ol>

## 3. Au-Pd-Ag alloys (Gold-Palladium-Silver) (High Silver)

- These alloys are developed to overcome the limitations of Au-Pt-Pd systems

### Composition

Gold: 39 - 53%

Silver: 12 - 22%

Palladium: 25 - 35%

Trace amounts of oxidizable elements are added for porcelain bonding

Advantages	Disadvantages
<ol style="list-style-type: none"> <li>1. Cost effective when compared to Au-Pt-Pd alloys</li> <li>2. Sag resistance is improved</li> <li>3. Rigidity is good</li> <li>4. Malleable</li> </ol>	<ol style="list-style-type: none"> <li>1. Porcelain discoloration due to high silver</li> <li>2. CTE is high</li> <li>3. Tarnish and corrosion resistance is less</li> </ol>

#### 4. Pd-Ag alloys (Palladium-silver)

- This is the 1st gold free system

##### Composition

- Available in two compositions

Palladium: 55 - 60%	Palladium: 50 - 55%
Silver: 25 - 30%	Silver: 35 - 40 %
Indium & Tin	Tin (Minimum to No Indium)
Trace elements of other oxidizable elements are also present	

Advantages	Disadvantages
<ol style="list-style-type: none"> <li>1. Less cost</li> <li>2. Density is low, hardness is low</li> <li>3. Castability is good</li> <li>4. Porcelain bonding is good</li> <li>5. Burnishable</li> <li>6. Nobility level is moderate</li> <li>7. Tarnish and corrosion resistance are good</li> <li>8. Can be given for long span FPDs</li> </ol>	<ol style="list-style-type: none"> <li>1. Discolorations on porcelain</li> <li>2. May cause problems during casting</li> <li>3. Palladium and silver absorb gases</li> <li>4. Internal oxides may form</li> <li>5. Carbon crucible is contraindicated</li> <li>6. CTE is high</li> </ol>

#### 5. Pd-Cu alloys (Palladium-copper)

##### Composition

Palladium: 70 - 80%

Copper: 9 - 15%

Gold: 1 - 2%

Platinum: 1%

Trace amounts of oxidizable elements like gallium, indium and tin are added for porcelain bonding

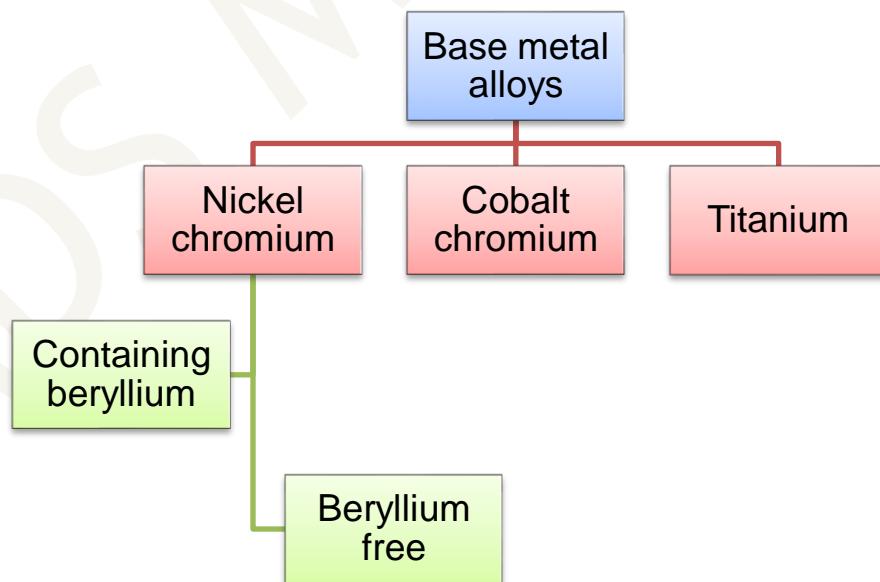
Advantages	Disadvantages
<ol style="list-style-type: none"> <li>1. Castability is good</li> <li>2. Cost is less when compared to gold alloys</li> <li>3. Density is low</li> <li>4. Resistance to tarnish &amp; corrosion</li> <li>5. Compatible with porcelains</li> <li>6. Available as ingots</li> </ol>	<ol style="list-style-type: none"> <li>1. Oxide formation is seen in dark colour</li> <li>2. Discoloration to porcelain</li> <li>3. Carbon crucible should not be used</li> <li>4. Gaseous absorption</li> <li>5. Thermal creep</li> <li>6. Not suitable for long span FPDs</li> <li>7. Difficulty in polishing, soldering</li> </ol>

## BASE METAL ALLOYS

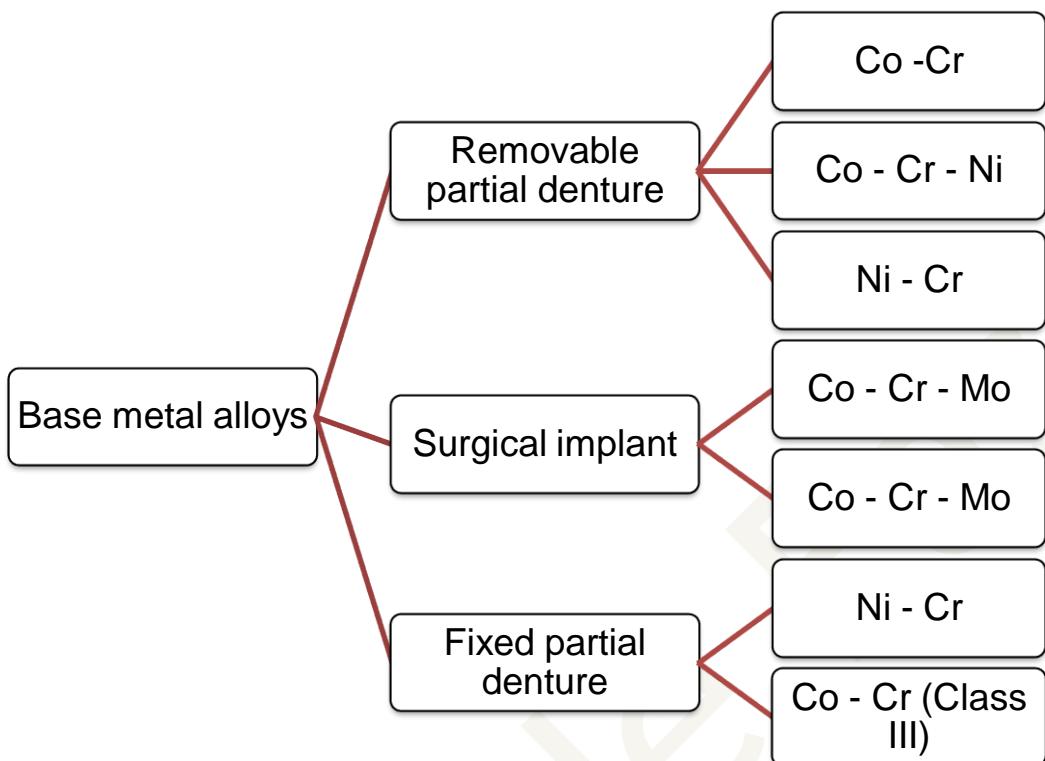
- Base metal alloys used in dentistry includes silver, zinc, copper, indium, tin, gallium, nickel
- They are used for
  - Cast partial denture framework
  - As a casting and wrought alloy
  - Manufacturing of surgical instruments
  - Periodontal splints

## Classification

### I. Based on Composition



## II. Based on Prosthetic use



### Nickel Chromium (Ni - Cr) system

- According to Bertolotti, these are used to fabricate all metal crowns, fixed partial dentures.
- Major elements are nickel and chromium with a minimum alloying element

<i>Ni - Cr - Beryllium free alloys</i>	<i>Ni - Cr- Beryllium alloys</i>
<p><b>Composition</b></p> <ul style="list-style-type: none"> <li>Nickel: 62 - 77 %</li> <li>Chromium: 11 -22%</li> <li>Trace elements like boron, iron, molybdenum or columbium or tantalum are used</li> </ul>	<p><b>Composition</b></p> <ul style="list-style-type: none"> <li>Nickel: 62 - 82%</li> <li>Chromium: 11 - 20%</li> <li>Beryllium: 2%</li> <li>Trace elements like aluminium, carbon, iron, gallium, molybdenum, manganese, silicon, titanium or vanadium are present</li> </ul>

<b>Advantages</b> <ol style="list-style-type: none"> <li>1. Lower cost</li> <li>2. Lower density</li> <li>3. More casting per ounce of metal</li> </ol>	<b>Advantages</b> <ol style="list-style-type: none"> <li>1. Superior properties on comparison with Ni - Cr alloy</li> <li>2. Lower cost</li> <li>3. Density is less, hence permitting more casting per ounce</li> <li>4. Sag resistance is high</li> <li>5. Can produce thin castings</li> <li>6. Poor thermal conductor</li> <li>7. Can be etched to improve retention</li> </ol>
<b>Disadvantages</b> <ol style="list-style-type: none"> <li>1. Cannot be used in patients with nickel sensitivity</li> <li>2. Cannot be etched as chromium does not dissolve in acids</li> <li>3. Inferior in casting on comparison to NI - Cr - Be alloys</li> <li>4. Produces more oxides</li> </ol>	<b>Disadvantages</b> <ol style="list-style-type: none"> <li>1. Cannot be used in patients with nickel sensitivity</li> <li>2. Exposure to beryllium may harm technicians and patients</li> <li>3. Technique sensitive</li> <li>4. Failure of bond is common due to formation of oxide layer</li> <li>5. Hardness is high (may cause wear)</li> <li>6. Soldering is difficult</li> <li>7. Difficult to cut through cemented castings</li> </ol>

### Properties of Ni - Cr Alloys

Density	8 g/cm <sup>3</sup>	Difficult to fabricate defect free castings
Fusion temperature	1350°C	Needs electrical induction furnace or oxyacetylene
Casting shrinkage	2%	Can be compensated by right choice of investment materials
Tensile strength	600 MPa	Adequate
Proportional limit	230 MPa	Prevents distortion
Modulus of elasticity	220 GPa	Higher MOE is an advantage for making larger restoration like bridges, PFM
Hardness	300 VHN	Difficult to polish
Ductility	30%	Can be burnished

## Cobalt Chromium (Co - Cr) alloys

- They are in use since 1920's.
- Possess higher strength, excellent resistance to corrosion and tarnish at high temperatures, bright lusture.
- They are also called as satellite because of their appearance like a shiny star under different conditions

Composition	Applications
<ul style="list-style-type: none"> <li>• Cobalt: 55 - 65%</li> <li>• Chromium: 23 - 30%</li> <li>• Nickel: 0 - 20%</li> <li>• Molybdenum: 0 - 7%</li> <li>• Iron: 0 - 5%</li> <li>• Carbon: upto 0.4%</li> <li>• Trace elements: Tungsten, managanese, silicon and platinum</li> </ul>	<ul style="list-style-type: none"> <li>• Denture base</li> <li>• Cast partial framework</li> <li>• Surgical implants</li> </ul>

- According to ADA no 14, a minimum 85% by weight of Chromium, cobalt and nickel is required

## Properties

Density	8 - 9 g/cm <sup>3</sup>	Difficult to fabricate defect free castings, but denture frameworks are lighter
Fusion temperature	1500°C	Needs electrical induction furnace or oxyacetylene
Casting shrinkage	2.3%	Can be compensated by right choice of investment materials
Tensile strength	850 MPa	Acceptable
Proportional limit	710 MPa	Acceptable, resists stress without causing deformation
Modulus of elasticity	225 GPa	More rigid. Good for fabricating connectors, but for clasps it is a disadvantage
Hardness	432 VHN	Difficult to polish
Ductility	2 %	May fracture while doing adjustments

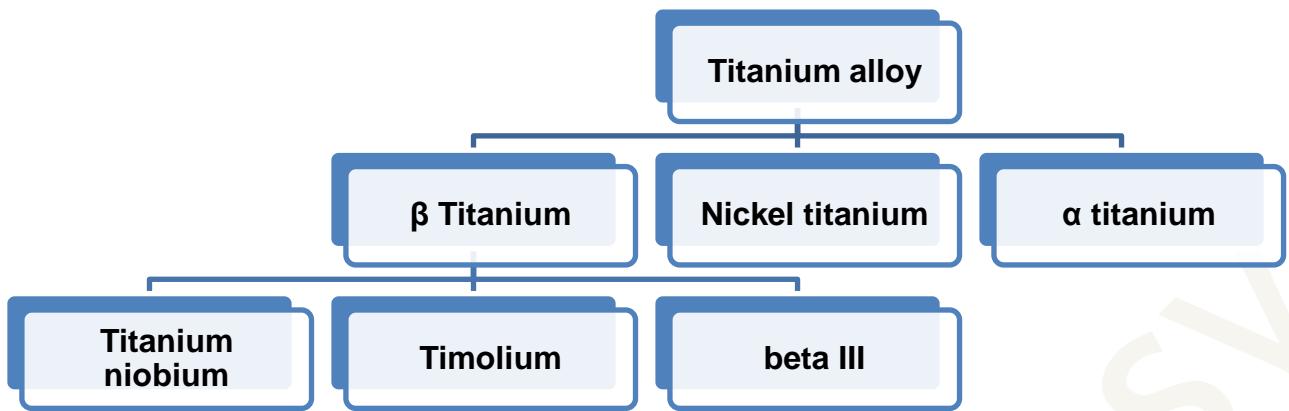
## Function of Various Alloying Elements

- **Chromium** is responsible for the tarnish and corrosion resistance of these alloys.
- **Cobalt** improves the physical properties like hardness, strength, elastic modulus.
- One of the most effective ways of increasing the hardness of cobalt-based alloys is by increasing their **carbon** content. A change in the carbon content of approximately 0.2% changes the properties to such an extent that the alloy would no longer be usable in dentistry as it becomes too hard or brittle.
- The presence of 3% to 6% **molybdenum** contributes to the strength of the alloys.
- **Aluminum** in nickel-containing alloys forms (Ni<sub>3</sub>Al) which increases the ultimate tensile and yield strengths of the alloy.
- The addition of 1% to 2% **beryllium** to nickel-based alloys lowers the fusion range by about 100°C.
- **Silicon and manganese** are added to increase the fluidity and castability of these alloys.
- **Nitrogen**, which cannot be controlled unless the castings are made in a controlled atmosphere, such as in a vacuum or under argon, also contributes to the brittle qualities of these cast alloys. When the nitrogen content of the final alloy is more than 0.1%, the castings lose some of their ductility.

## Comparison of properties of Ni - Cr and Co - Cr alloys

Property	Ni-Cr without Be	Ni-Cr with Be	Co-Cr
Strength (MPa)	255-550	480-830	415-550
Ultimate tensile strength (MPa)	550-900	760-1380	550-900
% elongation	5-35	3-25	1-12
Modulus of elasticity (MPa)	13.8-20.7 x 10 <sup>4</sup>	17.2-20.7 x 10 <sup>4</sup>	17.2-22.5x10 <sup>4</sup>
Vickers hardness	175-350	300-350	300-500
Casting temperature (°C)	1430-1570	1370-1480	1430-1590

## Titanium & Titanium Alloys



### Properties of titanium for their use in dentistry are

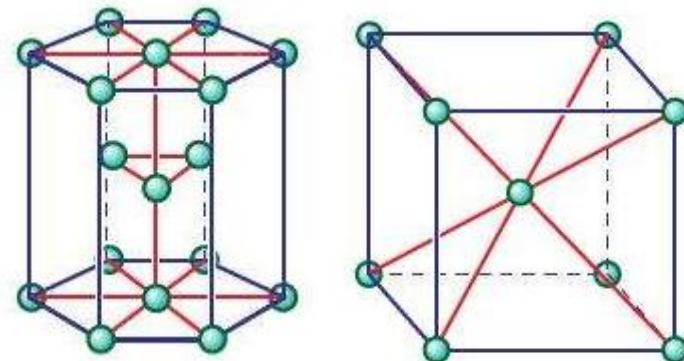
- High corrosive resistance
- Biocompatibility
- Nonmagnetic property
- Low specific gravity
- High strength

Titanium forms a very stable oxide layer making it resistant to corrosion and highly biocompatible, hence it is called the "material of choice" in dentistry

### Commercially Pure Titanium(cpTi)

#### Uses

- Dental implants, surface coatings, crowns, partial & complete dentures, and orthodontic wires.
- Commercially pure Ti is available in four grades according to the oxygen (0.18 to 0.40 wt%) and iron (0.20 to 0.50 wt%) content.



cpTi -  $\alpha$  phase (HCP) at room temperature,  $\beta$  Phase (BCC) on heating at  $883^{\circ}\text{C}$

- A component with a predominantly  $\beta$  phase is stronger but more brittle than a component with  $\alpha$  phase microstructure.

### Ti-6Al-4V

- It is also widely used titanium alloy in the field of dentistry
- At room temperature, Ti-6Al-4V exists as a two-phase ( $\alpha + \beta$ ) alloy.
- At approximately 975°C, an allotropic phase transformation takes place, transforming into single-phase BCC  $\beta$  alloy.
- This class of microstructure is recommended for Ti-6Al-4V surgical implants.

### Nickel-Titanium Alloys (Nitinol)

Ni	55% Ni
Ti	45% Ti
n	Naval
o	Ordnance
l	Laboratory

### Properties

- Low stiffness hence less forces
- Corrosion resistance is excellent
- Energy stored is larger than stainless steel
- Undergoes phase transformation with the changes in temperature
- At high temp, low stress - Austenite (BCC, ordered fashion)
- At low temp, high stress - Martensite (HCP, disordered fashion)
- Shape memory & super elasticity are unique properties of NiTinol

### Clinical Applications

Ideal for **orthodontic wires** when low forces are required under larger working range

Ideal for **endodontic files** in root canals that are curved to avoid penetration

### Disadvantages

1. Ability to be formed is limited
2. Friction is higher than stainless steel and lower than titanium
3. Difficult to solder
4. Cost effective
5. Nickel is allergic

## GUIDELINES FOR SELECTION AOF ALLOYS

1. Choosing the right alloy for a prosthodontic restoration is a difficult task.
2. There is no proven regulation for ideal alloy selection.
3. Avoid selecting the metal alloys based on their colour until and then their properties are similar
4. A thorough knowledge on composition of alloys and its specific use in laboratory is needed to eliminate selection of alloys which are allergic to patients and its use
5. Select use of single-phase alloys over multiple phase alloys
6. Keeping a track record of the type of alloy used for every patient
7. Select alloys from manufacturers who do studies on their alloys as they can provide most accurate information
8. Alloys that have minimal or no elemental release and with least corrosion properties
9. Should choose an alloy that is comfortable in laboratory use
10. An alloy must be chosen based on its clinical situation (like esthetics, occlusal, spacing, allergy) and its long-term performance

## CONCLUSION

- It is not always possible to use noble metals, precious metals and alloys for prosthetic fabrication.
- Most cast partial denture frameworks are fabricated using chrome cobalt alloys even though noble alloys are superior.
- Care should be taken to choose the right alloy for a longer outcome

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*Please Give Your Feedback on this Answer*

**Q. 08: Explain biocompatibility of dental materials. Describe briefly about the adverse effects from dental materials (10M).**

**Biocompatibility tests used in dentistry (10M)**

**Tissue response to alloys used in prosthodontics (20M)**

## CONTENTS/SYNOPSIS

Introduction

Ideal requirements of dental materials for biocompatibility

Evaluating the factors of concern towards biocompatibility

- Patient safety
- Safety of dental personnel
- Regulatory compliance issue
- Legal liability

Biological interface

- Factors affecting
- Types of interfaces

Systemic and Local Effects of Dental Materials

Levels of biocompatibility

- General biocompatibility
- Immunological biocompatibility
- Bio - energetic biocompatibility

Measuring the Biocompatibility

Types of tests to measure biocompatibility

- Invitro
- Animal tests
- Usage tests
- Examples
- Advantages and disadvantages

Phases in biomaterial testing

- Primary test
- Secondary test
- Usage test

Standards which regulate the biocompatibility measurement

Conclusion

References

## INTRODUCTION

- The major factors leading to a success in dental materials are:
  - Properties of material
  - Design
  - Biological compatibility of materials
- Biocompatibility is the ability of a material to elicit an appropriate biological response in each application in the body.
- It generally depends on
  - Chemistry of the material
  - Physical properties
  - Soft and hard tissues that are exposed to the material
  - Duration
  - Amount of substances leaching from material
- Since no material is compatible biologically there might be some adverse effects, hence it is important to test the biocompatibility for risk analysis

## IDEAL REQUIREMENTS OF DENTAL MATERIALS FOR BIOCOMPATIBILITY

Should not

1. Sensitize locally or systemically
2. Produce allergic response
3. Be carcinogenic
4. Contain substances that may diffuse easily and cause toxicity
5. Be harmful to adjacent soft and hard tissue in oral cavity

## EVALUATING THE FACTORS OF CONCERN TOWARDS BIOCOMPATIBILITY

- Following are the factors to be in concern of dental professional regarding biocompatibility

### I. Patient safety

- Evidence says that adverse reactions through dental materials is not common, but still can happen
- These reactions can be systemic or local
- Hence it is the responsibility of the professional to assess the risk factors of dental materials to be used based on their history

### II. Safety of dental personnel

- The staff are the ones who are exposed primarily while fabrication, processing or manipulation.
- Examples: mercury vaporization, chronic exposure to latex gloves,

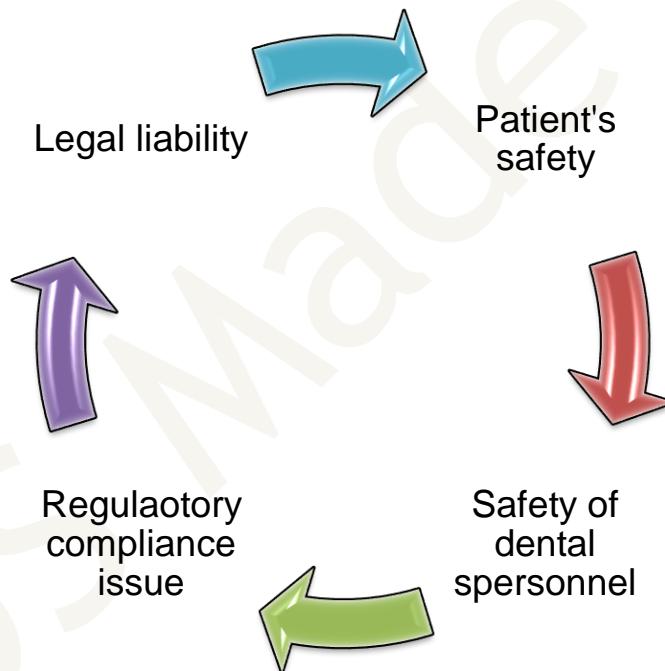
- resin materials, metal dust during trimming of metal frameworks
- Hence care should start from dental personnel by using proper protective measure

### III. Regulatory compliance issue

- Issues of biocompatibility are often linked to regulations that may affect dental practice.
- Example: use of latex, mercury waste

### IV. Legal liability

- Chances of legal risk as dental materials may affect the well being of patients and dental personnel
- Generally, it is rare to have legal issues due to biomaterials in dentistry
- But when they do happen, it might cause problems emotionally and financially to the dentist



## BIOLOGICAL INTERFACE

- Biological interface refers to interaction between body and the material, which is not normally present
- This interface is a dynamic interaction
- These interfaces depend on

### Factors

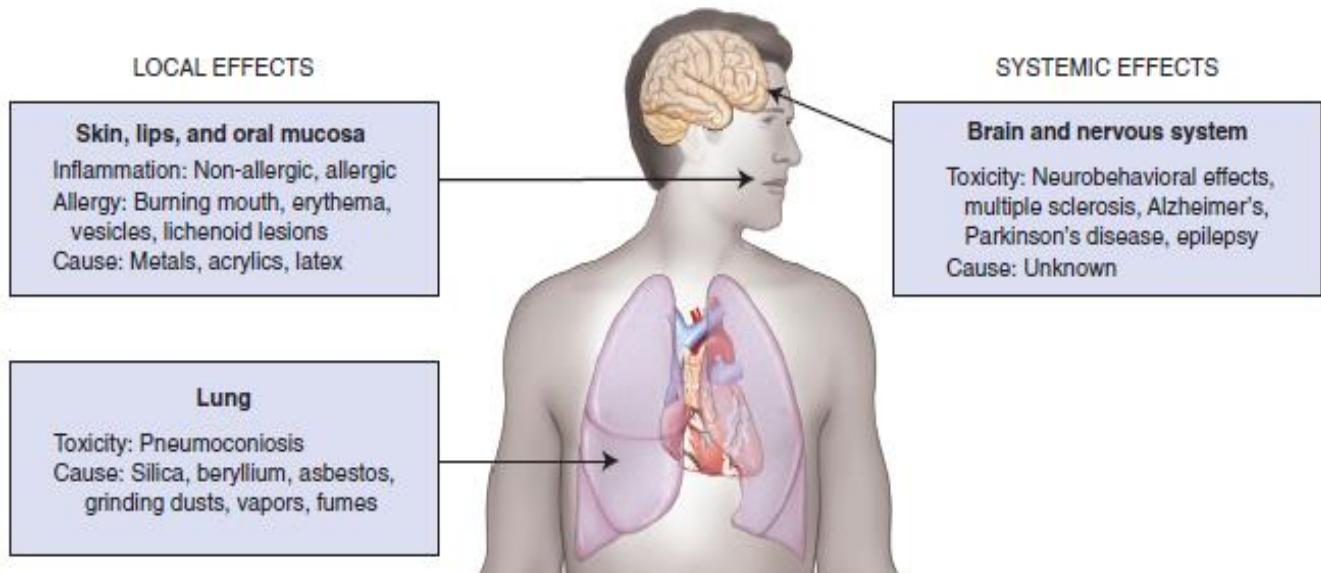
- Location of material
- Its duration in the body
- Properties of the material
- Health of the host

### Types of interfaces between

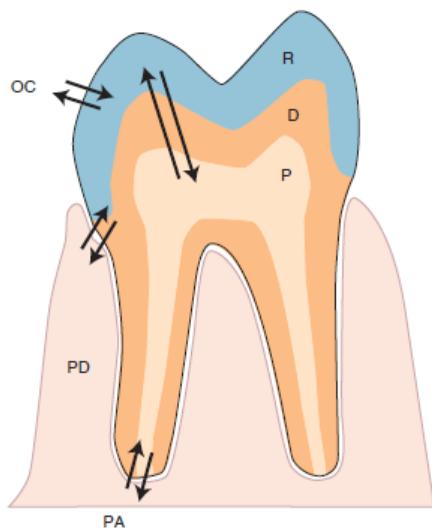
- Material and oral cavity
- Material and pulp
- Material and periodontium
- Material and periapical bone

## SYSTEMIC AND LOCAL EFFECTS OF DENTAL MATERIALS

- Systemic side effects of materials used in dental field are rare with a frequency of 1:1000 to 1:10,000, which depends on type of treatment and material used.
- Generally artificial materials on exposure to oral environment produces few risks of side effects and adverse reactions like;
  - Toxicity
  - Inflammation
  - Allergic reactions



Restorative Material	Adverse Effects (Systemic & Local)
<i>Dental amalgam</i>	<ul style="list-style-type: none"> <li>• Contact dermatitis</li> <li>• Sensitivity to metals</li> <li>• Lichenoid reaction</li> <li>• Adverse pulpal response</li> <li>• Postoperative sensitivity</li> <li>• Sensitivity of pulp to heat</li> <li>• Symptoms of acute/ chronic mercury toxicity</li> </ul>
<i>Cements</i>	<ul style="list-style-type: none"> <li>• Eugenol cement is a cytotoxic and allergic materials</li> <li>• Sensitivity due to GIC</li> </ul>
<i>Acrylic denture base materials, Resin based composite</i>	<ul style="list-style-type: none"> <li>• Contact dermatitis</li> <li>• Facial dermatitis to dental personnel due to BIS - GMA</li> <li>• Sensitivity to methacrylate</li> <li>• Cytotoxic effect to systemic health</li> <li>• Systemic effects due to inhalation of free monomers, leached substrate</li> <li>• Postoperative sensitivity due to marginal gaps and stress created from polymerization</li> <li>• Overextended denture causes local irritation</li> <li>• Burning sensation of oral mucosa due to leaching of residual monomer</li> </ul>
<i>Cast metal alloys</i>	<ul style="list-style-type: none"> <li>• Contact dermatitis</li> <li>• Sensitivity to metal alloys (nickel, copper, beryllium)</li> <li>• Lichenoid reaction</li> <li>• Systemic effects due to leaching of metal ions</li> <li>• Gingivitis and stomatitis due to RPD metal framework</li> <li>• Occupational hazard to the dental personnel due to constant exposure to inorganic dust may cause pneumoconiosis</li> <li>• Overhanging restorative margin may cause local irritation</li> </ul>
<i>Ceramics</i>	<ul style="list-style-type: none"> <li>• Excessive wear due to opposing tooth substrate leads to excessive silica exposure causing respiratory effects</li> <li>• Susceptibility to chipping or fracture of ceramic veneer</li> </ul>



Pathway of degraded dental materials leaching into the tooth anatomy  
 R - Restoration  
 D - Dentin  
 P - Pulpal tissue  
 OC - Oral cavity  
 PD - Periodontal ligament  
 PA - Periapical tissue and bone

## LEVELS OF BIOCOMPATIBILITY

### General biocompatibility

- Determines the toxicity of material at cellular level

### Immunological biocompatibility

- Determines the reaction at individual level
- Tests used are Clifford materials reactivity test, Kinesiologic testing

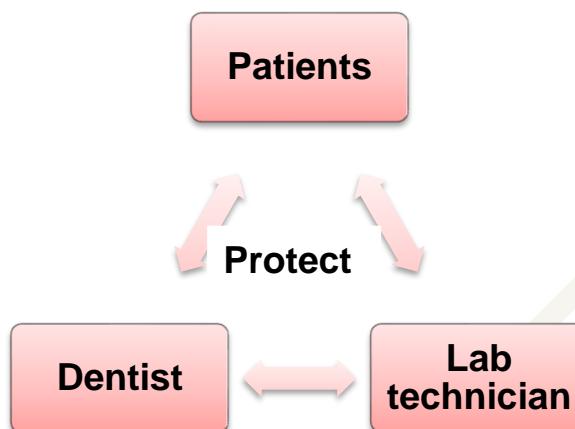
### Bioenergetic biocompatibility

- It determines the interaction of material with body on an energetic level
- Tests used are Electrodermal screening, Applied kinesiology

## MEASURING THE BIOCOMPATIBILITY

### Primary Purpose

- To protect (patients, dentists, technicians) from exposure during handling the dental materials



## TYPES OF BIOCOMPATIBILITY TESTS

- It is not possible to measure biocompatibility of any dental material by using one single test method.
- It is needed to be evaluated by a series of in vivo and in vitro test
- Austian (1970) introduced a structured approach in testing biocompatibility

### I. Non specific toxicity (Cell culture/ small laboratory animals)

- These tests are conducted on models which do not simulate clinical scenario

### II. Specific toxicity (Usage tests)

- These are conducted on models which simulates the clinical condition

### III. Human clinical trials

According to **Philips** there are three types of tests used to measure biocompatibility

Invitro tests

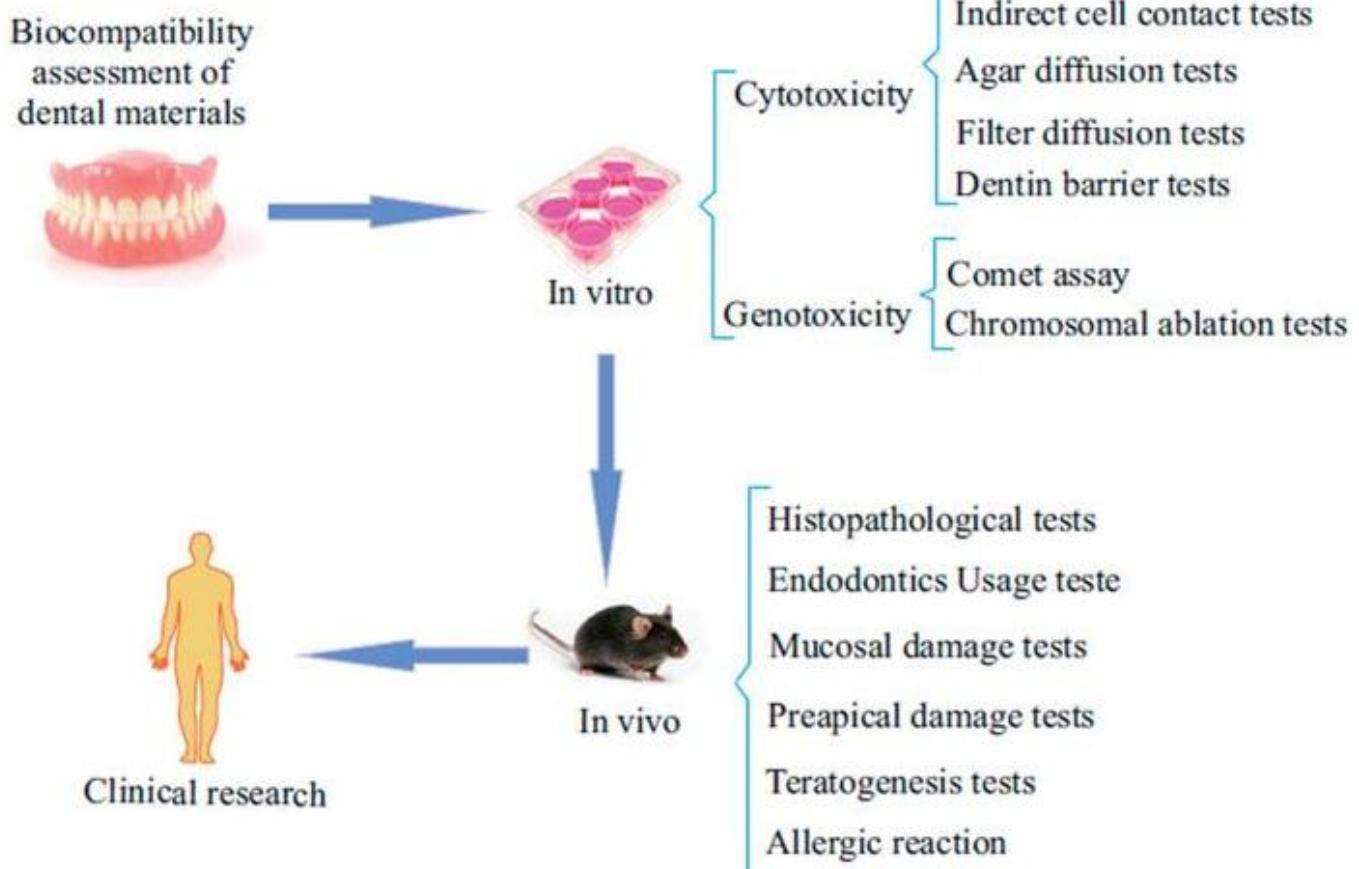
Animal tests

Usage tests

Parameter	In Vitro Tests	Animal Tests	Usage Tests
<b>Testing area</b>	External to the organism	A material into an intact organism of some type	<ul style="list-style-type: none"> <li>In animals or humans (clinical trials)</li> <li>The human clinical trial is the "gold standard" of usage tests</li> </ul>
<b>Conducted in</b>	Test tube, cell-culture dish, flask or another container	Mice, rats, hamsters, ferrets, or guinea pigs, but many other- types of animals have been used, including sheep, monkeys, baboons, pigs, cats, and dogs	Direct contact with animal
<b>Biological system</b>	Consist of mammalian cells, cellular organelles, tissues, bacteria, or some sort of enzyme	Direct contact with animal	Mucosa and gingival usage test, Intraosseous implant test
<b>Types</b>	Cytotoxicity test <ul style="list-style-type: none"> <li>Direct</li> <li>Indirect</li> </ul>	Mutagenesis assay <ul style="list-style-type: none"> <li>Short-term or long-term systemic toxicity</li> <li>Exposure to intact or abraded membranes</li> <li>Immune sensitization or bone response</li> </ul>	Tests for detecting cell <ul style="list-style-type: none"> <li>Relevance to the use of material is assured</li> </ul>

Examples of Invitro tests	Examples of Animal tests	Examples of Usage tests
<ul style="list-style-type: none"> <li>Cytotoxicity tests</li> <li>Cell metabolism/ function tests</li> <li>Barrier usage tests</li> <li>Mutagenesis assay</li> </ul>	<ul style="list-style-type: none"> <li>Test on irritation of mucous membrane</li> <li>Sensitization test on skin</li> <li>Implantation tests</li> </ul>	<ul style="list-style-type: none"> <li>Irritation of dental pulp tests</li> <li>Mucosa usage tests</li> <li>Gingiva usage tests</li> </ul>

Test	Advantages	Disadvantages
In vitro tests	Quick to perform Least expensive Can be standardized Large-scale screening Good experimental control Excellence for mechanisms of interactions	Relevance to in vivo is questionable
In vivo tests	Allows complex systemic interactions Response more comprehensive than in vitro tests More relevant than in vitro tests	Relevance to use of material is questionable Expensive Time consuming Legal/ethical concerns Difficult to control Difficult to interpret and quantify
Usage tests	Relevance to use of material is assured	Very expensive Very time consuming Major legal/ethical issues Can be difficult to control Difficult to interpret and quantify



## PHASES IN BIOMATERIAL TESTING

To test a new biomaterial there are generally three types of tests



- Initial testing done on the new material
- Mostly Invitro tests are used and rarely to check the systemic toxicity animal tests are done
- A material will go to next level testing only if it passes the primary test
- Eg., Invitro testing of a new alloy

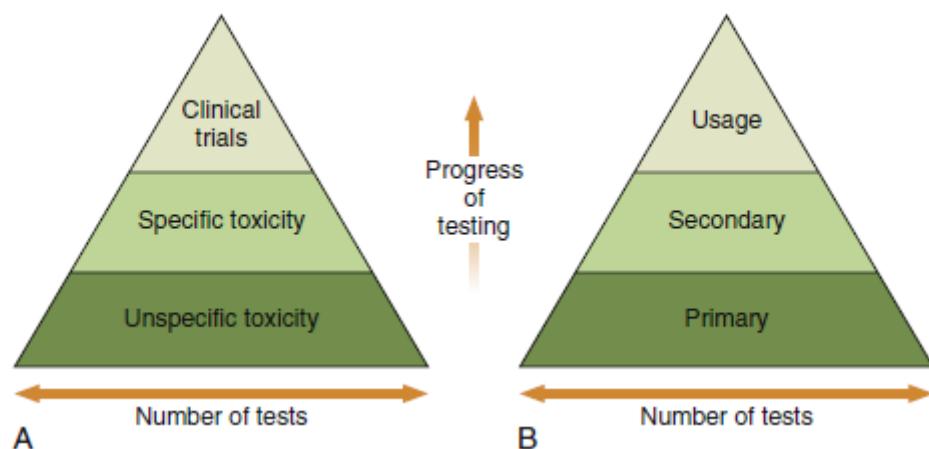


- Generally conducted in animals
- Secondary tests explore beyond toxicity or mutagenicity toward issues such as allergy, inflammation, and other sub lethal and chronic biological responses
- Only materials that have favourable results in the secondary tests are subjected to usage tests



- The material must be tested in a clinically relevant situation

Strategies for the usage of biocompatible tests to assess the safety of materials:



A - Early strategy to test the toxicity, B - Contemporary strategy (most standard)

**STANDARDS WHICH REGULATE THE BIOCOMPATIBILITY MEASUREMENT**

- ANSI (American National Standard Institute)/ADA (American Dental Association) Specification 41
- ISO (International Organization for Standardization) 10993

**CONCLUSION**

- It is mandatory for the dental practitioner to understand and know the importance of biocompatibility of dental materials, to provide a maximum benefit and minimum risk to the patient.

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**Please Give Your Feedback on this Answer**

**Q. 03: Write in detail about casting defects (7M)**

**Principles of casting (7M)**

**Porosities in dental casting (7M)**

**Casting in dentistry - note on casting defects. Describe in detail how to avoid them (20M, 15M)**

**Induction casting (15M)**

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## INTRODUCTION

- Casting is defined as the act of forming an object in a mold by solidification of a fluid that has been injected into the mold (GPT 8)
- It is a commonly used procedure in the field of dentistry to make restorations such as inlays, onlays, crowns, bridges and removable partial dentures.
- The procedure of obtaining the restoration from a wax pattern includes a series of steps based on the type of restoration being cast



## HISTORY

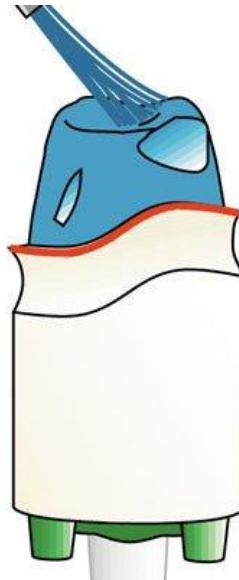
- Earlier days casting has been a technique used by craftsmen to fabricate jewelry

<b>3000 B.C</b>	<b>Mesopotamians casted copper</b>
<b>11th Century</b>	Theophilus described lost wax technique as a technique to fabricate jewelry
<b>1558</b>	Benvenuto cellini has attempted casting of gold and bronze
<b>1884</b>	Aghulihon de saran used 24K gold to form inlay
<b>1887</b>	J. R. Knapp invented blow pipe, which used for casting
<b>1897</b>	Phillibrook described casting of metal filling
<b>1907</b>	William Taggart introduced <i>Lost wax technique</i>
<b>1908</b>	Lane introduced the idea of casting in a bigger mold using silica as an investment material. He was the 1st scientist to introduce <i>mold expansion</i> to compensate shrinkage
<b>1910</b>	Van horn discovered the importance of <i>wax expansion</i>
<b>1930</b>	Carl Scheu discovered <i>Hygroscopic setting expansion</i>

## DIE PREPARATION

- A die is prepared from die stone or the impression is electroformed.
- Commonly used die materials are Type IV (0.1% setting expansion), Type V (0.3% setting expansion) and non gypsum materials like acrylic, epoxy resins, polyester are also being used.
- Greater the expansion, higher the capacity to compensate shrinkage of alloys.

- A die spacer is coated or painted over the die to provide relief space for the luting cement
- The most used die spacers are resins (also model paints, nail polish, polymers dissolved in volatile liquids), applied 0.5mm above the finish line to provide relief for luting cement and accommodate complete seating of restoration.



### WAXING/ FORMATION OF THE WAX PATTERN

- There are two fundamental ways to prepare a wax pattern for a dental restoration
  1. Direct wax pattern
  2. Indirect wax pattern

Direct Wax Pattern	Indirect Wax Pattern
<ul style="list-style-type: none"><li>• In this direct method, the pattern is prepared on the tooth in the mouth.</li><li>• This method can only be used for small inlay restorations.</li><li>• Type-I Inlay wax is used</li></ul>	<ul style="list-style-type: none"><li>• In this method, a model (die) of the tooth is first made, and then the pattern is made on the die</li><li>• This method is used for all types of restorations</li><li>• Type II Inlay wax is used</li><li>• The advantage of the indirect method is, it makes the property of flow less critical, because pattern may be removed at a lower temperature and with greater ease from the die</li></ul>

## SPRUE AND PRINCIPLES OF SPRUE DESIGN

- Sprue pin or sprue former is defined as the channel through which molten metal or ceramic flows into the mold cavity.

### Objectives of sprue former

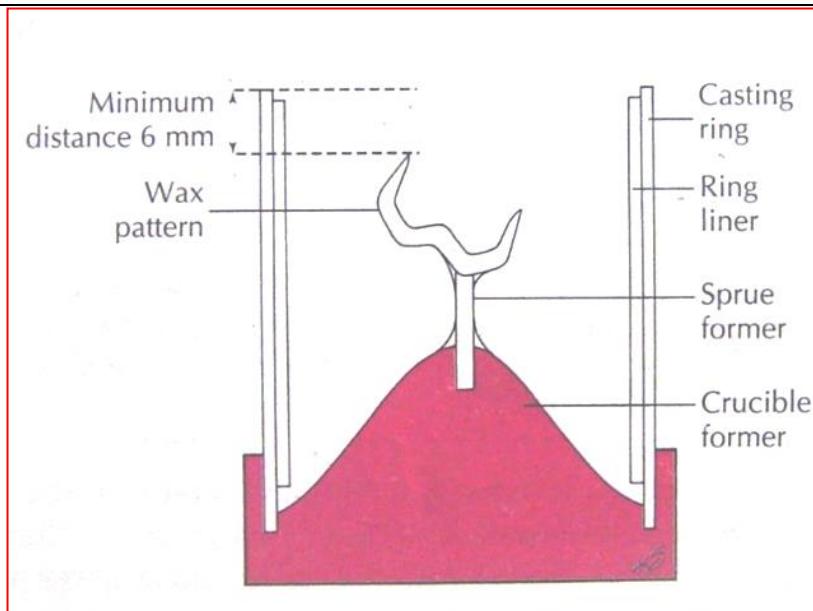
1. To form a mount for the wax pattern
2. To create a channel for the elimination of wax during burn out
3. To form a channel for the flowing - in of molten alloy during casting
4. To compensate for alloy shrinkage during solidification procedure

### Sprue design

- According to Brown & Sharpe, prefabricated wire gauge numbers and diameters

DIAMETER		
Brown & Sharpe Gauge Number	mm	in.
6	4.115	0.1620
8	3.264	0.1285
10	2.588	0.1019
12	2.053	0.0808
14	1.628	0.0641
16	1.291	0.0508
18	1.024	0.0403

<b>Sprue size</b>	<ul style="list-style-type: none"> <li>• Large inlays require sprues that are 14 - gauge (4 to 5 mm long) and</li> <li>• Small inlays require 16 - gauge (3 to 4 mm long) sprues.</li> <li>• Large crowns require 10 - gauge sprues and</li> <li>• Small crowns require 12 - gauge sprue</li> </ul>
<b>Sprue Length</b>	<ul style="list-style-type: none"> <li>• With an average sprue length of 4 to 5 mm, the wax pattern should be positioned approximately 6 mm from the end of the casting ring</li> </ul>



<b>Types of Sprue</b>	<ul style="list-style-type: none"> <li>• <b>Wax:</b> used for casting of small and large casting, which use single stage burnout</li> <li>• <b>Plastic/Resin:</b> used for castings of alloys which use to stage burn out with Phosphate bonded investment. Their main disadvantage is its softening temperature, which is higher than wax pattern and may block escape of wax. They may be used for casting FPD's because of their high rigidity, which minimizes distortion. Plastic sprues may be completely solid (or) hallow plastic help in wax eliminate</li> <li>• <b>Metal sprues:</b> should be a non-rust metal to avoid contamination of wax. Hallow metallic sprue increase contact surface area and strengthen the attachment between the sprue and pattern. They are removed from the investment at the same time as the crucible former. Care should be taken to examine for any fractured investment material after metal sprue removal</li> <li>• For small inlays, a hollow - metal sprue may be used</li> <li>• Plastic sprues have also been used for casting</li> </ul>
<b>Sprue Diameter</b>	<ul style="list-style-type: none"> <li>• Should be the size of the thickest part of the wax pattern.</li> <li>• Smaller the size of wax pattern, smaller the sprue size should be.</li> <li>• Larger sprue on smaller pattern may cause distortion and very small sprue diameters may cause localized shrinkage porosity due to early solidification</li> </ul>

	<ul style="list-style-type: none"> <li>The Y - sprue design is often used on MOD inlay restorations</li> </ul>
<b>Position of sprue</b>	<ul style="list-style-type: none"> <li>Ideal position for the sprue former is the greatest bulk point or area of the wax pattern, which allows flow of molten alloy through the cavity completely</li> </ul>
<b>Sprue Direction</b>	<ul style="list-style-type: none"> <li>Should be directed toward the margins such that it minimizes the turbulence of the flow of the molten metal and favors the fine margins of the wax pattern</li> <li>To get a satisfactory casting it is attached at a 45-degree angle to the proximal area</li> </ul>
<b>Sprue Attachment</b>	<ul style="list-style-type: none"> <li>Sprue former is attached to the wax pattern in a flared manner allowing the entry of the molten metal into the area</li> <li>It should be attached to the largest area of the wax pattern in cross sectional view for easy flow and minimum turbulence</li> <li>Patterns can be attached to the wax pattern either directly or indirectly</li> <li>Direct spruing: Sprue former provides direct connection between wax pattern and base sprue or crucible former</li> <li>Indirect spruing: A Reservoir is placed in between the wax pattern and crucible former, Used for multiple single or FPD units</li> </ul> <p><b>Attachment morphology</b></p> <ul style="list-style-type: none"> <li>The attachment of sprue former to the wax pattern should be such that the transition is smooth and do not possess pits / irregularities into which investment can flow</li> <li>Irregularities produces tags of investment which is vulnerable for fracture by molten alloy leading to casting failure.</li> <li>Usually it is flared for high density gold alloys but restricted for low density alloys</li> </ul>

- Once spruing is done the wax pattern and sprue former assembly is carefully removed from the die.

- During removal of pattern no pressure should be applied to prevent its distortion. Then it is positioned into the crucible former to adjust the distance between the wax pattern and casting ring.

### Advantages of flaring of sprue and pattern attachment

- Tuccillo and Nielsen → flaring minimizes investment debris and aspirated air; allow smooth flow of molten metal.
- Nielsen and Shalita → flaring cause the spread of heat over an increased region.
- The effects of sprue attachment designs were evaluated using 4 different sprue designs
  1. Straight
  2. Flared
  3. Gradual constriction
  4. Abrupt constriction
- It was found that Straight and flared sprue attachment produced better castability and less porosity than, either of constricted sprue attachment.

### CRUCIBLE FORMER

- The sprue is attached to crucible former which constitutes the base of casting relation with casting ring during investing
- It helps by holding sprue in desired ring
- Crucible formers are basically of 2 types

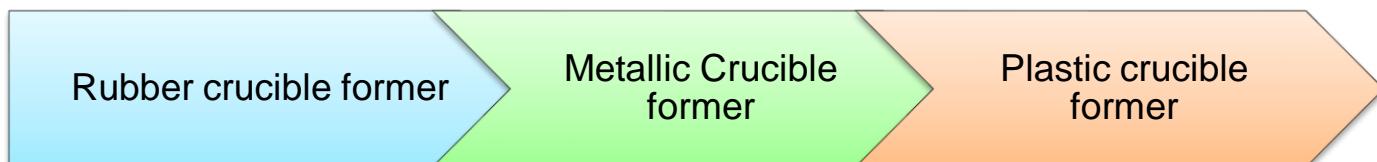
#### 1. Steep-sided core

- Used when casting is done using centrifugal casting force
- The tall crucible formers allow the use of short sprue

#### 2. Shallow cone

- Used to cast metal using stream/air pressure

### Available as



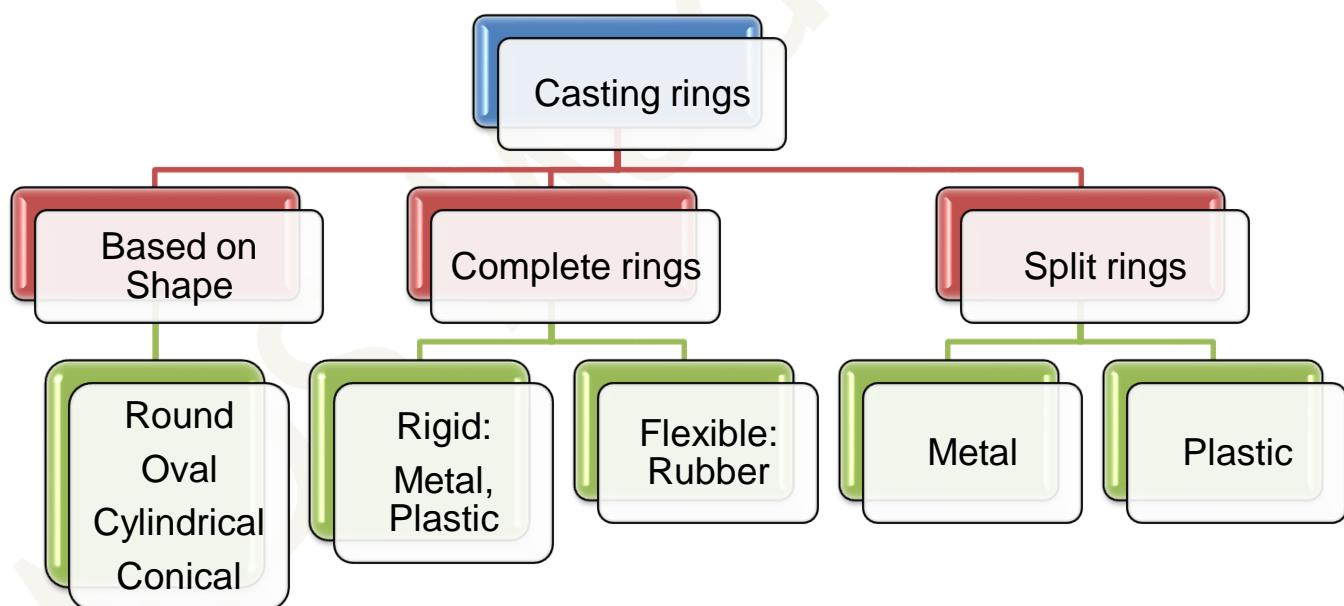
- They form a conical depression in investment, which guides flow of molten metal.
- It should be clean.
- The attachment area should be smooth and without irregularities to prevent creation of investment tags which are vulnerable to fracture when alloy is forced into mold.

## CASTING RINGS

- Casting rings are used to confine the fluid investment around the wax pattern while the investment sets.

### Considerations in selection of castings rings

- The internal diameter of casting ring should be 5 - 10mm greater than the widest measurement of the pattern and about 6 mm higher.
- For single crown/inlay small rings are used with a diameter of 32 mm
- For large fixed partial denture, 63mm round/oval shaped casting ring are used.
- They are available as



### Ringless Casting System

- Plastic ring with rubber crucible formers are used. T
- Conical in shape with tapering walls.
- As the investment sets the investment is tapped out of ring followed by burnout without casting ring leading to greater expansion.
- Used for traditional gold-based alloys.

- Usually casting rings are rigid in nature
- Because of this the mold may become smaller rather than larger due to the reverse pressure resulting from confinement of the setting expansion
- To overcome this flexible rings/ split rings are used
- But the most used technique is to provide expansion by lining the ring with a ring liner

## CASTING RING LINER

### Objectives

1. Allows for mold expansion
2. Reduces the heat loss (as it is a thermal insulator) when the ring is transferred from the furnace to the casting
3. Permits the easy removal of the investment after casting

### Types

#### 1. Asbestos Ring Liners

- Use has been discontinued due to its health hazards

#### 2. Non - Asbestos Ring Liners

- Alumino silicate ceramic liner
- Cellulose (paper) liner

### Asbestos liner

- Asbestos acts a refractory material to higher temperature and shows an enough water sorption
- There are 3 types of asbestos
  1. White asbestos (least toxic) – Used in dentistry
  2. Blue asbestos (most toxic)
  3. Brown asbestos (Intermediately toxic)
- Asbestos is no longer used in dentistry as it causes diseases like asbestosis, Bronchogenic lung cancer, mesothelioma
- The carcinogenic action is due to the dimensions and durability of asbestos fibers, which are greater than  $4\mu\text{m}$  in length and less than  $1.5\mu\text{m}$  in diameter  
(According to JPD 1987; 57, 362-369 it is  $8\mu\text{m}$  length and  $0.25\mu\text{m}$  diameter)

**Cellulose liner**

- Shows adequate water absorption.
- It is burnt during burnout procedure, hence, to keep the investment in contact with ring after burnout the liner is kept 3mm short of ring ends.
- It also restricts the longitudinal setting and hygroscopic expansion.

**Ceramic ring liner**

- Made of alumino-silicate fibrous material.
- They do not absorb water, but its network of fibers can retain small amount of water on its surface or wetting agents can be used to increase the water sorption
- Acts as refractory to higher temperature.
- The binder in ceramic liner may cause toxicity leading to development of Mesothelioma
- They posses fibers of length 5.3-17.8  $\mu\text{m}$ , diameter 0.2 - 0.97  $\mu\text{m}$ .

**INVESTING**

Investing is the process by which the wax pattern along with sprue attachments is embedded in a material called an investment



Before investing the wax, pattern should be free of debris or oil etc., to provide better wetting of investment material



A wetting agent is applied on the wax pattern to reduce air bubbles



Gypsum and phosphate bonded investment materials are used for this purpose



Mix the investment in a vacuum mixer and vibrate



A casting ring is added to contain the investment while the material is poured carefully around the pattern



Some investment is applied on the wax pattern with a brush to reduce the trapping of air bubbles placed on the vibrator and gradually filled with the remaining investment mix. Allow it to set for 1 hour

- The incidence of nodules on casting is more in hand mixing than vacuum mixing. Application of surface tension reducing agent decreased the nodules (Johnston, IJP, 1992, 5; 424-433).
- The best method is vacuum mix and vacuum pour technique. But most popular method vacuum mix and open pour.

## Factors affecting setting of investment

### *In open air*

- Usually when high-heat thermal expansion technique is used, the investment can set in open air for 1 hour.
- The setting time is 1 hour for both gypsum and phosphate bonded investments.

### *Hygroscopic technique*

- Once the casting ring is poured it is immersed into a water bath at temperature  $38^{\circ}\text{C}$  immediately
- This can be altered by

Water/Powder ratio  $\rightarrow$  Lesser the W: P  $\rightarrow$  Higher the HSE

Time of immersion  $\rightarrow$  longer the delay of immersion is lesser the HSE

Increase in water bath temperature  $\rightarrow$  increases HSE

## BURNOUT

- Burnout is *the process of heating an invested mold to eliminate the embedded wax or plastic pattern.*

## Purpose

1. To eliminate the wax (pattern) from the mould
2. To expand the mould (thermal expansion)
3. To eliminate residual water in investment
4. Avoids the temperature differences between the hot molten alloy and investment

## Procedure

Remove the crucible former and metal sprue after the investment material is set  
 ↓

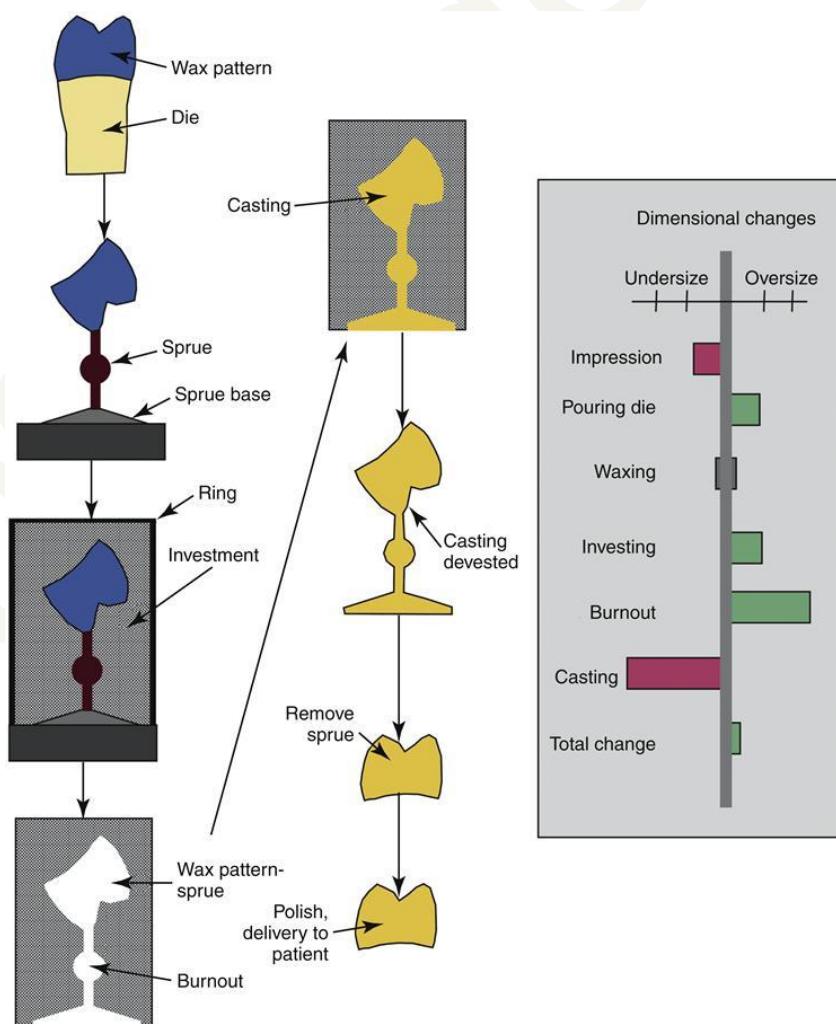
Burnout should start immediately while the materials is still wet or else it must be preserved in a humidifier  
 ↓

Heating should be gradual to a prescribed maximum temperature based on the type of investment material  
 ↓

For Gypsum bonded it may range from 500 - 700°C, for phosphate bonded it may range from 700 - 1030°C based on type of alloys and expansions  
 ↓

Rapid heating produces steam which causes the walls of the mould cavity to flake and causes cracks in the investment due to uneven expansion  
 ↓

The casting should be completed as soon as the ring is ready. If casting is delayed the ring cools and the investment contracts and the crown become smaller



## CASTING PROCESS

- It involves the process of melting the casting alloy and forcing the molten alloy into the mold by using casting machines.
- Requires Heat source and Casting force

### Heat source for melting the alloy

- There are two methods of alloy melting
  1. Torch melting
  2. Electrical melting

<i>Torch Melting</i>	<i>Electrical Melting</i>
Most common method of melting	---
Used for melting of gold alloys	Can be used for all types of alloys (It is desirable to use a flux for gold crown and bridge alloys to aid in minimizing porosity)
The fuel used in most instances is a mixture of natural or artificial gas and air, although oxygen-air and acetylene can also be used	It includes electric resistance melting which uses a furnace with a carbon or ceramic crucible

### Parts of Flame

<i>Mixing zone</i>	<ul style="list-style-type: none"> <li>• Zone in which the air and gas are mixed before combustion</li> <li>• <i>No heat is present in this zone</i></li> </ul>	Yellow	---
<i>Combustion zone</i>	<ul style="list-style-type: none"> <li>• The gas and air are partially burned</li> <li>• It should always be kept away from the molten alloy during fusion</li> </ul>	Green	Oxidizing
<i>Reducing zone</i>	<ul style="list-style-type: none"> <li>• <i>The hottest part of the flame</i></li> <li>• It should be kept constantly on the alloy during melting</li> </ul>	Dimly Blue	Reducing in nature
<i>Oxidizing zone</i>	<ul style="list-style-type: none"> <li>• Area in which combustion occurs with the oxygen in the air</li> </ul>	----	<i>Oxidizing zone</i>

	<ul style="list-style-type: none"> <li>• <i>This portion of the flame should not be used to melt the alloy</i></li> </ul>		
--	---	--	--

## Flux

- When properly used, the flux increases the fluidity of the alloy, and the film of flux turned on the sulfate of the molten alloy helps prevent oxidation

## Types

Reducing Flux	Boric acid Flux
<ul style="list-style-type: none"> <li>• Reducing fluxes containing powdered charcoal are often used, but small bits of carbon may be carried into the mold and cause a deficiency at a critical margin</li> <li>• Although such reducing fluxes are excellent for cleaning old alloy, a better flux for the casting procedure may be made from equal parts of fused borax powder ground with boric acid powder.</li> </ul>	<ul style="list-style-type: none"> <li>• The boric acid aids in retaining the borax on the surface of the alloy. The flux is added when the alloy is completely melted and should be used with both old and new alloy</li> </ul>

## CASTING MACHINES

### Casting Crucible

- It is a refractory device which is that part of the casting machine, upon which the alloy is seated.
- There are four types of casting crucibles are available i.e. clay, carbon, quartz and zirconia - alumina.

Type of Crucible	Used for
Clay	Crown and bridge alloys
Carbon	Both crown and bridge alloys and for higher fusing gold-based metal ceramic alloys
Alumina, quartz or silica	For high fusing alloys of any type

### Types of Casting Machines

#### Centrifugal Casting Machine

- Centrifugal casting machine consists of a broken arm, on which metal alloy is heated using a torch flame on a ceramic crucible
- Flame is produced using a mixture of

- Propane and air
- Acetylene and air
- Natural gas and air
- Acetylene and oxygen
- The arm of the centrifugal machine initiates rotation, which causes the molten alloy from crucible to move through into the mold

#### ***Electrical Resistance-Heated Casting Machine***

- Current is used in this machine which passes through a resistance heating conductor
- The conductor heats the alloy in a graphite or ceramic crucible
- Used commonly for base metal alloy metal ceramic prosthesis
- Advantage: Alloy remains in molten state longer
- Carbon crucible is contraindicated for palladium alloys, cobalt chromium alloys and nickel chromium alloys

#### ***Induction Melting Machine***

- In this machine alloy is melted in an induction field within the crucible.
- Consists of a water-cooled metal tubing around
- Once the metal is molten either in air or vacuum, centrifugal forces are used to flow the metal into the mold
- Commonly used for base metal alloys

#### ***Direct-Current Arc Melting Machine***

- Consists of electrodes which can produce a temperature that exceeds 4000°C
- Alloys melts very quickly in this machine
- Disadvantage: High risk of overheating the metal, may cause damage to the mold

#### ***Vacuum / Air pressure type casting machine***

- In this machine molten alloys is moved into the mold by gravity or vacuum
- Additional pressure is used to force the alloy into the mold
- To melt platinum alloys, casting machine using vacuum arc heated-argon pressure is required

## CLEANING AND FINISHING OF THE CASTING

### Quenching

- Done for gold alloys after casting
- The alloy is left in an annealed (softened) condition for burnishing, polishing and similar procedures.
- The investment becomes soft and granular and is easily removed.

### Recovery of Casting

- After the casting process, investment is removed and casted metal is recovered

### Pickling

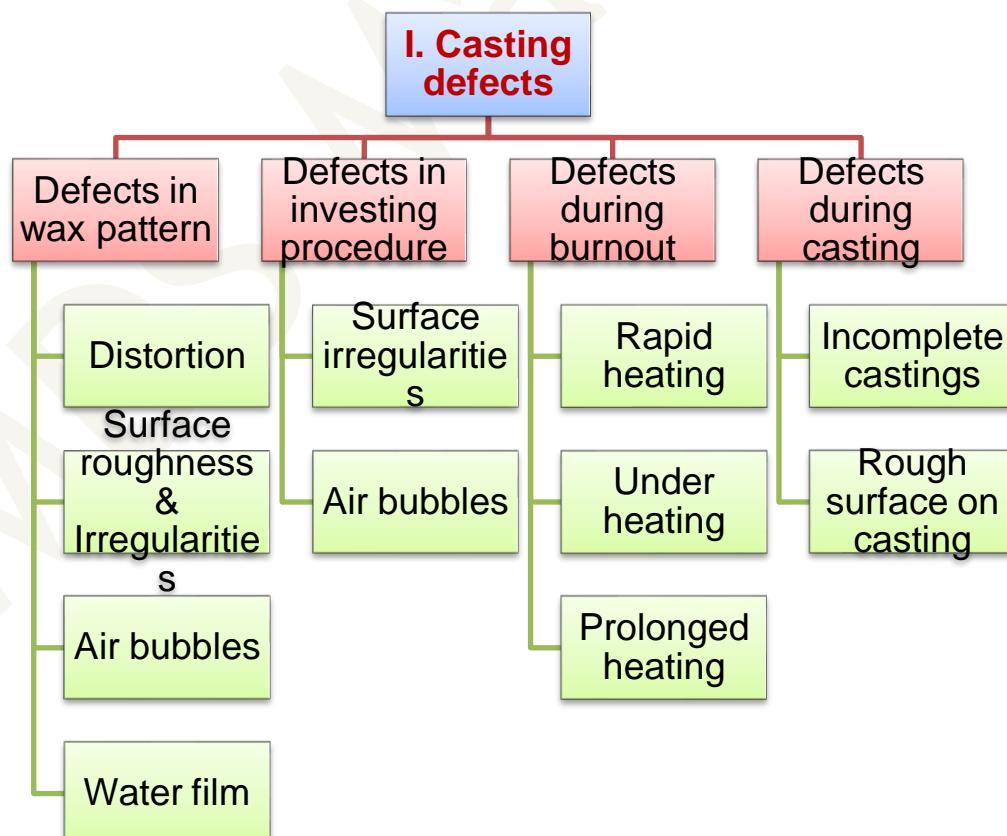
- It is a process of removal of surface films which consists of heating the discolored casting in an acid
- The acids used are 50% HCL and Sulphuric acid
- Causes corrosion due to hazard fumes

### Polishing

- Polishing has to be performed minimally to achieve the final results

## CASTING DEFECTS

### Classification of Defects



According to Anusavice	According to Rudd and Marrow
<ul style="list-style-type: none"> <li>• Distortion</li> <li>• Surface roughness and irregularities</li> <li>• Porosity</li> <li>• Incomplete or missing detail</li> </ul>	<ul style="list-style-type: none"> <li>• Incomplete casting</li> <li>• Rounded margins</li> <li>• Porosity</li> <li>• Rough surfaces on casting</li> <li>• Pits in casting</li> <li>• Fins in casting</li> <li>• Bubbles or nodules on casting</li> </ul>

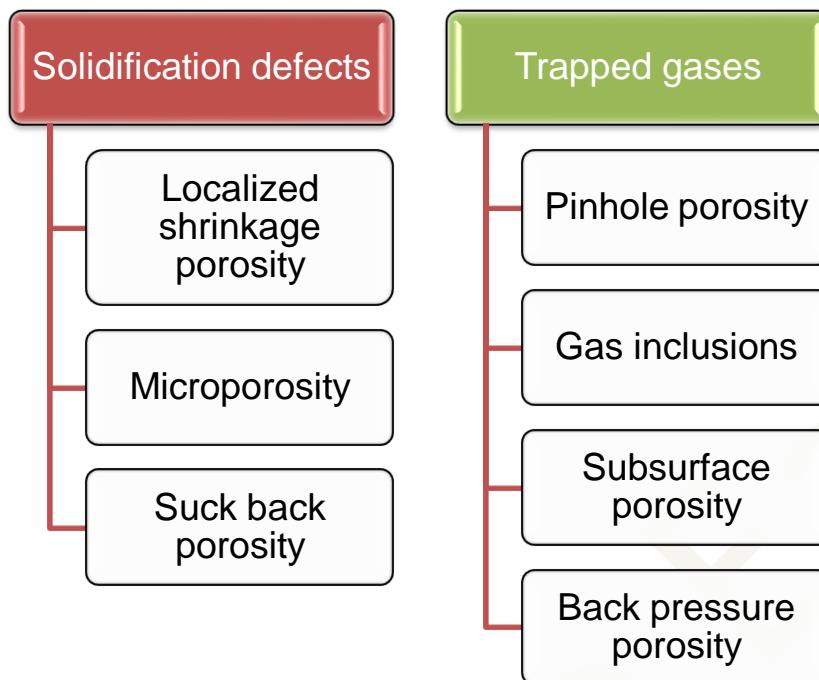
Defects & Causes	Avoided by
<p><i>1. Distortion</i></p> <ul style="list-style-type: none"> <li>• Due to the distortion of the wax pattern</li> <li>• Factors influencing distortion: Pattern design, type of wax used and thickness of wax.</li> <li>• Thinner the wax, higher is the distortion</li> <li>• Lower the setting expansion, lesser is the distortion</li> </ul>	<ul style="list-style-type: none"> <li>• Proper manipulation of wax</li> <li>• Proper handling of the wax pattern</li> </ul>
<p><i>2. Surface Roughness &amp; Irregularities</i></p> <ul style="list-style-type: none"> <li>• Surface roughness is a finely spaced imperfections on surface with predominant pattern.</li> <li>• Surface irregularities are called imperfections that are isolated over the entire surface. Eg; Nodules</li> </ul>	<ul style="list-style-type: none"> <li>• Following proper manipulation techniques</li> </ul>
<p><i>3. Air bubbles</i></p> <ul style="list-style-type: none"> <li>• Improper mix of investment material may produce air bubbles depositing over the surface of wax pattern, which leads to formation of small nodules on the casting</li> </ul>	<ul style="list-style-type: none"> <li>• Ideal method to avoid air voids is by using vacuum investing technique</li> <li>• In manual method, eliminate air from investment material by using a vibrator.</li> <li>• Application of wetting agent prevents the accumulation of air bubbles on the surface of</li> </ul>

	wax pattern
<b>4. Water films</b>	<ul style="list-style-type: none"> <li>Presence of dirt or oil films over the wax pattern may cause separation of investment material from the surface of wax leading to formation of watery film.</li> <li>Improper water powder ration of investment material or due to movement of wax pattern after pouring the investment.</li> <li>Appears as ridges or veins.</li> </ul> <ul style="list-style-type: none"> <li>Application of wetting agent</li> </ul>
<b>5. Liquid/ powder ratio</b>	<ul style="list-style-type: none"> <li>Ratio of liquid to powder of investment material must be followed accurately.</li> <li>Increased L/P ratio - Rough casting</li> <li>Incomplete removal of air from vacuum may cause rough casting</li> </ul> <ul style="list-style-type: none"> <li>Liquid and powder ratio of investment material must be measured accurately</li> </ul>
<b>6. Incomplete Casting</b>	<ul style="list-style-type: none"> <li>It is due to the molten alloy that has been prevented from completely filling the mold</li> <li>The causes are,</li> <li>Use of insufficient alloy</li> <li>High viscosity of the alloy</li> <li>Premature solidification of alloy</li> <li>Insufficient venting of the mold</li> <li>Low casting pressure</li> </ul> <ul style="list-style-type: none"> <li>Have casting temperature above indicated fusion temperature of alloy</li> <li>Use air pressure and vacuum machines with proper force</li> </ul>

## 7. Porosity

- It is the most common type of defects in casting procedures.
- It can occur both internal and external surface of the casting
- External porosity causes surface roughness, whereas internal porosity weakens the casting along with discoloration

## Classification of porosities in noble metal alloys are



Type of Porosity	Causes	Minimized by
<b>Localized Shrinkage Porosity</b>	<ul style="list-style-type: none"> <li>Caused by premature termination of the flow of molten metal during solidification</li> <li>Generally, occurs near the sprue casting junction</li> </ul>	Can be avoided by using sprue of correct thickness, attaching sprue to thickest portion of wax pattern and placing a reservoir close to the wax pattern
<b>Suck - Back Porosity</b>	<ul style="list-style-type: none"> <li>Often occurs at an occluso axial line angle or inciso axial line angle that is not well rounded</li> <li>The entering metal impinges on to the mold surface at this point and creates a higher localized mold temperature in this region known as a hot spot</li> </ul>	can be eliminated by flaring the point of sprue attachment and reducing the mold - melt temperature differential, i.e. lowering the casting temperature by about 300°C
<b>Microporosity</b>	<ul style="list-style-type: none"> <li>It results in small irregular voids</li> <li>It occurs from rapid solidification if the mold or casting</li> </ul>	It can be reduced by increasing the melting temperature of the

	temperature is too low	metal and mould temperature
<b>Pin Hole Porosity</b>	<ul style="list-style-type: none"> <li>Results from the entrapment of gas during solidification</li> <li>Many metals dissolve or occlude gases while they are molten. On solidification, the absorbed gases are expelled and thus pinhole porosity results.</li> </ul>	It can be minimized by pre-melting the gold alloy on a graphite crucible or a graphite block if the alloy has been used before
<b>Gas Inclusion Porosity</b>	<ul style="list-style-type: none"> <li>It is also resulting from the entrapment of gas during solidification and are usually much larger than pin hole porosities</li> <li>These porosities are caused by gas occluded from a poorly adjusted torch flame or by use of the mixing or oxidizing zones of the flame rather than the reducing zone</li> </ul>	It can be avoided by correctly adjusting and positioning the torch flame during melting
<b>Sub Surface Porosity</b>	<ul style="list-style-type: none"> <li>They may be caused by the simultaneous nucleation of solid grains and gas bubbles at the first moment that the alloy freezes at the mold walls</li> </ul>	Can be diminished by controlling the rate at which the molten metal enters the mold
<b>Entrapped-Air Porosity / Back Pressure Porosity</b>	<ul style="list-style-type: none"> <li>It produces large concave depressions which are caused by the inability of the air in the mold to escape through the pores in the investment or by the pressure gradient that displaces the air pocket toward the end of the investment via the molten sprue and button</li> <li>It is frequently found in a 'pocket' at the cavity surface of a crown on mesio occlusal distal casting</li> </ul>	It can be eliminated by proper burnout, an adequate mold and casting temperature, a sufficiently high casting pressure and proper P/L ratio

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5. Contemporary fixed prosthodontics- Rosenstiel
6. Dental laboratory procedure- Rudd and marrow
7. Modern practice in fixed prosthodontics- Rudd and Marrow.
8. Laboratory procedures for full and partial denture- Derek Stannought
9. Jpd-1987,57,362-368
10. Jpd-1989,61,418-424

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*Please Give Your Feedback on this Answer*

- Q. 01: Discuss the evolution of ceramics in prosthodontics with emphasis on latest advances (Jan 2020, 20M).**
- Q. 02: Write an essay on dental ceramics (Oct 2018, 15M).**
- Q. 03: Zirconia is the new age dental material - Elaborate and give your views (Oct 2019, 20M, Oct 2016, 6M).**
- Q. 04: Castable ceramics (June 2017, 7M, June 2016, 7M).**
- Q. 05: Write about methods of strengthening ceramics (Nov 2017, 7M).**
- Q. 06: Nano ceramics (June 2016, 15M).**

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## INTRODUCTION

- Ceramics is one of the four major restorative materials used in dentistry.
- The word ceramics has been derived from Greek word *Keramos* meaning burnt stuff. Ceramics are usually made of silicate materials with a combination of metallic and nonmetallic elements.
- According to American ceramic society, ceramics are inorganic, nonmetallic, crystalline in nature and are formed between metallic and nonmetallic elements (Eg: Aluminium & Oxygen, Silicon & Nitrogen, Calcium & oxygen).
- Porcelain is referred as a compositional range of ceramic materials like kaolin, quartz and feldspar in proportions and fired at high temperature.
- Porcelain is a white translucent ceramic that is fired to glazed state.

## APPLICATIONS OF CERAMICS IN DENTISTRY

- Single tooth restorations
- Short span and long span bridges
- Inlay and onlays
- Laminate veneers
- Artificial denture teeth
- Ceramic brackets for orthodontic treatment

## HISTORY & EVOLUTION OF DENTAL CERAMICS

- A variety of materials have been used to simulate tooth in early civilization.
- In 700 B.C., Etruscans made artificial tooth using ivory, bone, human teeth and animal teeth which are supported by gold wires.
- Since human teeth are scarce and expensive, animal teeth undergo corrosion with saliva, elephant ivory consist of pores which cause staining, hippopotamus ivory has been more desirable

Scientist	Research
<b>John Greenwood (1789)</b>	<ul style="list-style-type: none"> <li>For George Washington, he carved teeth using hippopotamus ivory for complete dentures</li> </ul>
<b>Nicholas Dubois de Chemant and Alexis Duchateau (French dentist) (1774 A.D)</b>	<ul style="list-style-type: none"> <li>Patented 1st successful porcelain material (1789) from an improved 'mineral paste teeth' developed by Duchateau (1774)</li> </ul>
<b>Giuseppangelo Fonzi (1808 A.D)</b>	<ul style="list-style-type: none"> <li>Formulated terrometallic porcelain teeth with platinum pins</li> </ul>
<b>C.M Richmond (1879 A.D)</b>	<ul style="list-style-type: none"> <li>Solved the retention problem with porcelain crowns and posts made of wood, by fusing porcelain to a platinum post (Richmond crown)</li> </ul>
<b>Herbst (1882 A.D)</b>	<ul style="list-style-type: none"> <li>Introduced glass inlays</li> </ul>
<b>Charles Land (1886)</b>	<ul style="list-style-type: none"> <li>Introduced 1st feldspathic porcelain inlays and crowns.</li> <li>Patented 1st ceramic crowns (1903)</li> </ul>
<b>Weinstein et al (1962)</b>	<ul style="list-style-type: none"> <li>Patent for long standing and esthetic metal ceramic restoration</li> </ul>
<b>Vita Zahnfabrik (1963)</b>	<ul style="list-style-type: none"> <li>Introduced 1st commercial porcelain for PFMs</li> </ul>
<b>McLean and Hughes (1965)</b>	<ul style="list-style-type: none"> <li>Improved the flexural strength of porcelain by incorporating <math>\text{Al}_2\text{O}_3</math></li> </ul>
<b>In 1980s</b>	<ul style="list-style-type: none"> <li>Shrink free all ceramic crown system and Castable glass ceramic system were introduced</li> </ul>
<b>Adair and Grossman (1984)</b>	<ul style="list-style-type: none"> <li>Demonstrated development of DICOR</li> </ul>
<b>Mormann and Brandestini (1987)</b>	<ul style="list-style-type: none"> <li>Introduced prototype machine which captures 3D image of prepared tooth followed by development of restoration using 3D design software and CAD CAM (CEREC I)</li> </ul>
<b>Vita (1989)</b>	<ul style="list-style-type: none"> <li>In ceram Alumina was introduced to fabricate single unit and 3 unit restorations</li> </ul>

<b>Sirona (1997)</b>	• CEREC 2
<b>Sirona (2000)</b>	• CEREC 3
<b>Ivoclar Vivadent (2005)</b>	• IPS e.max Press is introduced

## CLASSIFICATION

### I. Based on the sintering temperature

Type	Sintering temperature range	Applications
High fusing	> 1300 <sup>0</sup> C	Used to fabricate denture teeth, sintered alumina and Zirconia cores
Medium fusing	1101 - 1300 <sup>0</sup> C	Denture teeth, presintered Zirconia
Low fusing	850 - 1100 <sup>0</sup> C	Crowns and bridges, Veneers
Ultra low fusing	< 850 <sup>0</sup> C	Crowns and bridges, Veneers

### II. Based on their method of fabrication

Application	Fabrication	Crystalline Phase	Products	Manufacturers
All-ceramic	Soft machined	Zirconia (3Y-TZP)	Cercon	Dentsply International
			Lava	3M Company
			IPS e.max ZirCAD	Ivoclar Vivadent
			In-Ceram YZ	Vident
		Zirconia (cubic & tetragonal)	Zpex Smile	Tosoh Corporation
	Hard machined	Lithium disilicate ( $Li_2Si_2O_5$ )	IPS e.max CAD	Ivoclar Vivadent
		Lithium silicate ( $Li_2Si_2O_5$ and $Li_2SiO_3$ )	Vita Suprinity	Vident
			Celtra Duo	Dentsply
		Feldspar [ $(Na, K)AlSi_3O_8$ ]	Vita Mark II	Vident
		Leucite ( $KAlSi_2O_6$ )	IPS Empress CAD	Ivoclar Vivadent
Heat pressed	Leucite ( $KAlSi_2O_6$ )		IPS Empress	Ivoclar Vivadent
		Lithium disilicate ( $Li_2Si_2O_5$ )	IPS e.max Press	Ivoclar Vivadent
		Fluorapatite [ $Ca_5(PO_4)_3F$ ]	IPS e.max ZirPress	Ivoclar Vivadent
	Sintered	Leucite ( $KAlSi_2O_6$ )	IPS Empress layering ceramic	Ivoclar Vivadent
		Alumina ( $Al_2O_3$ )	Procera AllCeram	Nobel Biocare
Metal-ceramic	Sintered	Fluorapatite [ $Ca_5(PO_4)_3F$ ]	IPS e.max Ceram layering ceramic	Ivoclar Vivadent
		Leucite ( $KAlSi_2O_6$ )	VMK-95	Vident
Denture teeth	Manufactured	Feldspar	TruByte	Dentsply International
		Feldspar	VITA LUMIN Vacuum	Vident

### III. Based on their method of processing

<i>Method of processing</i>	<i>Examples</i>
• Condensation	• Ceramco, VITA VMK, Duceram LFC,
• Hot pressing	• IPS empress 2, OPC 3G, Finesse Pressable
• Casting	• Dicor
• Slip casting	• In-Ceram Alumina, In-Ceram Spinell, In-Ceram Zirconia
• CAD CAM fully sintered form	• Cerec VITABLOCS, In-Denzir, Bruxzir
• CAD CAM partially sintered form	• Cercon, Lava, e.max ZirCAD
• Copy milling	
• Machining, grinding of dry presses powder	• Procera AllCeram

### IV. According to the Type of Porcelain

- Feldspathic porcelains
- Leucite reinforced porcelain
- Aluminous porcelains
- Alumina core porcelain
- Glass infiltrated alumina porcelain
- Glass infiltrated magnesium spinnel
- Glass ceramics

### V. According to the Application

- Denture teeth
- Metal ceramics
- Laminate and veneers
- Inlays, onlays
- Crowns and bridges
- Orthodontic brackets

### VI. According to the Substructure Material

- Cast metal
- Snagged foil/ metal
- Glass ceramics
- Sintered glass ceramics
- Crystallized porcelains
- Copy milled porcelains
- CAD/ CAM Porcelains

**DENTAL PORCELAIN COMPOSITION****Feldspar**

- Primary component (75- 85 %)
- Consists of potash ( $K_2O$ ),  $Na_2O$ ,  $SiO_2$
- Lowest fusing ingredient, melts first and flows during firing process

**Kaolin**

- Consists of  $Al_2O_3.2SiO_2.2H_2O$  (4-5%)
- Acts as binder & improves the capacity to mold during firing
- It is opaque and can reduce the translucency of porcelain

**Quartz (Silica)**

- Occupies 13-14%
- Improves the strength of fired porcelain.
- Acts as framework to all the remaining components as it is stable during firing.

**Glass modifiers**

- Oxides of sodium, potassium and calcium (9-15%)
- Acts as flux, reduces the glass viscosity
- Increases the thermal expansion

**Opacifying agents**

- Cerium oxide, zirconium oxide, titanium oxide, tin oxide (8-15%)
- Very fine particle size ( $<5 \mu m$ ) to prevent a speckled appearance in porcelain

**Pigments**

- Titanium oxide – yellowish brown
- Manganese oxide – lavender
- Iron oxide or nickel oxide – brown
- Cobalt oxide – blue
- Copper oxide – green

**Advantages**

- Good esthetics
- Biocompatibility
- Resistance to electricity
- Thermal insulation
- Resistance to wear

**Disadvantages**

- Brittle
- Technique sensitive to fabricate
- Causes wear to the opposing natural tooth
- Difficulty to repair

- |   |  |
|---|--|
| <ul style="list-style-type: none"><li>• Can be made into any shape</li><li>• Can be bonded to tooth structure</li></ul> | <ul style="list-style-type: none"><li>• Higher in cost for fabrication</li></ul> |
|---|--|

## FABRICATION

- I. Condensation
- II. Sintering
- III. Glazing and shading
- IV. Cooling

### I. Condensation of Dental Porcelain

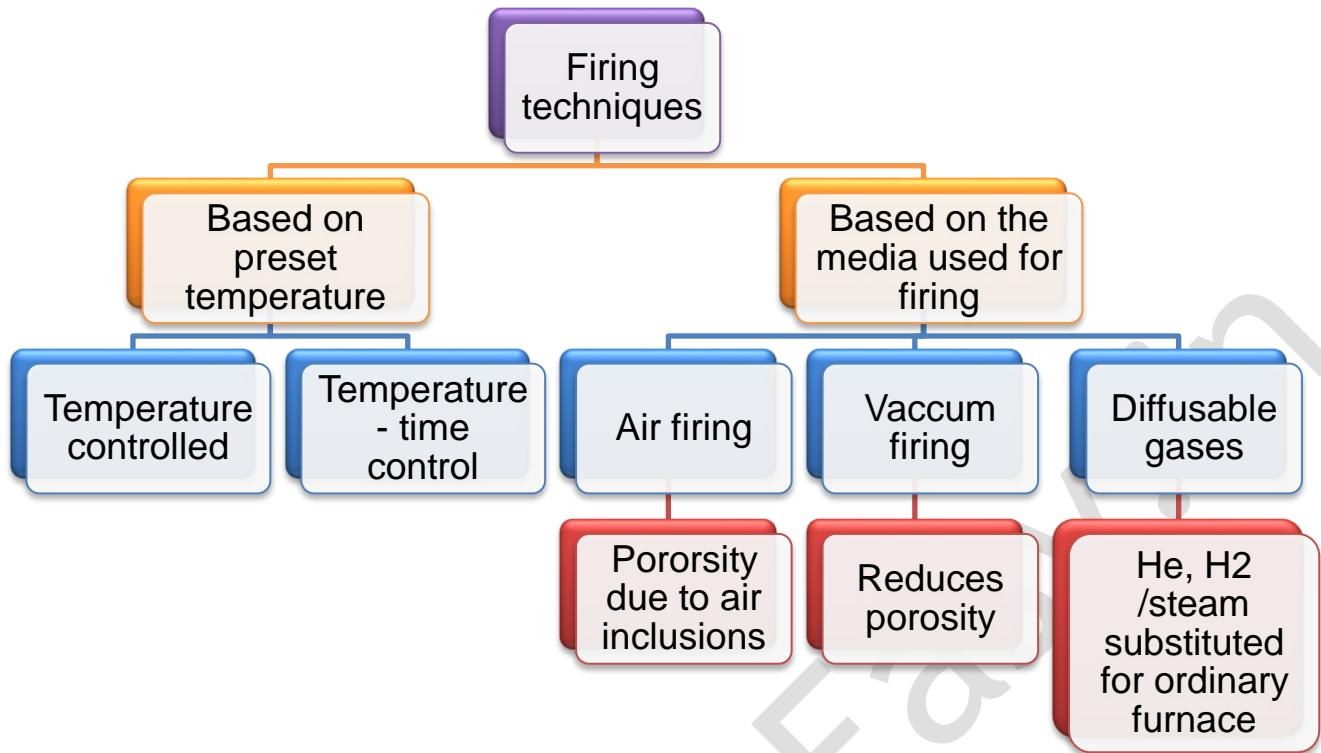
- It is a process in which particles are packed together by removing the liquid binder
- Distilled water- most used liquid binder
- Other binders: glycerin, propylene glycol or alcohol
- Movement of ceramic particles is achieved by Vibration, Spatulation, Brush techniques
- **Methods:** Manual or ultrasonic condensation

### II. Firing/ Sintering of Porcelain

- Sintering is defined as a process of heating without melting closely packed particles to form a coherent mass by inter- particle bonding and enough diffusion to decrease the surface area and increase the density of the structure

#### Steps

1. Preheating the furnace
2. Condensation of ceramic
3. Firing the green porcelain



### Stages of maturity

- Based on the degree of chemical reaction and amount of shrinkage stages of maturation are divided into three categories
  1. Low bisque stage
  2. Medium bisque stage
  3. High bisque stage

	Low bisque stage	Medium bisque stage	High bisque stage
Characteristics	Grains of porcelain start to soften and coalesce at the contact points	Flow of glass grains increase and the residual entrapped furnace air becomes sphere shaped	Firing shrinkage is complete, and has adequate strength, for any corrections by grinding prior to glazing
Particle cohesion	Incomplete	Considerable	Complete
Porosity	Highly porous and absorbs water	Reduced although still porous	Slight/absent depending upon the material used
Shrinkage	Minimal	Majority / definite	Complete
Strength	Weak & friable	Moderate	High
Surface texture	Porous	Matte surface	Egg shell appearance
Color & translucency	Opaque	Less opaque	Color and translucency developed

### III. Glazing and shading

- Forms a smooth and shiny layer which is unaffected to wear and tear

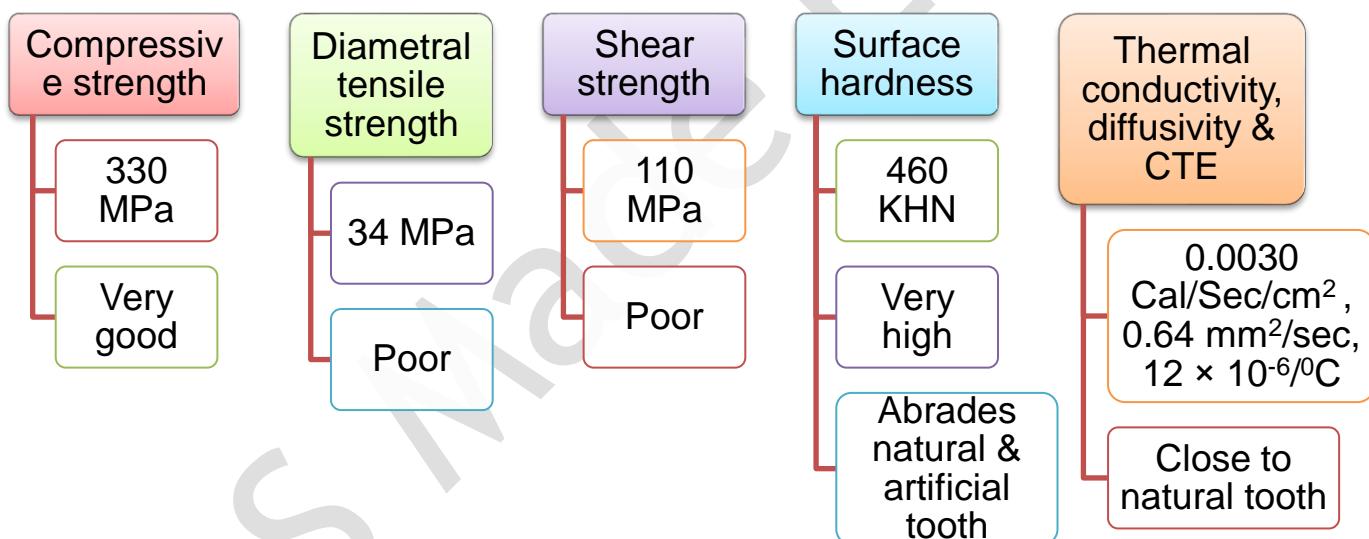
- Reduces crack propagation effectively
- Two types: Add on glazing and self glazing
- To provide life like appearance to ceramic prosthesis stains can be added along with glazes.

#### IV. Cooling

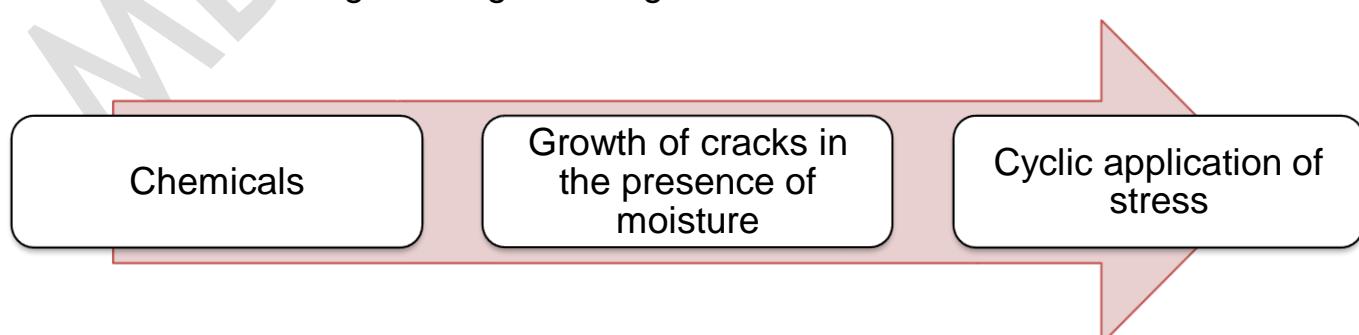
- Should be done slowly
- Sudden cooling leads to formation of cracks and loss of strength

### PROPERTIES OF CERAMICS

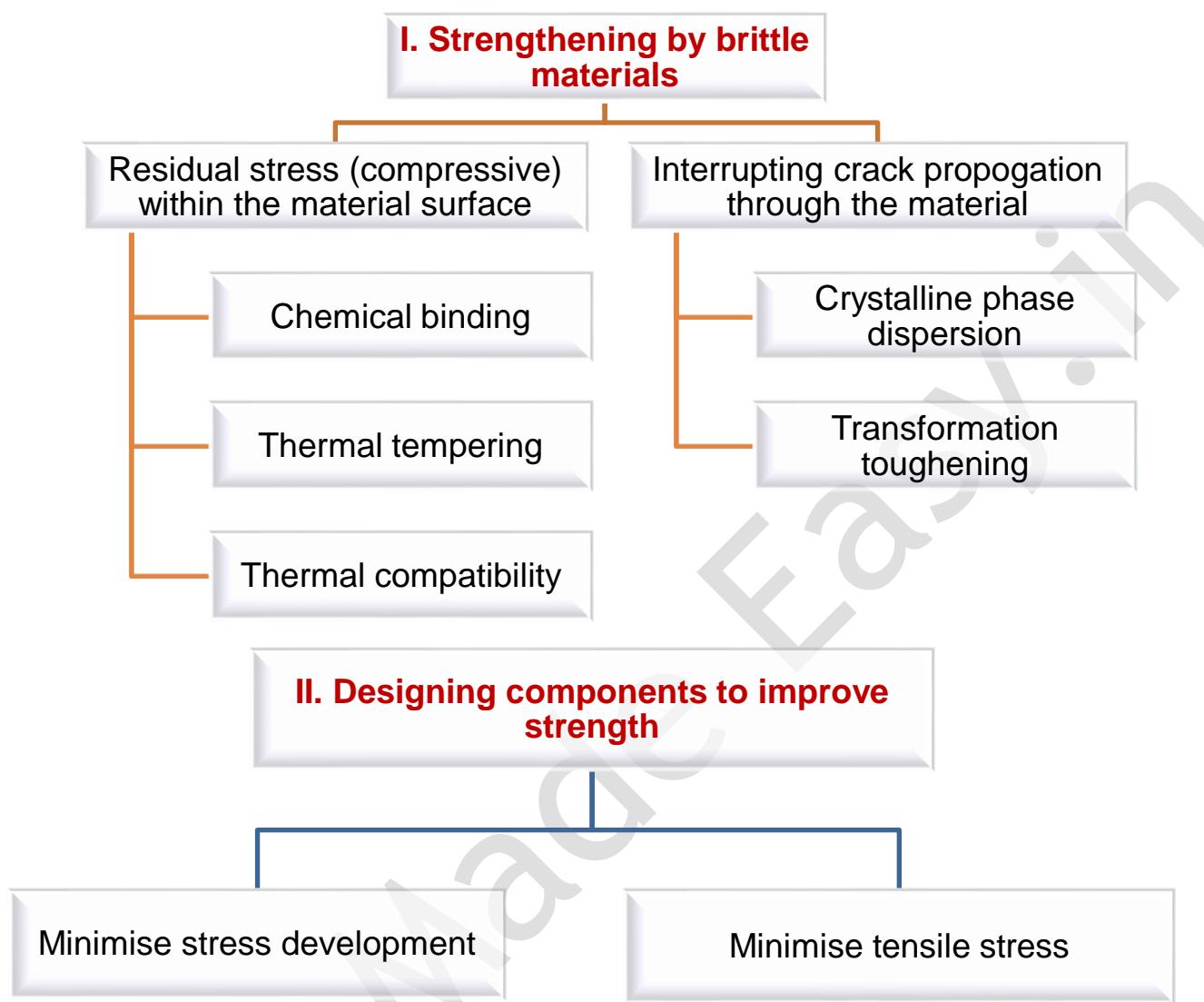
- Excellent biocompatibility to oral tissues and aesthetics
- The structure of porcelain is the most important mechanical property as it depends on its **composition, integrity of surface and presence of voids**.
- Ceramics have excellent resistance to compressive stress and poor resistance to tensile and shear stress. Hence the brittle nature of ceramics.



- Durability and longevity of ceramics depends on its fatigue strength. Factors affecting the fatigue strength of ceramics are:



## METHODS OF STRENGTHENING CERAMICS



- To minimise the drawbacks of ceramics like low fracture resistance, tensile strength, brittle nature etc., the following are the methods to strengthen the ceramics and improve the designing of components

<b>Minimising the internal stress</b>	<b>Residual compressive stress</b>	<b>Firing cycles</b>
<p>Interference in ceramic and metal structure causes stress</p> <p>To minimise:</p> <ul style="list-style-type: none"> <li>Greater thickness on occlusal surface</li> </ul>	<ul style="list-style-type: none"> <li>On cooling, metal has more thermal contraction than porcelain leaving it with residual compressive stress which provides</li> </ul>	<p>Increase in firing cycles</p> <p>↓</p> <p>Increases concentration of leucite crystal</p> <p>↓</p> <p>Affects the CTE of porcelain</p>

<ul style="list-style-type: none"> <li>Avoid sharp line angles, sudden changes in shape and size of ceramic contour</li> </ul>	<p>strength to the prosthesis indirectly by neutralizing the tensile stresses</p> <p><i>Thermal compatibility</i></p> <ul style="list-style-type: none"> <li>It is advised to choose metal with higher CTE (coefficient of thermal expansion) than porcelain with a minimum difference of <math>0.5 \times 10^{-6}/^{\circ}\text{C}</math></li> </ul>	<p>↓</p> <p>Stress development after cooling</p>
--	---	--

Residual compressive stresses can be introduced by three mechanisms:

- Chemical tempering
- Thermal tempering and
- Thermal compatibility

<i>Chemical binding</i>	<i>Thermal tempering</i>
<ul style="list-style-type: none"> <li>Most effective in producing residual stress</li> </ul> <p>Glass particles with sodium are placed in potassium nitrate molten bath</p> <p>↓</p> <p>Exchange of ions (Smaller sodium ions are replaced by larger potassium ions)</p> <p>↓</p> <p>Larger potassium ions produces larger compressive stresses</p>	<ul style="list-style-type: none"> <li>Produces residual stress by rapidly cooling the object surface at its molten state forming a rigid outer glass with molten core</li> <li>As the core starts solidifying, it starts to shrink, thus producing residual compressive stress at outer surface and residual tensile stress within the core</li> </ul>

<i>Dispersion strengthening</i>	<i>Transformation toughening</i>
<ul style="list-style-type: none"> <li>Ceramics are strengthened by adding crystals in their dispersed phase which avoids crack propagation</li> <li>Eg., Alumina in alumina porcelain</li> </ul>	<ul style="list-style-type: none"> <li>Ceramics are strengthened due to change in the crystalline form under stress, further preventing the crack propagation</li> <li>Eg., zirconia crystals change from tetragonal to monoclinic phase on</li> </ul>

heating between 1470°C - 2010°C

**PORCELAIN FUSED TO METAL (PFM)**

- Metal ceramic restorations is a combination of mechanical properties of dental alloys with superior esthetic properties of porcelain.
- Generally PFM includes a metal substructure and bonded porcelain veneer.

Indications	Contraindications
<ul style="list-style-type: none"> <li>• Teeth that require complete coverage</li> <li>• Fixed partial denture retainer</li> <li>• Cases of extensive tooth destruction</li> <li>• Need of superior retention and strength</li> <li>• Restoration of teeth with multiple deflective axial surfaces</li> <li>• An endodontically treated tooth in conjunction with</li> <li>• Suitable supporting structure</li> <li>• Correction of minor inclinations</li> </ul>	<ul style="list-style-type: none"> <li>• Patients with active caries</li> <li>• Untreated periodontal disease</li> <li>• younger patients with large pulp chambers</li> <li>• Risk of pulp exposure</li> <li>• When a more conservative retainer is feasible</li> </ul>

**Requirements**

1. High fusion temperature of alloy
2. Fusion temperature of ceramic should be low
3. Ceramic must wet the alloy
4. Good bond between ceramic and metal is essential
5. Compatible coefficients of thermal expansion
6. Ceramic and metal are necessary
7. Adequate stiffness and strength of alloy core
8. High sag resistance of alloy is essential
9. An accurate metal coping is required
10. Adequate design of restoration is critical

## Functions of Metal Substructure

1. Primary Functions	2. Secondary Functions
<ul style="list-style-type: none"> <li>The casting provides the fit of the restoration on the prepared tooth</li> <li>The oxides formed over the metal bonds chemically to porcelain</li> <li>The coping acts as a strong foundation for layering brittle ceramics</li> <li>The substructure restores the proper emergence profile of the tooth</li> </ul>	<ul style="list-style-type: none"> <li>Metal occlusal and lingual articulating surfaces can be less destructive to the enamel of opposing natural teeth</li> <li>The occluding surfaces can be easily adjusted and polished intra orally</li> <li>Fabrication of a restoration with minimal occlusal clearance has more potential for success with a metal substructure than all-ceramic materials</li> </ul>

Alloys currently used for porcelain bonding are

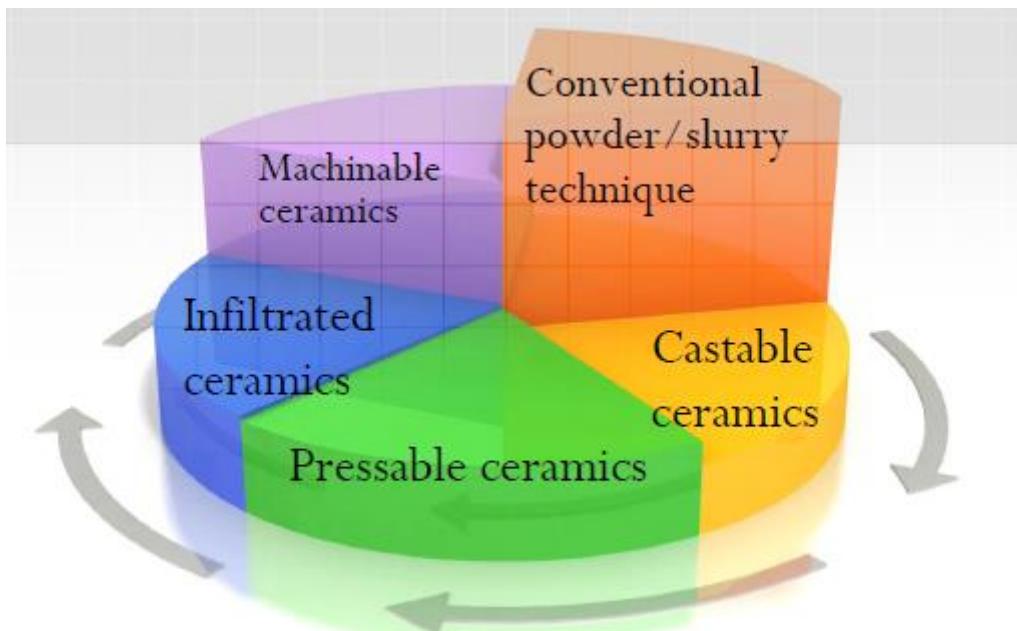
- High gold alloys
- Low gold alloys
- Silver palladium alloys
- Nickel chromium alloys

## Bond Failures in Metal-Ceramics (O'Brien-1977)

Adhesive Failures	Cohesive Failures
Metal oxide - porcelain Metal - metal oxide	Metal oxide - metal oxide Cohesive within metal Cohesive within porcelain

## ALL CERAMICS

- Based on fabrication methods all ceramic systems are classified as follows

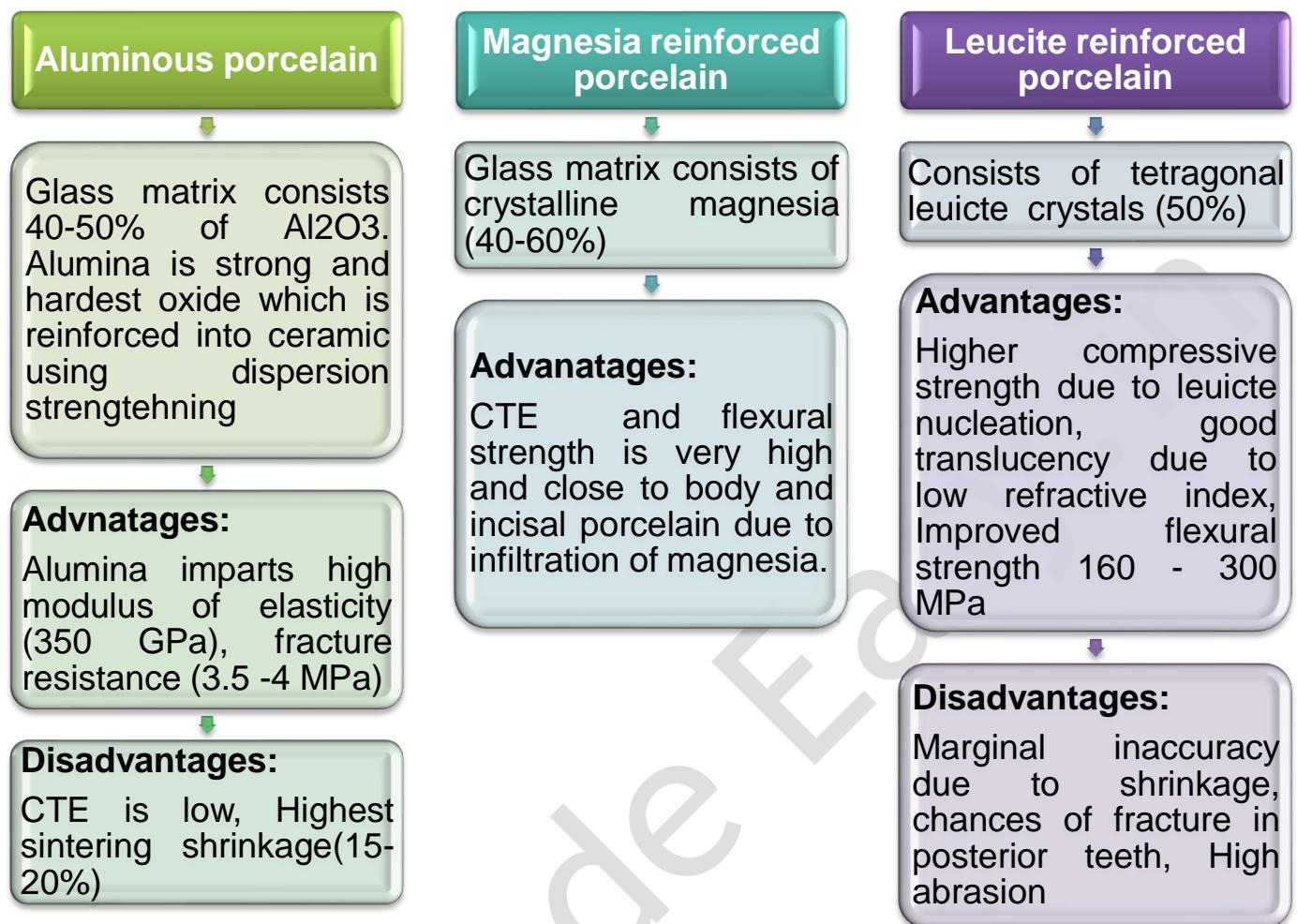


### I. Conventional ceramics/ Sintered porcelains

- Sintering is a process in which ceramic powder particles are consolidated at high temperatures.
- It promotes physical and chemical reactions which are responsible for the final properties of ceramics
- Available in different shades of powder form
- Process of fabrication of prosthesis

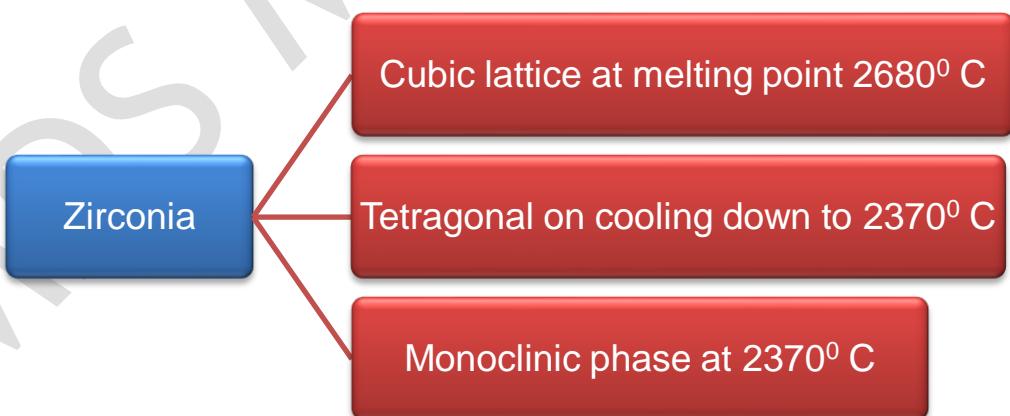


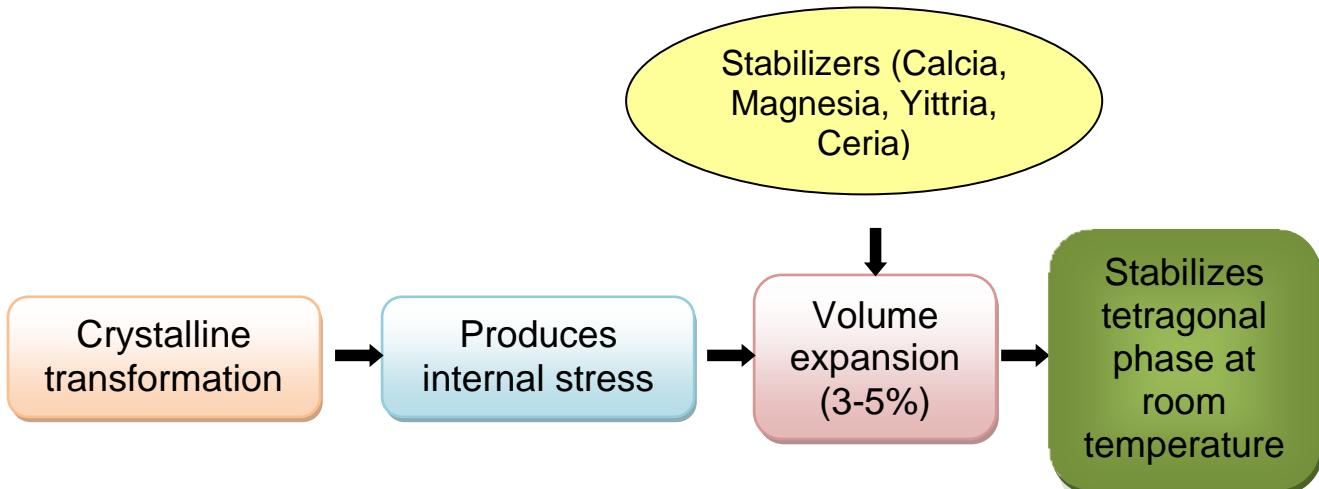
- Should be mixed with water to prepare slurry which is built up in layers on the die
- Condensation reduces the porosity and increases density and strength
- Preheating at 450 - 650°C removes excess water and improves green strength



### Zirconia based porcelain

It is a polycrystalline material added to feldspathic porcelain to improve the strength (transformation toughening).





Stabilized zirconia has high flexural strength, fracture resistance, thermal shock resistance and reduced translucency.

#### ***Applications of conventional ceramic systems:***

- They have good translucency and hence highly esthetic
- Used for Veneering on cores (Zirconia)
- Examples: IPS emax, IPS Eris, Lava Ceram, Cercon ceram

## **II. Castable ceramics/ Glass ceramics**

- Available as ceramic ingots
- Heat treated using lost wax & centrifugal casting technique under controlled devitrification process (ceramming), hence called Castable ceramics.
- First commercially available material is called **Dicor**
- Significance of castable ceramics is its **chameleon effect** to adapt the colour of its adjacent tooth

Ceramming occurs in two phases: Crystal nucleation & crystal growth



Increases strength and fracture resistance

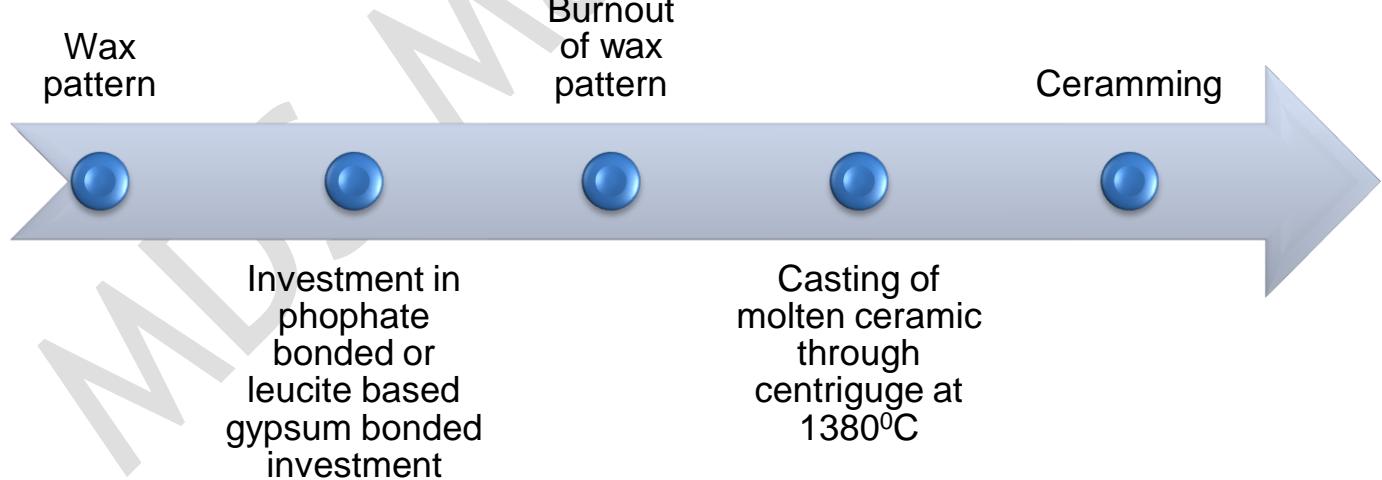


Interrupts crack propagation under masticatory load

### Composition:

Major Ingredients	Minor Ingredients
<ul style="list-style-type: none"> <li>• <math>\text{SiO}_2</math> : 45-70%</li> <li>• <math>\text{K}_2\text{O}</math> : upto 20%</li> <li>• <math>\text{MgO}</math> : 13-30%</li> <li>• <math>\text{MgF}_2</math> (nucleating agent)</li> </ul>	<ul style="list-style-type: none"> <li>• <math>\text{Al}_2\text{O}_3</math> : upto 2% (durability &amp; hardness)</li> <li>• <math>\text{ZrO}_2</math> : upto 7%</li> <li>• Fluorescing agents (esthetics)</li> <li>• <math>\text{BaO}</math> : 1 to 4% (radiopacity)</li> </ul>

### Fabrication:



### Recent advances of castable ceramics are

- Cera pearl
- Optimal pressable ceramic
- Canasite glass ceramic

- Olympus castable ceramics.

### Advantages

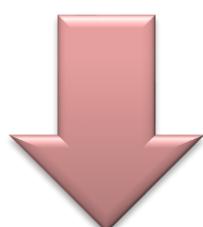
Highly esthetic

Entire restoration is fabricated with one piece material

Has chameleon effect

Efficient marginal fit

simple technique



### Disadvantages

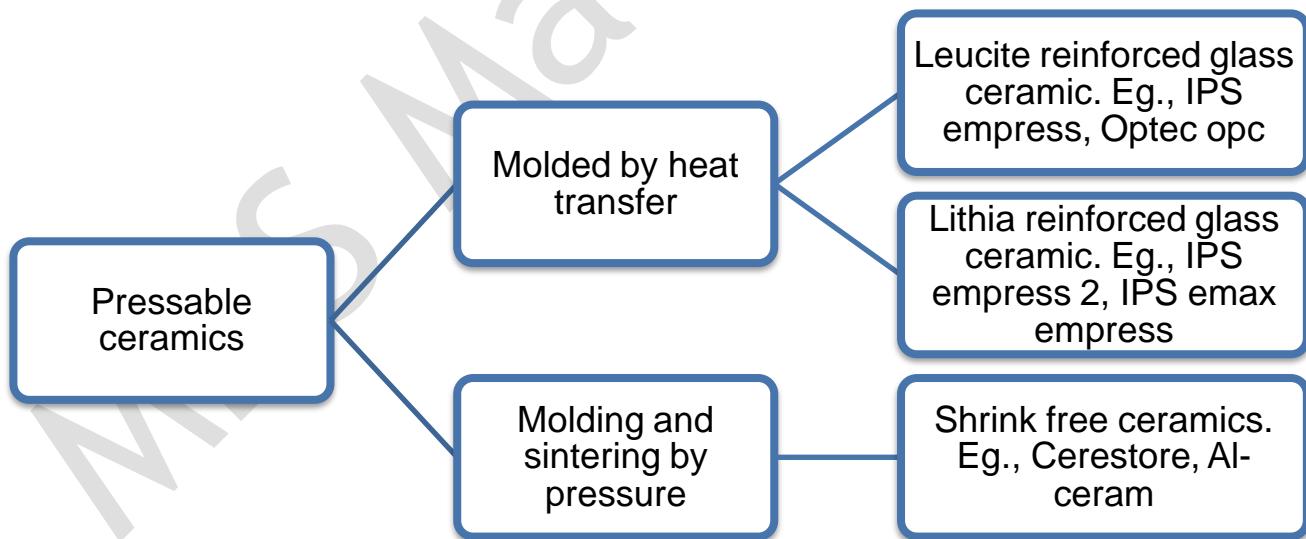
Failure rate is 8 %

Stains should be made with low fusing porcelain

Stains may be removed during occlusal adjustments

### III. Pressable ceramics

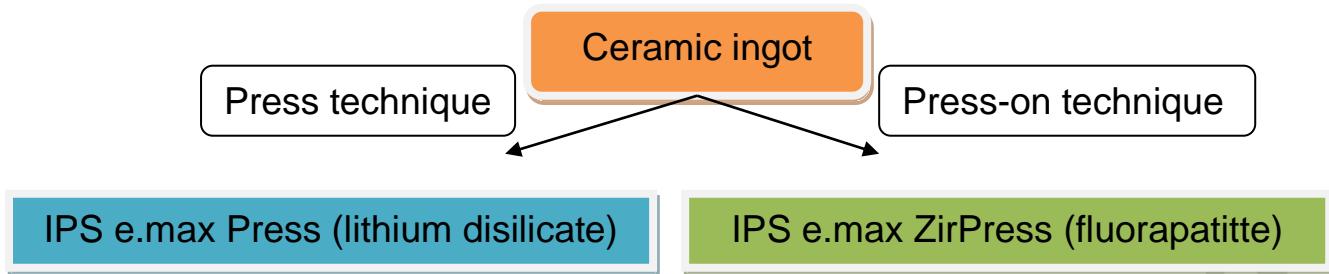
- Pressable ceramics are heated at a specific temperature and forced under pressure into refractory mold.
- Also called as "heat - pressed" ceramics
- This technique prevents porosity, formation of secondary crystals, improves density and mechanical properties



Pressable ceramics are divided into two generations:

<b>Leucite-based ceramic (IPS Empress)</b>	<b>Lithium disilicate-based materials (IPS Empress 2 and IPS E max)</b>
<ul style="list-style-type: none"> <li>• Consists of leucite (<math>KAlSi_2O_6</math> or <math>K_2O \cdot Al_2O_3 \cdot 4SiO_2</math>)</li> <li>• Amounts varying from 35% to 55% by volume</li> </ul>	<ul style="list-style-type: none"> <li>• Contains lithium disilicate (<math>Li_2Si_2O_5</math>) as a major crystalline phase</li> <li>• Around 65%</li> </ul>
<ul style="list-style-type: none"> <li>• Heat-pressing temperatures for this system are between 1150° and 1180°C with a dwell at temperature of about 20 minutes</li> </ul>	<ul style="list-style-type: none"> <li>• They are heat-pressed in the 890° to 920°C temperature range</li> </ul>
<ul style="list-style-type: none"> <li>• The final microstructure of these heat-pressed ceramics consists of leucite crystals, 1 to 5 <math>\mu m</math>, dispersed in a glassy matrix</li> </ul>	<ul style="list-style-type: none"> <li>• The final microstructure consists of highly interlocking prismatic lithium disilicate crystals (5.2 <math>\mu m</math> in length, 0.8 <math>\mu m</math> in diameter) dispersed in a glassy matrix</li> </ul>
<ul style="list-style-type: none"> <li>• The amount of porosity in the heat-pressed ceramic is 9 vol%</li> <li>• Two techniques are available: a staining technique and a layering technique involving the application of veneering ceramic</li> </ul>	<ul style="list-style-type: none"> <li>• The amount of porosity after heat-pressing is about 1 vol%</li> <li>• The heat-pressed restorations are later veneered with ceramics of matching thermal expansion</li> </ul>
<ul style="list-style-type: none"> <li>• Veneering temperature is around 910°C</li> </ul>	<ul style="list-style-type: none"> <li>• Veneering temperature is around 800°C</li> </ul>
<ul style="list-style-type: none"> <li>• The flexural strength of these ceramics (120 MPa) is about double that of conventional feldspathic porcelains</li> </ul>	<ul style="list-style-type: none"> <li>• Main advantage of the lithium disilicate-based ceramics is their enhanced flexural strength (300 MPa) and fracture toughness (2.9 MPa)</li> </ul>
<ul style="list-style-type: none"> <li>• Indicated in anterior single crowns</li> </ul>	<ul style="list-style-type: none"> <li>• 3 unit FPDs in the anterior region</li> </ul>
<p>The main disadvantages are the initial cost of the equipment and Need to use resin cement to bond the crown micromechanically to the tooth structure</p>	

## Recent advances of Pressable ceramics



- Empress pressing equipment is used for processing IPS e.max Press, which provides high accuracy of fit.
- Flexural strength of IPS e.max Press is higher than IPS Empress.
- Using injection mold technology, "shrink-free Cerestore" system was introduced. Commercially available as Alceram, consisting of magnesium spinel ( $MgAl_2O_4$ ) as major crystal with excellent marginal fit.

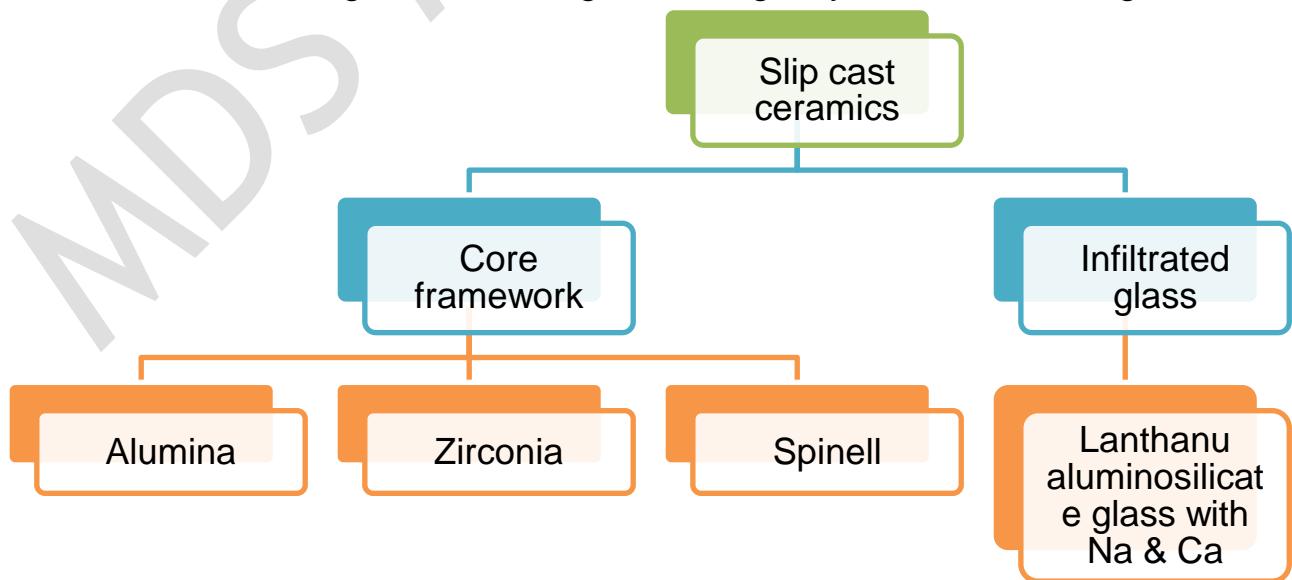
## IV. Infiltrated or slip cast ceramics

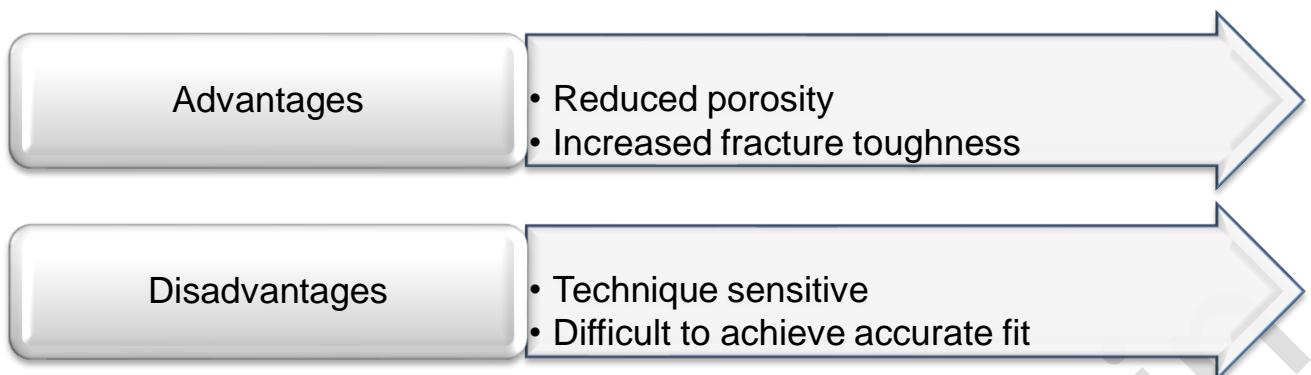
Slip casting refers to pouring or painting of an aqueous suspension of porcelain slip over a refractory die, followed by firing at high temperatures.

Porosities over the refractory die absorbs water from slip through capillary action.

During firing, the refractory die shrinks more than the slip which is condensed leading to easy separation.

The resultant ceramic is highly porous and should be infiltrated using molten ceramic glass or undergo sintering fully before veneering.





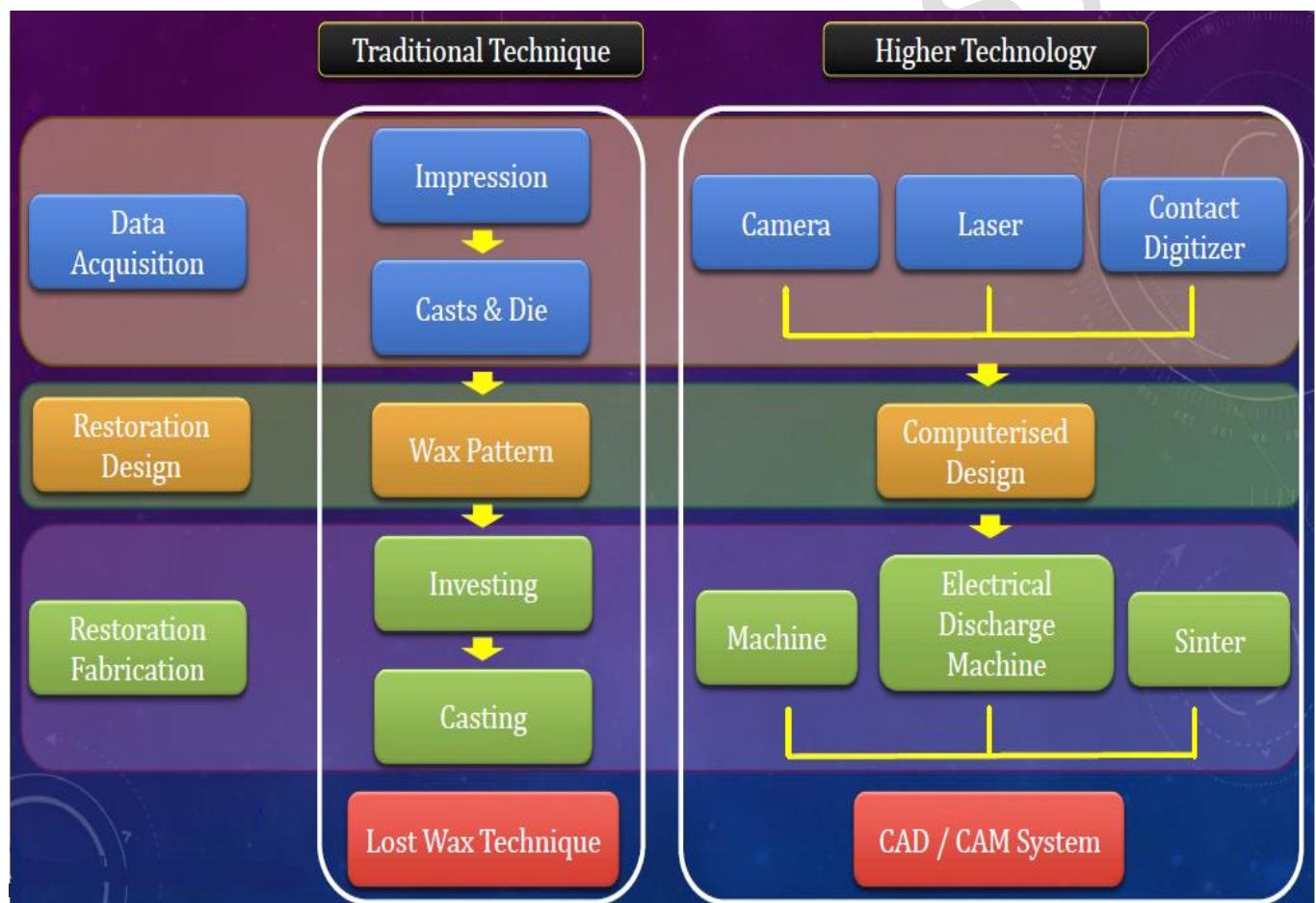
Based on type of core material, slip casted ceramics are classified into three categories:

	<b>Inceram - Alumina</b>	<b>Inceram - Spinell</b>	<b>Inceram - Zirconia</b>
<b>Composition</b>	Consists of alumina (99.5%), glass lanthanum	Consists of magnesia and alumina	Consists of zirconium (30%) & aluminium (70%) oxides
<b>Flexural strength</b>	500 MPa	350 MPa	700 MPa
<b>Translucency</b>	Translucent	Highly translucent	Opaque
<b>Indications</b>	Single unit anterior & posterior crowns, anterior 3 unit bridges	Single unit anterior crowns, inlays and onlays	Posterior crowns and bridges
<b>Advantages</b>	Accurate fit with minimal shrinkage, opaque in colour, lesser wear of opposing teeth, plaque accumulation is less	Greater in strength, can be used as core material, inlays, onlays & veneers	Greater flexural strength when compared to Inceram alumina, excellent accuracy at margins, biocompatible
<b>Disadvantages</b>	Technique sensitive, poor esthetics, cannot be etched.	Cannot be etched	Opaque, poor esthetics, cannot be etched

## V. Machinable ceramics

- Evolution of CAD-CAM lead to development of Machinable ceramics.
- Originally this technology was introduced for fully sintered ceramic blocks using hard machining and currently it can be used for partially sintered ceramics using soft machining.

Hard machining	Soft machining
<ul style="list-style-type: none"> <li>Machinable ceramics for CAD CAM restorations are fluormica glass ceramic, feldspar based, leucite based and lithium disilicate based ceramics</li> </ul>	<ul style="list-style-type: none"> <li>Partially sintered zirconia ceramic blocks are used for soft machining. the main advantage of this technique is that they compensate the volume shrinkage.</li> </ul>



## Classification of Machinable ceramics

<i>Analogous system</i>	<i>Digital system</i>
<p>Copy milling</p> <ul style="list-style-type: none"> <li>• Fabrication of prototype for scanning</li> <li>• Copying and reproduction by milling</li> </ul> <p>Erosive techniques:</p> <ul style="list-style-type: none"> <li>• Sono erosion</li> <li>• Spark erosion</li> </ul>	<p>Direct</p> <p>Indirect: 3D scanning, CAD modeling</p>

## CAD/CAM (Computer aided designing/Computer aided manufacturing)

### Components:

- Scanner
- CAD Unit (software)
- CAM Unit (production)

Eg., CEREC, CEREC2, CEREC3, DURET, CICERO, COMET systems

- CAD CAM ceramic restorations can be produced from either monolithic lithium disilicate, or Zirconia ceramic using milled copings and further veneered.
- POM method: Pressing a ceramic veneer onto a metal is called POM method

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Need only single visit, eliminating impression making and fabricating interim prosthesis</li> <li>• Patient acceptance will be good due to better adaptation</li> <li>• Porcelains will be void free and no shrinkage</li> <li>• Aseptic conditions</li> <li>• Less abrasion to natural tooth</li> </ul>	<ul style="list-style-type: none"> <li>• Fabrication of multiple units is limited</li> <li>• Characterization is difficult</li> <li>• Imaging is difficult in wet oral condition</li> <li>• Technique sensitive</li> <li>• Expensive</li> </ul>

## RECENT ADVANCES

### I. Ceramic Abutments

- These are the most recent application of ceramics
- Instead of titanium alloys, ceramic abutments are used in anterior restoration to avoid gray colouration

### II. Ceramic coated implants

- They promote bio integration and stronger bone implant bonds.
- Thickness of these ceramic coatings should be in the range of 50 - 100 $\mu$ m
- The coatings are deposited on to the metal alloys using plasma spraying technique
- **Disadvantages**
  1. Bond strength of ceramic might be questionable as ceramic is a brittle material
  2. Chances of degradation of ceramic coating on long term implant integration with bone is still not known.
  3. Debonding of ceramic from the alloy could be of significant loss

### III. Nano ceramics

Nano optimised ceramics include

#### 1. Nano fillers

- Improves the polishing ability and decreases wear

#### 2. Nanopigments

- Uses chameleon effect and adjusts the shade of restoration with the adjacent teeth

#### 3. Nanomodifiers

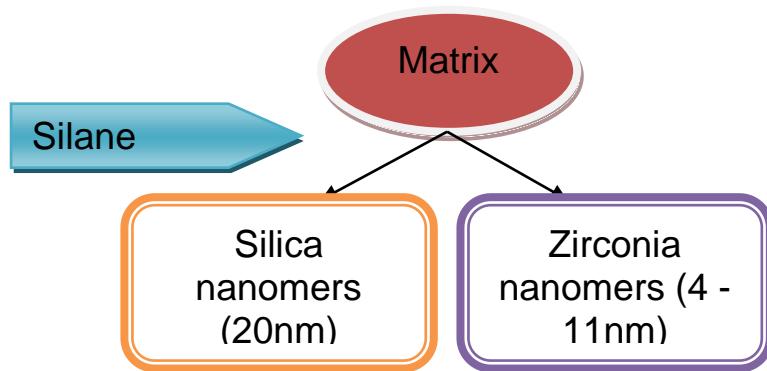
- Improves the material stability and prevents sticking to instruments

#### 4. Nano fluorapatite glass

- e.max Ceram is a nano fluorapatite ceramic veneer with a very minimal CTE similar to that of lithium disilicate core material

#### 5. Resin Nanoceramics

- Comprises of nano sized ceramic particles (80%) and resin matrix (20%) with Bis-GMA, UDMA, TEGDMA and Bis-EMA



- Example: Lava Ultimate (3M ESPE)

### Advantages

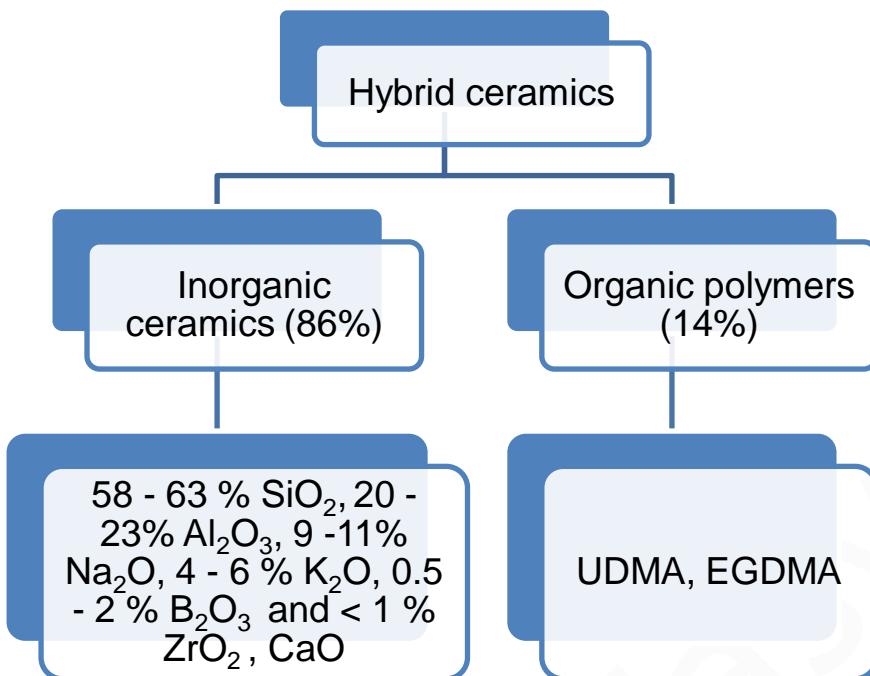
- Elastic modulus of nanocermaics is relatively closer to tooth, hence provides fracture resistance against occlusal load.
- Wear is minimal because of compatible hardness value similar to natural tooth
- Colour stability
- Long term survival of polished surfaces

### 6. Hybrid ceramics (polymer infiltrated glass ceramics)

- Consists of organic (polymers) and inorganic (ceramics)materials which are bonded chemically by silane molecules.
- Example: Vita Enamic

### Properties

- Elastic modulus of hybrid ceramics is similar to teeth.
- Hardness is lesser on comparison with silica based ceramics, hence less wear than traditional ceramics



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**Please Do Not Forget to Mark Your Feedback on this Answer**

**Q. 16: Classify dental waxes and write in detail about Inlay casting wax (20M)**

**CONTENTS/SYNOPSIS**

Introduction

Requirement of wax pattern materials

General composition

Classification

- According to function
- According to composition

Characteristics properties

- Thermal properties
- Mechanical properties
- Rheological properties

Pattern waxes

- Inlay wax
  - Properties of inlay wax
- Casting wax
- Base plate wax

Processing Waxes

- Boxing Wax
- Utility Wax
- Sticky Wax

Impression Waxes

- Bite Registration Wax
- Corrective Wax

Manipulation of wax pattern

Recent advances

Conclusion

Reference

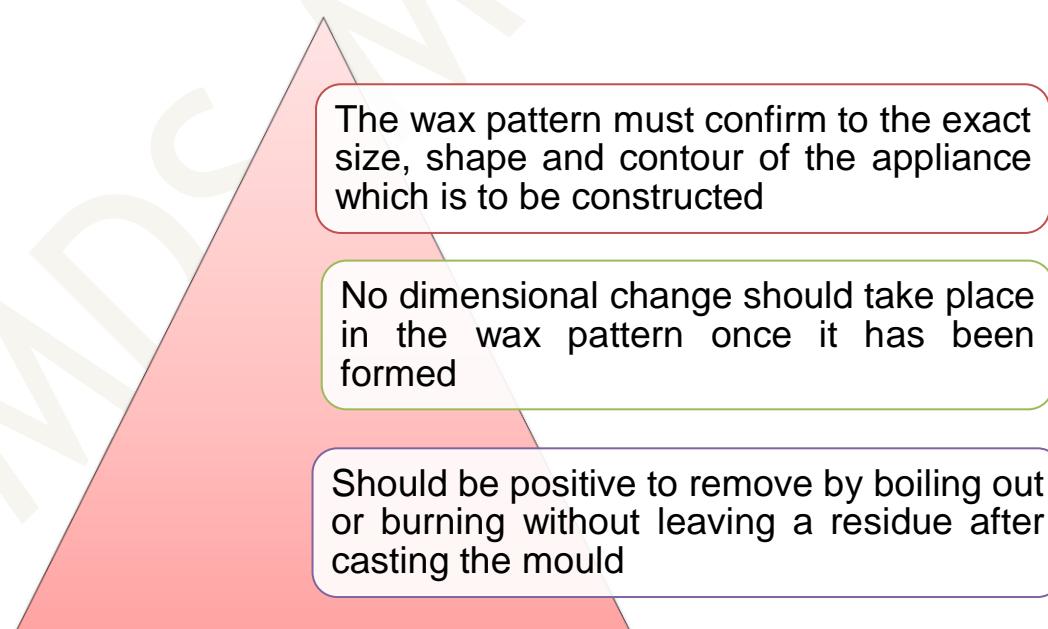
## INTRODUCTION

- Waxes are thermoplastic materials which are normally solids at room temperature but melt without decomposition, to form into liquids.
- There are wide varieties of dental waxes used both in laboratory and clinical chair side.

## HISTORY

- Waxes have been the most versatile natural substances used by man during evolution.
- The oldest wax used was beeswax
- 3000 B.C - Beeswax have been in use for mummification as a protective layering.
- Greek and Romans - Used wax for applications to seal ships, matrix binder, coating for objects and tablets.
- 1700 - Wax models are used relation to prosthetic work by Matthaeus Gottfried Purmann
- 19th Century - Investigation on waxes have began
- 1935 - First synthetic liquid paraffin's are produced (Fischer - Trop's procedure)

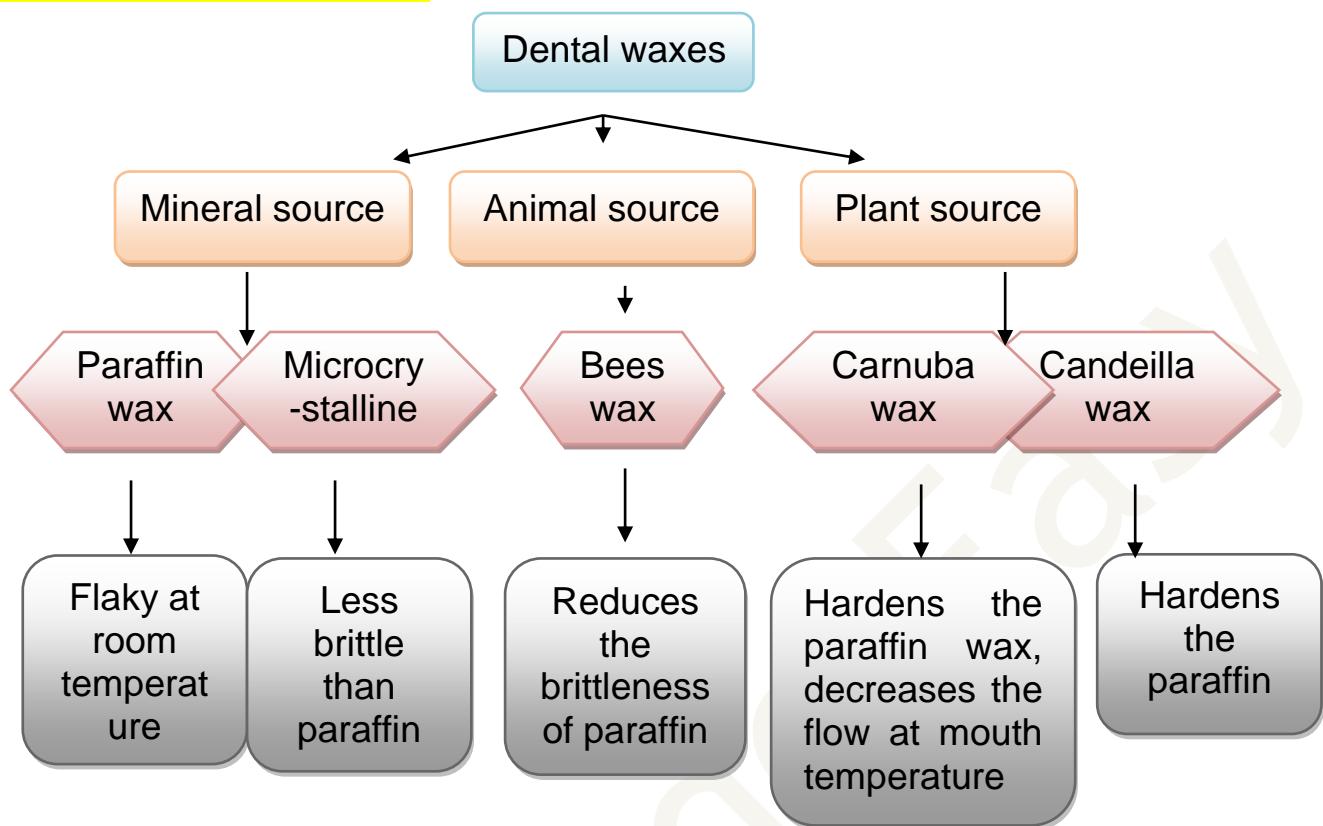
## REQUIREMENTS OF WAX-PATTERN MATERIALS



The wax pattern must confirm to the exact size, shape and contour of the appliance which is to be constructed

No dimensional change should take place in the wax pattern once it has been formed

Should be positive to remove by boiling out or burning without leaving a residue after casting the mould

**GENERAL COMPOSITION****CLASSIFICATION****I. According to Function**

<b>Pattern Wax</b>	<b>Processing Wax</b>	<b>Impression Wax</b>
<ul style="list-style-type: none"> <li>Modeling</li> <li>Inlay</li> <li>Casting</li> <li>Base plate</li> </ul>	<ul style="list-style-type: none"> <li>Boxing</li> <li>Utility</li> <li>Sticky</li> <li>Cording</li> </ul>	<ul style="list-style-type: none"> <li>Bite Registration</li> <li>Corrective</li> </ul>

**II. According to Composition**

<b>Natural Waxes</b>	<b>Synthetic Waxes</b>	<b>Additive Waxes</b>
<p>Complex combination of organic compounds of high molecular weight</p> <ul style="list-style-type: none"> <li>Mineral (Hydrocarbons Ester)</li> </ul>	<p>Consists of a complex combination of organic compounds with varied chemical compositions</p> <p>Highly refined unlike natural waxes</p> <ul style="list-style-type: none"> <li>Polyethylene waxes</li> </ul>	<p>Gum Arabic: Viscous and amorphous exudate of plants which dissolves in water.</p> <p>Provides viscosity</p> <p>Examples: Gumarabic,</p>

<ul style="list-style-type: none"> <li>• Plant</li> <li>• Insect</li> <li>• Animal</li> </ul> <p><b>Disadvantage:</b> Composition of natural waxes are not consistent, contaminated frequently</p>	<ul style="list-style-type: none"> <li>• Polyethylene glycol waxes</li> <li>• Halogenated hydrocarbon waxes</li> <li>• Hydrogenates waxes</li> <li>• Wax esters</li> </ul> <p><b>Examples:</b> Castor wax, Acrawax C, Flexowax C, Albacer, Aldo</p>	<p>Tragacanth</p> <ul style="list-style-type: none"> <li>• Fats (stearic acid): Tasteless, odorless, colourless           <ul style="list-style-type: none"> <li>↑ Melting range</li> <li>↑ Hardness</li> </ul> </li> <li>• Resins (dammer)           <ul style="list-style-type: none"> <li>↑ Toughness</li> <li>↑ Film-forming</li> </ul> </li> <li>• Oils: Hydrocarbon oils are added to soften the waxes</li> </ul>
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## CHARACTERISTIC PROPERTIES

### I. Thermal Properties

#### *Solid-Solid transition temperature/ Glass transition temperature*

- It is the temperature at which there is rapid increase in coefficient of thermal expansion along with molecular mobility.
- Changes the crystalline structure of wax
- It allows easy manipulation of the wax without flaking.
- This temperature should be slightly above the mouth temperature

#### *Coefficient of thermal expansion*

- Highest coefficient of thermal expansion
- It allows the wax to expand on heating and shrinks on cooling
- Causes inaccuracies or distortion of wax pattern

#### *Melting range*

- Waxes have melting ranges rather than melting point because of the presence of components with different molecular weights

#### *Thermal conductivity*

- Low thermal conductivity

## II. Mechanical Properties

- Low compressive strength
- Low modulus of elasticity and proportional limit
- **Clinical relevance:** Modulus of elasticity of inlay wax has an important role in hygroscopic expansion of investment material used for casting as the stress from investment material is subjected onto wax patterns which may cause deformation. Hence it is advised to use waxes with different elastic modulus

## III. Rheological properties

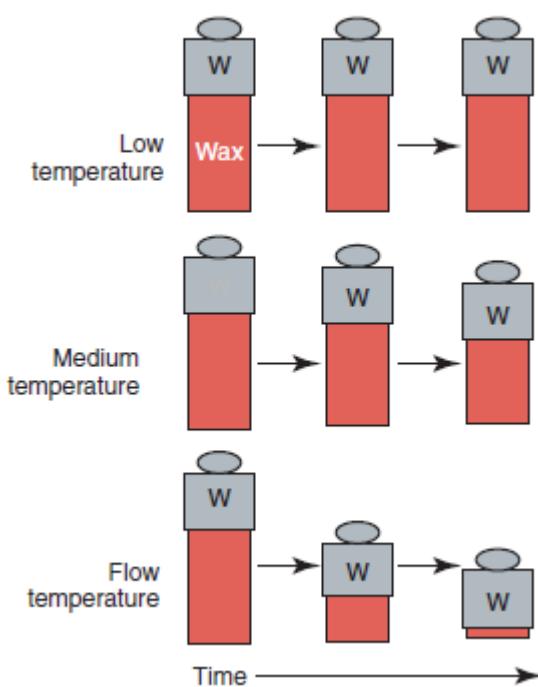
Residual Stress (wax distortion)		
Stress remaining in a wax pattern because of Manipulation <ol style="list-style-type: none"> <li>1. Heating</li> <li>2. Cooling</li> <li>3. Bending</li> <li>4. Carving</li> </ol>	To Prevent Residual stress from forming <ul style="list-style-type: none"> <li>• Waxes should not be carved or burnished at temperature below their melting range</li> <li>• Wax pattern should be carved with warm instruments</li> <li>• Melted wax is added in small increments to prevent rapid or uneven cooling</li> </ul>	To Prevent the Release of stress already created <ul style="list-style-type: none"> <li>• Wax pattern should not be</li> <li>• Subjected to temperature changes</li> <li>• Stored at high temperature</li> <li>• Minimize the time between finishing and investing the pattern (Less than 30 mm)</li> </ul>

### Flow

- It is a time dependant deformation under constant load as a result of slippage of molecules onto each other
- Flow depends on temperature of wax, time and the forces applied
- ↑ Temperature - ↓ Viscosity of wax turning it to liquid
- Control of flow is an important factor to manipulate wax

### Ductility

- Waxes with lower melting temperature have a greater ductility
- The ductility of wide melting range waxes > Ductility of narrow melting range waxes
- The highly refined waxes are brittle



Rheological property of wax: Flow.  
Diagram represents the changes in flow and dimensions of the wax block based on the load applied and temperature

## PATTERN WAXES

- Used to make models for the fabrication of restorations like crowns or fixed partial dentures

### Inlay wax

- Used for the fabrication of wax patterns (crown, bridges etc)
- Available as rounded sticks ( $7.5 \times 6\text{mm}$ ) - red, blue, yellow, green
- Different hardness forms are available based on casting requirements
- Composition: Paraffin, Carnauba, Ceresin, Beeswax
- Type 1 Medium wax: Direct pattern
- Type 2 Soft wax: Indirect pattern

### Casting wax

- Used to fabricate metal frameworks for cast partial denture
- Available as sheets or in preformed shapes
- Composition like inlay waxes
- Classification: Class A (28 gauge), Class B (30 gauge), Class C (preformed)
- Slightly sticky to hold the pattern in position
- Ductility is high, vaporizes at  $500^\circ\text{C}$  without any residue, should be pliable at  $40 - 45^\circ\text{C}$

### Base plate wax

- Used to customise vertical dimension, plane of occlusion, arch form, hold the teeth in position during processing of dentures

- Available as sheets ( $15 \times 7.5 \times 0.13$  cm) in pink or red in colours
- Composition: Ceresin, carnauba wax, synthetic waxes
- Type 1:(Soft) To make dentures
- Type 2:(Medium) To make patterns suitable to mouth temp.
- Type 3: (Hard) Similar to inlay wax

### Properties of Inlay Wax

<i>Uniformity</i>	When softened, the wax should be uniform																												
<i>Surface texture</i>	There should be no flakiness or similar surface roughening when the wax is bent and moulded after softening																												
<i>Hardness</i>	After the wax pattern has solidified, it is necessary to carve the original tooth anatomy in the wax and to carve the wax at the margins so that the pattern conforms exactly to the surface of the die																												
<i>Residue</i>	ANSI/ADA Specification No. 4 requires that the melted wax, when vaporized at $500^{\circ}\text{C}$ ( $932^{\circ}\text{F}$ ), leave no solid residue more than 10% of the original weight of the specimen																												
<i>Dimensional stability</i>	The wax pattern should always be completely rigid and dimensionally stable until it is eliminated																												
<i>Flow</i>	<table border="1"> <thead> <tr> <th>Type</th> <th><math>30^{\circ}\text{C}</math> Max.</th> <th><math>37^{\circ}\text{C}</math> Max.</th> <th><math>40^{\circ}\text{C}</math> Min.</th> <th><math>40^{\circ}\text{C}</math> Max.</th> <th><math>47^{\circ}\text{C}</math> Min.</th> <th><math>47^{\circ}\text{C}</math> Max.</th> </tr> </thead> <tbody> <tr> <td>I</td> <td>-</td> <td>1.0</td> <td>-</td> <td>20</td> <td>70</td> <td>90</td> </tr> <tr> <td>II</td> <td>1.0</td> <td>-</td> <td>50</td> <td>-</td> <td>70</td> <td>90</td> </tr> </tbody> </table>	Type	$30^{\circ}\text{C}$ Max.	$37^{\circ}\text{C}$ Max.	$40^{\circ}\text{C}$ Min.	$40^{\circ}\text{C}$ Max.	$47^{\circ}\text{C}$ Min.	$47^{\circ}\text{C}$ Max.	I	-	1.0	-	20	70	90	II	1.0	-	50	-	70	90	Inlay waxes are less rigid and flows at room temperature.						
Type	$30^{\circ}\text{C}$ Max.	$37^{\circ}\text{C}$ Max.	$40^{\circ}\text{C}$ Min.	$40^{\circ}\text{C}$ Max.	$47^{\circ}\text{C}$ Min.	$47^{\circ}\text{C}$ Max.																							
I	-	1.0	-	20	70	90																							
II	1.0	-	50	-	70	90																							
<i>Coefficient of thermal expansion</i>	Rate of expansion of Type I inlay wax is higher from slightly below mouth temperature till $45^{\circ}\text{C}$																												

## PROCESSING WAXES

- They are used in various auxiliary roles - Fabrication of models, Impressions and Soldering

### Boxing Wax

- Used to make a plaster or stone model from an impression.
- Establishes peripheral height.
- Should be slightly tacky to enable attachment
- Composition: Bees wax, paraffin, soft waxes

### Carding Wax

- Used to fix porcelain or acrylic teeth after manufacturing.
- Also used for boxing operation

### Sticky Wax

- To assemble metallic or resin pieces temporarily in position
- To seal plaster splint to a stone cast in the process of forming porcelain facings

### Utility wax

- Also called adhesive waxes
- Used on lingual part of FPD pontic to stabilize
- Available as stick & sheet forms in dark red, orange colours
- Highest floww and ductility, adhesive at 21 - 24°C

### Blockout wax

- Used to block the undercut areas on the models or casts while processing Co-Cr frame work

**IMPRESSION WAXES**

- They are used for taking impression within the mouth

<b>Bite Registration Wax (Occlusal indicator wax)</b>	<b>Corrective Wax</b>
<ul style="list-style-type: none"> <li>• Used to occlude and position the opposing arch of tooth</li> <li>• Flow is 2.5 - 22% at mouth temperature, susceptible to distortion while removing from the mouth</li> <li>• Available as 28-gauge wax sheets</li> </ul>	<ul style="list-style-type: none"> <li>• Wax is veneered over an impression</li> </ul> <p style="text-align: center;">↓</p> <ul style="list-style-type: none"> <li>• To register the detail of soft tissues in a functional state.</li> <li>• Consists of paraffin, ceresin &amp; beeswax</li> <li>• Flow is 100% at 37°C</li> </ul>

**MANIULATION OF WAX PATTERN**

<b>I. Direct technique</b>	<b>I. Indirect technique</b>
<ul style="list-style-type: none"> <li>• Dry heat is used</li> <li>• Wax is softened under the heat and shaped inside the oral cavity</li> </ul>	<ul style="list-style-type: none"> <li>• Wax is melted using direct flame or electric wax pots</li> <li>• Wax is applied on to the lubricate die using either a wax spatula or painting brush</li> </ul>

**RECENT ADVANCES**

- Conventionally wax patterns are prepared manually and then casted, whereas newer developments CAD CAM machines fabricate wax pattern
- Wax pattern is made using milling technique based on virtual model formulated through digital data obtained from oral cavity
- Recently rapid prototyping also known as 3D printing is also used to fabricate wax patterns for restorations which later can be casted in conventional manner
- Advantages: high precision and reduced lab timing

**CONCLUSION**

- Dental waxes play a major role in the field of dentistry as they are used to make some high precision work. Hence it is essential to have knowledge in dental to use them effectively.

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*Please Give Your Feedback on this Answer*

**Q. 05: Dentine bonding agents (7M)**

**CONTENTS/SYNOPSIS**

Introduction

Role of adhesive dentistry

Adhesion

- Definition
- Mechanism of adhesion
- Indications for adhesives
- Enamel adhesion
- Dentine adhesion

Dentine bonding agents

- Ideal requirements of dentine bonding agents
- Conditioning of dentine
- Priming of dentine
- Mechanism of bonding

Classification of dentine bonding agents

- Classification based on generations
- Classification based on mechanism of adhesion
- Classification with generations and bonding mechanisms (According to Van Meerbek et al)
- Generations (1st - 8th)
- Mechanism of adhesion

Clinical factors affecting dentine adhesion

Recent advances

Failures of dentine bonding agents

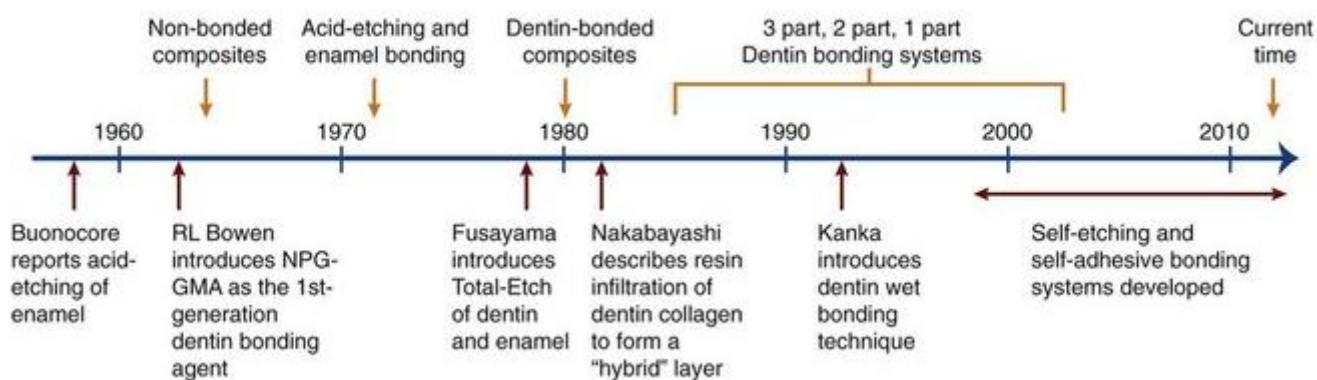
Conclusion

Reference

## INTRODUCTION

- With the increase in demand for esthetics in dentistry, classic concepts of treatment approaches with minimal invasion and type of materials to be used have been changed dramatically.
- Hence the introduction of restorative adhesive materials to minimize the need for tooth preparation extensively.

## HISTORY



## ADHESION

### I. Definition

- According to the American society for testing and materials, adhesion is defined as a state in which two surfaces are held together by interfacial forces like valence or interlocking forces or both
- It has three components

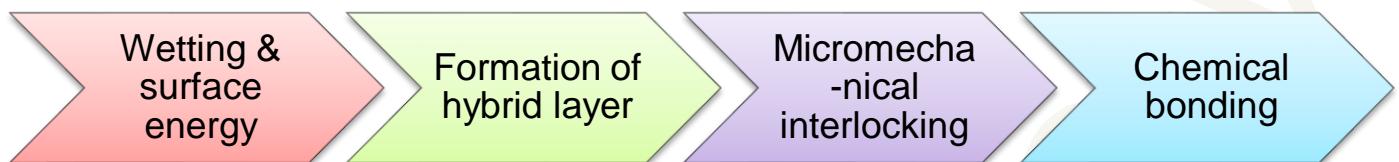
**Adhesive:** It is a material that joins two substrates, resisting separation and transferring load from one substrate to another

**Adherend:** Surface to which an adhesive adheres

**Adhesive strength:** It is the capacity to bear load of an adhered joint

## II. Mechanism of Adhesion

- To achieve a true adhesion between restorative material and tooth structure, following conditions should be favorable
  - Conservation of sound tooth structure
  - Optimal retention
  - Prevention of microleakage
- The following are the factors that affects the adhesion



## III. Indications for Adhesives

- To restore class I, II, III, IV, V and VI lesions
- Alter the shape and colour of teeth
- Seal pits and fissures
- Desensitization (cervical abrasion, exposed roots)
- Bonding (fractured tooth segments, amalgam restorations to tooth, broken posts, ortho brackets)
- Coronal filling after endodontic therapy

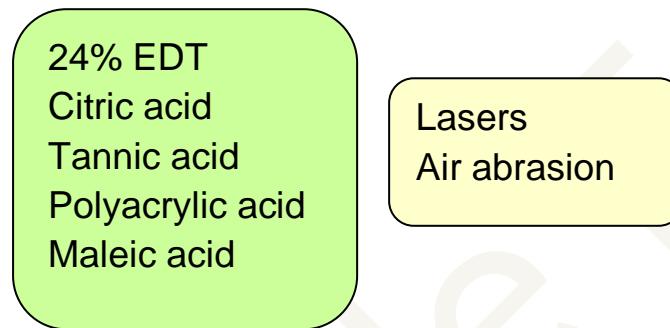
## IV. Enamel Adhesion

- 1955 - Michael Buonocore described the technique of etching the enamel surface using diluted phosphoric acid, which provides retention of self curing acrylic resins.
- Etching creates 10 - 40  $\mu\text{m}$  micro porosities in the enamel through which the resin material mechanically interlocks creating small tags. (Resin - Enamel - Adhesion)

Etching patterns	<ul style="list-style-type: none"> <li>Type 1: dissolution of prism cores without involving prism peripheries</li> <li>Type 2: Peripheral enamel is dissolved with core intact</li> <li>Type 3: Less distinct than type 1 &amp; type 2</li> </ul>
Etchant concentration	<ul style="list-style-type: none"> <li>37% phosphoric acid gel is used (Silverstone found that 30 - 40% of this acid will form very retentive enamel surface)</li> <li>&gt;40% Calcium is dissolved leading to poor defined</li> </ul>

	etching • <27% forms dicalcium phosphate dihydrate which cannot be removed easily
Etching time	• Ideal time - 15 seconds

- Earlier 60 seconds of etching time was recommended while etching permanent tooth using 30 - 40% phosphoric acid. Several studies have showed that 15 seconds and 60 seconds of etching time gave similar results.
- Alternative etchants and etchant systems are



- Er:YAG laser etching is inferior when compared with conventional etching, as laser etching creates an extensive subsurface fissuring which is not favourable for adhesion.

### Bond Strength

- Studies have shown that a minimum of 17 - 21 MPa is needed to create a good bond between tooth and composite

## V. Dentin Adhesion

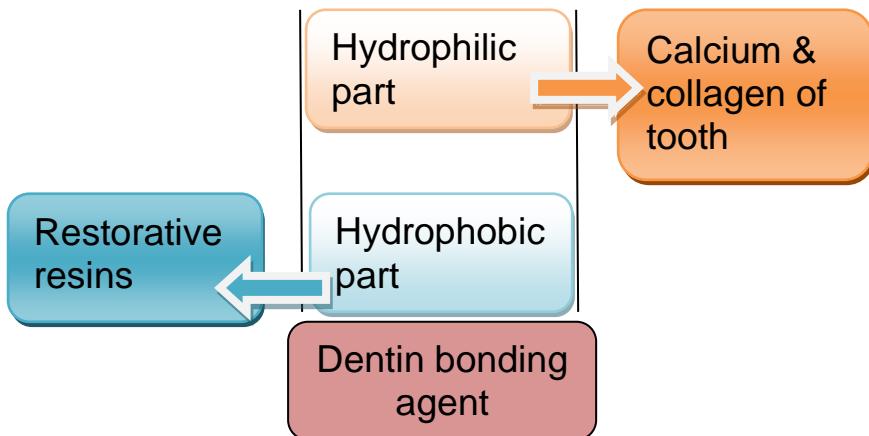
- Dentin adhesion occurs either mechanically, chemically or both
- Due to the structural difference between enamel and dentine there are few challenges in dentin adhesion

Dentine structure	Smear layer	Resin dentin interface stress
<ul style="list-style-type: none"> <li>• Dentin has only 50% Hydroxyapatite crystals when compared with enamel.</li> <li>• Dentinal tubules</li> </ul>	<ul style="list-style-type: none"> <li>• It is a residual layer of organic and inorganic components formed during preparing a tooth with a bur or</li> </ul>	<ul style="list-style-type: none"> <li>• Polymerization shrinkage of composites causes stresses upto 7MPa</li> <li>• Stresses are relieved when composites are</li> </ul>

<p>exert a pressure of 25-30mmHg, lessening the stability of bond between composite resin and dentin</p> <ul style="list-style-type: none"> <li>• There is a decrease in number of dentinal tubules from 45000 (near pulp) to 20000 (near DEJ)</li> <li>• Diameter of the tubule also decreases from 2.37 - 0.63<math>\mu</math>m near DEJ</li> <li>• Adhesion can be affected by remaining dentin thickness (RDT)</li> </ul>	<p>instrument</p> <ul style="list-style-type: none"> <li>• It is 1 - 10<math>\mu</math>m thick</li> </ul> <p><b>Composition</b></p> <ul style="list-style-type: none"> <li>• Collagen matrix, Inorganic tooth preparation, blood, saliva and bacteria</li> <li>• Complete removal of smear layer by etching increases dentin permeability by 90%</li> </ul>	<p>bonded on one surface</p> <ul style="list-style-type: none"> <li>• Self etching adhesives shows bond strength &gt; 20MPa</li> </ul>
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## DENTIN BONDING AGENTS

- It is defined as a thin layer of resin applied between conditioned dentin and resin matrix.
- The following are the factors that affect the dentin bonding agents
  - Presence of high-water content in dentin interferes with bonding
  - Formation of smear layer over dentine surface
- Based on the factors affecting the bonding agents should have the following characteristics
- Should be hydrophilic to displace the water, permit it to penetrate the dentin porosities
- Should be hydrophobic as resins are hydrophobic.



### Ideal requirements of dentin bonding agents

1. Adequate removal of smear layer and dissolution of hydroxyapatite
2. Dentinal collagen matrix must be maintained
3. Wetting should be good
4. Monomer penetration should be efficient
5. Should be able to polymerize with tooth structure
6. Copolymerize with resin matrix

Dentin Conditioning	Dentin Priming
<ul style="list-style-type: none"> <li>• It is a process of etching the dentinal surface with either acids or chelating agents (calcium).</li> <li>• Material used are: 37% phosphoric acid, EDTA, nitric acid, citric acid.</li> <li>• Duration: 15 - 20 seconds</li> <li>• Acid dissolves the hydroxyapatite crystals in intertubular and peritubular dentin, removes the smear layer and exposes the collagen fibrils.</li> <li>• Increased acid exposure: denaturation and collagen collapse</li> <li>• Decreased acid exposure: Insufficient etching</li> </ul>	<ul style="list-style-type: none"> <li>• It is a process of applying primers to conditioned dentin to improve the diffusion of resin into demineralized dentin</li> <li>• Primers are a combination of monomers with both hydrophilic and hydrophobic components in an organic solvent</li> <li>• Priming agents: HEMA (hydroxyethyl methacrylate), 4 META (4-methacryloxyethyl trimellitate anhydride)</li> </ul>

## Mechanism of Bonding

Conditioning of dentin removes the smear layer and dissolves hydroxyapatite



Air drying - shrinks the collagen molecules



Priming the dentin rehydrates and swells the collagen



Polymerization of resin monomer and interweave with collagen



Penetration of monomer into the dentine surface (formation of Hybrid layer)

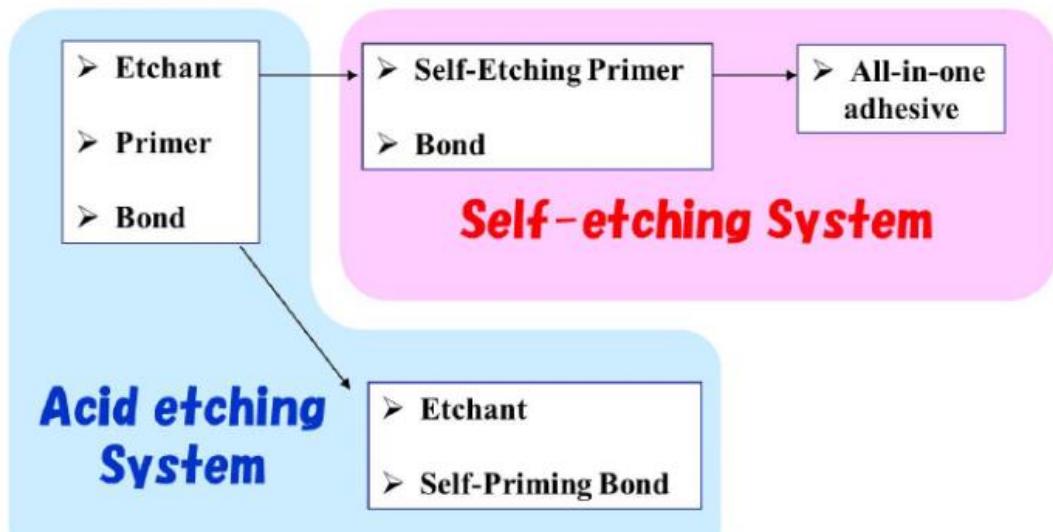
## CLASSIFICATION OF DENTIN BONDING AGENTS

### I. Classification based on generations

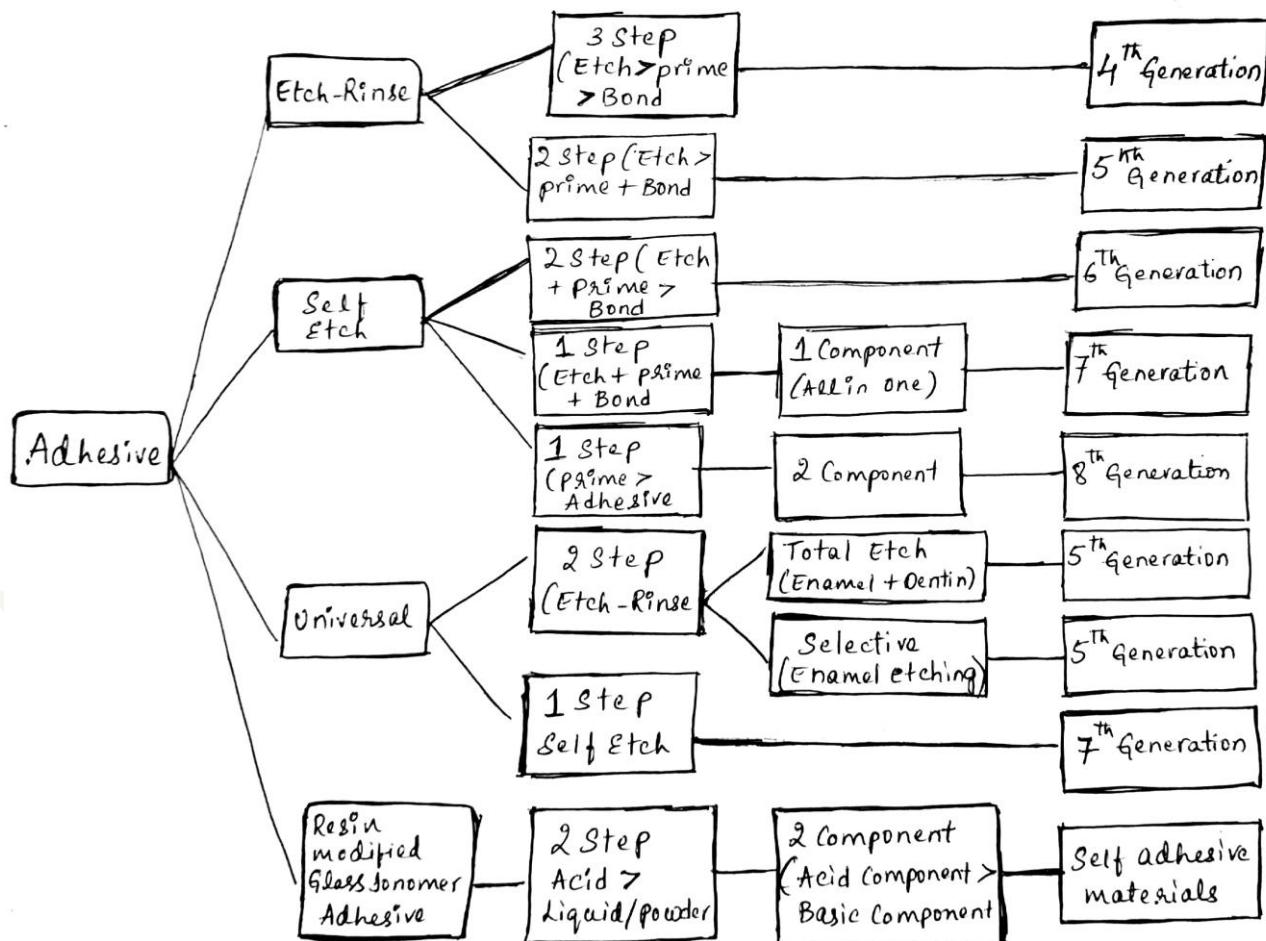
Generation	Number of steps	Surface pre-treatment	Components	Shear bond strength (MPa)
1 <sup>st</sup>	2	Enamel etch	2	2
2 <sup>nd</sup>	2	Enamel etch	2	5
3 <sup>rd</sup>	3	Dentine conditioning	2–3	12–15
4 <sup>th</sup>	3	Total etch	3	25
5 <sup>th</sup>	2	Total etch	2	25
6 <sup>th</sup>	1	Self-etch adhesive	2	20
7 <sup>th</sup>	1	Self-etch adhesive	1	25
8 <sup>th</sup>	1	Self-etch adhesive	1	Over 30

## II. Classification based on mechanism of adhesion

3 step → 2 step → 1 step



## III. Classification with generations and bonding mechanisms (According to Van Meerbeek et al)



### First Generation

- Developed in the early 1960's
- Consists of surface active co monomer NPG-GMA (N-phenylglycine glycidyl methacrylate).
- **Mechanism:** They bond by chelation with calcium
- **Example:** Cervident (SS)
- **Properties:** Poor bond strength, hence used to restore lesions which does not need any mechanical retention

### Second Generation

- Introduced in 1978
- Based on phosphorous esters of methacrylate
- **Mechanism:** Ionic interaction between negatively charged phosphate and positively charged calcium groups in smear layer
- **Advantage:** Higher bond strength (3 times) on comparison with 1st generation
- **Disadvantage:** Lower bond strength on comparison with higher generations
- Poor bonding in oral environment, primary bonding is with smear layer instead of dentin
- **Example:** Scotchbond (3M ESPE), Clearfil Bond system (Kuraray), Prisma Universal bond (Dentsply), Bondlite (Kerr corporation)

### Third Generation

- Introduced in 1984
- They are designed just to modify the smear layer instead of total removal.
- In this system etchants like 10% citric acid and 3% ferric chloride are applied followed by phosphate-based material HEMA and 10-MDP (10-methacryloxy decyl dihydrogen phosphate) to initiate polymerization
- **Example:** C & B meta bond (Sun Medical), Amalgam bond Plus, Super bond D Liner
- Available as system with dentin conditioner, primer and bonding agent.

### Fourth Generation

- Introduced in 1980s and 1990s
- These are the first dentin bonding agents to remove smear layer completely (Golden standard in dentin bonding)
- It follows a three step etch-rinse-adhesive
- 30-40% phosphoric acid is used to etch both dentin and enamel and applied for a period of 15 - 30 seconds making sure the surface of left moist to

prevent collagen collapse

- Used in cavity restoration, bonding porcelains and alloys
- Example:** All-bond 2, Opti-bond FL, Scotchbond Multipurpose, Permaquai (Ultradent)

#### ***Fifth Generation***

- Introduced in 1990s and future decade
- They are modified version of fourth generation to reduce the working time
- Available as one step or one bottle system with a combination of primer and adhesive into one with a general composition of HEMA, Bis-GMA, dimethacrylate, polyacrylic acid, water and ethanol.
- Etchant is 35 -37% phosphoric acid for 15- 20 seconds.
- Advantage:** Susceptible to water dissolution
- Disadvantage:** Inferior to fourth generation in bond strength

#### ***Sixth Generation***

- Introduced in late 1990s and early 2000s
- Also known as self etching primers as etching step has been removed in this generation.
- Consists of two step & one step self etch adhesives, two component self etch adhesives
- Advantage:** No need to maintain the moisture of dentin
- Disadvantage:** Enamel bond is 25% weaker than 4th and 5th generations
- Example:** AdheSE, Opti Bond Solo Plus, clearfil SE Bond, clearfil Protech Bond

#### ***Seventh Generation***

- Introduced in late 1999 and early years of 2005
- It is a one bottle self etching system with a combination of conditioner, primer and adhesive resin
- It is a combination of hydrophilic and hydrophobic components
- Disadvantage:** Bond strength is lower when compared to 4th and 5th generation
- Examples:** Clearfil S Bond (Kurray), G-Bond, Xeno IV (Dentsply)

#### ***Eighth Generation***

- Introduced in 2010 by voco America (voco futurabond DC)
- Consists of nanosized fillers (12nm) which increases the penetration of resin and thickness of hybrid layer.
- Advantages:** Better bond strength with both enamel and dentine, absorbs

stress and have a longer shelf life

### Mechanism of Adhesion

Three steps	Two steps -1	Two steps -2	One step
<ul style="list-style-type: none"> <li>Supplied as three different bottles with etchant, primer and bonding agent.</li> <li>Most complicated to use</li> <li>Highest bond strength and ductility</li> </ul>	<ul style="list-style-type: none"> <li>Supplied in two bottles, one with etchant and the other with combination of prime and bond.</li> </ul>	<ul style="list-style-type: none"> <li>Supplied in two bottles with self etching primer and bonding agent.</li> <li>The primer modifies smear layer and incorporates resin in the layer</li> </ul>	<ul style="list-style-type: none"> <li>Single bottle formula with a blend of self etching primer and bonding agent.</li> <li>Easiest to use, acceptable bond strength</li> </ul>

### Clinical factors affecting Adhesion

1. Amount of fluoride on teeth
2. Blood contamination
3. Salivary flow
4. Moisture and oil contamination through handpiece or three way syringe
5. Size and location of dentinal tubules
6. Presence of organic substances like plaque, calculus, stains and debris and also dental materials like liners and bases
7. Dehydrated tooth
8. Presence of residual cements

### RECENT ADVANCES

#### Universal Adhesive

- It can be used as selective etch, total etch, self etch
- Can be used with dual cure, light cure, self cure materials
- Can be used for both direct and indirect substrate
- Can bond to all tooth materials like enamel, dentin, metals, ceramics, porcelain including zirconia
- Example: ScotchBond Universal, All-Bond universal

## FAILURES IN DENTIN BONDING AGENTS

Failure may occur at various level between

- Mineralized and demineralized dentin
- Demineralized dentin and bonding agent
- Layers of bonding agent
- Bonding agent and composite resin

Failure may cause by

- Wetness of dentin
- Flexure of tooth
- Material factors

## CONCLUSION

- With the growing esthetic demand, several improvements have been made in dental materials and treatment procedures.
- In all these bonding is a crucial step to ensure the durability of the material.
- Hence an ideal bonding agent should bond properly with both enamel and dentin, strong enough to resist occlusal and masticatory forces, simulate mechanical properties of tooth and be resistant to oral environment

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1. William J. O'Brien. Dental materials and their selection. 4th edition
2. Sakaguchi R, Ferracane J, Powers J. Craig's Restorative Dental Materials, 14<sup>th</sup> edition
3. Anusavice, Kenneth J. Phillip's science of Dental materials,12<sup>th</sup> edition
4. Powers and wataha. Dental materials Foundations and Applications, 11th edition
5. Sofan E et al. Classification review of dentin adhesive systems: from the IV generation to the universal type. Annali di stomatologia 2017;VIII(1):1-17.
6. Ganesh R. Dentin bonding agents - A Review. Acta Scientific Dental Sciences 3.6 (2019):108-111.

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*Please Give Your Feedback on this Answer*

**Q. 09: Polyvinyl siloxane impression material (7M).**

**Elastomeric impression materials (7M).**

**Merits and demerits of elastomeric impression materials (10M)**

**Compare and contrast the properties of various elastomeric impression materials (7M).**

**Recent advances in elastomeric impression materials (20M, 7M)**

### CONTENTS/SYNOPSIS

Introduction

Desirable qualities of impression materials

Classification of impression materials

- Based on mechanism of setting and mechanical properties
- Based on the clinical condition

Elastomeric impression materials

- History
- Clinical application

Composition & chemistry

- Polysulphide
- Condensation silicone
- Addition silicone
- Polyether

Consistency and mixing systems

Properties

Failures of elastomeric impression materials

- Rough/ uneven surfaces
- Bubbles
- Irregularly shaped voids
- Rough/ chalky stone cast
- Distortion

Recent advances

- Hydrophilized addition silicones
- Monophase impression material
- Visible light cured polyether urethane

Conclusion

Reference

## INTRODUCTION

- Impression materials are used to replicate and represent the form of the tooth and their relationship with the remaining oral structures.

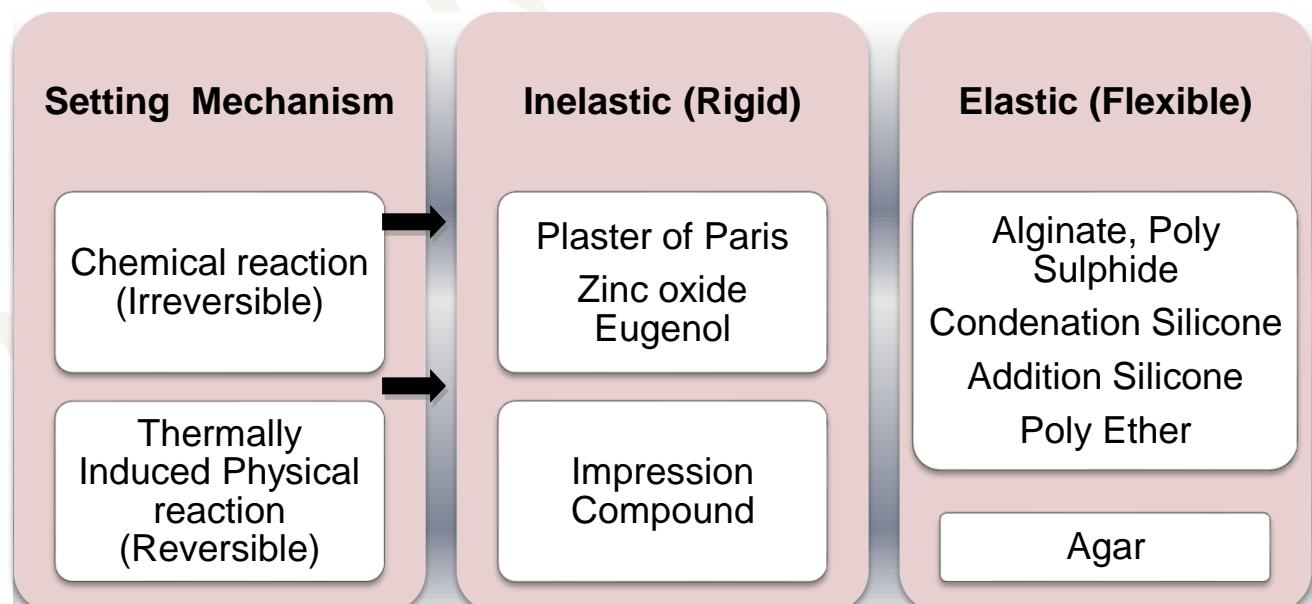
## DESIRABLE QUALITIES OF IMPRESSION MATERIALS

- Pleasant taste and odor
- Nontoxic or nonirritant
- Good shelf life
- Adequate flow
- Enough viscosity to be held in a tray
- Wettability to the oral structures
- Should be able to set either physically or chemically within in the mouth
- Tear strength to protect the impression from distortion
- Dimensional stability to be able to pour casts
- Compatible biologically
- Economical

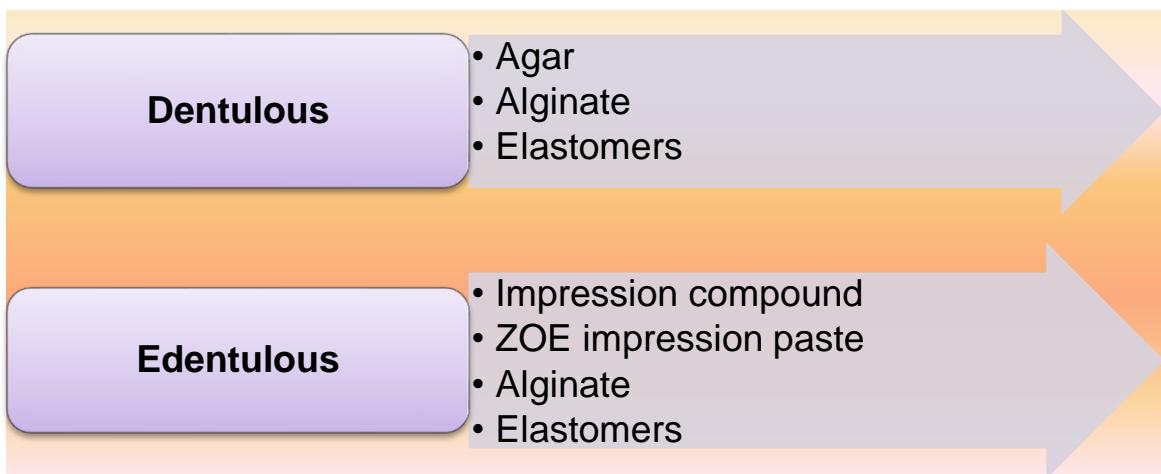
## CLASSIFICATION OF IMPRESSION MATERIALS

- According to Philips' Science of dental materials, 12th Ed

### I. Based on mechanism of setting and mechanical properties



## II. Based on the clinical condition



### ELASTOMERIC IMPRESSION MATERIALS

- Elastomers are impression materials that are polymer based and sets chemically.
- According to GPT 9, an elastomeric impression material is a group of flexible chemical polymers which are cross linked chemically or physically.
- They are easily stretched and rapidly recovers to their original dimension on release of stress applied.

### History

- In the olden days impressions were made using inelastic materials like hydrocolloids for both hard and soft tissues

1950's	After world war II a group of synthetic rubbery materials called elastomers (polysulphides, condensation silicone) were developed to make impressions of both hard and soft tissues
1960's	Polyether was developed in Germany
1970's	Addition silicone was introduced
1988	Light cure elastomers were introduced
1990 - 2000	New automatic dispensing systems are introduced

### Clinical applications

- Impression making for all prosthetic applications (Dentulous & edentulous)
- Border molding using special trays
- Bite registration
- Duplicating material for refractory cast

**COMPOSITION & CHEMISTRY****I. Polysulphide**

<b>Composition</b>	<b>Setting Reaction</b>
<b>Base Paste</b>	$\text{HS - R - SH} \xrightarrow{\text{PbO}_2 + \text{S}} \text{HS - R - S - S - R - SH} + \text{H}_2\text{O}$
<ul style="list-style-type: none"> <li>• Liquid polysulfide polymer (Mercaptan)</li> <li>• Titanium dioxide, lithopone: filler</li> <li>• Dibutyl phthalate: plasticizer</li> <li>• Sulphur (approx. 0.5%): accelerate the reaction</li> </ul>	<ul style="list-style-type: none"> <li>• Condensation polymerization</li> <li>• Exothermic reaction 3-4°C</li> </ul>
<b>Catalyst / Accelerator / Reactor Paste</b>	
<ul style="list-style-type: none"> <li>• Lead dioxide - oxidizing agent, to initiate polymerization through chain lengthening between terminal -SH groups and cross-linking between the pendant -SH groups gives polysulfide its characteristic brown colour</li> <li>• Oleic or stearic acid: Retarder</li> <li>• Titanium dioxide, lithopone: Filler</li> <li>• Dibutyl phthalate: plasticizer</li> </ul>	
<b>By product:</b> Water	

## II. Condensation Silicone

<b>Composition</b>	<b>Setting reaction</b>
<b>Base Paste</b> <ul style="list-style-type: none"> <li>• <math>\alpha</math>-<math>\omega</math>-hydroxyl-terminated</li> <li>• polydimethyl siloxane</li> <li>• Stannous octoate – catalyst</li> </ul>	<ul style="list-style-type: none"> <li>• Reaction of tri- and tetra-functional alkyl silicates, commonly tetraethyl orthosilicate, in the presence of stannous octoate</li> </ul>
<b>Catalyst / Accelerator / Reactor Paste</b> <ul style="list-style-type: none"> <li>• Alkyl silicate (ortho ethyl silicate)</li> <li>• Stannous octoate</li> <li>• Inert filler</li> </ul>	<ul style="list-style-type: none"> <li>• The formation of the elastomer occurs through cross-linking between terminal groups of the silicone polymers and the alkyl silicate to form a three-dimensional network</li> </ul>

*By product:* Ethyl Alcohol – Evaporation leads to the contraction of impression

## III. Addition Silicone / Poly Vinyl Siloxane

<b>Composition</b>	<b>Setting reaction</b>
<b>Base Paste</b> <ul style="list-style-type: none"> <li>• Poly (methyl hydrogen siloxane)</li> <li>• Divinyl polysiloxane</li> <li>• Fillers</li> <li>• Putty viscosity: 60-70%</li> <li>• Medium viscosity: 35-75%</li> <li>• Low viscosity: 5-15%</li> </ul>	<ul style="list-style-type: none"> <li>• Ionic Polymerization</li> <li>• Addition type – no by products</li> </ul>
<b>Accelerator Paste</b> <ul style="list-style-type: none"> <li>• Divinyl polysiloxane</li> <li>• Inert oils &amp; fillers</li> <li>• Platinum salt</li> <li>• Palladium</li> <li>• Retarders</li> </ul>	<p>If balance among two polymers is not maintained</p> <p>↓</p> <p>Leads to secondary reaction</p> <p>↓</p> <p>Produces hydrogen gas</p> <p>↓</p> <p>Forms bubbles on the impression surface</p> <p>↓</p> <p>Voids in cast</p>

*By product:* Hydrogen

## IV. Polyether

<p><b>Composition</b></p> <p><b>Base Paste</b></p> <ul style="list-style-type: none"> <li>• Poly ether polymer</li> <li>• Colloidal silica – filler</li> <li>• Glycol ether or phthalate</li> <li>• Plasticizer</li> </ul> <p><b>Accelerator Paste</b></p> <ul style="list-style-type: none"> <li>• Aromatic sulfonate ester (Cross-linking agent)</li> <li>• Colloidal silica – Filler</li> <li>• Phthalate or glycol ether – Plasticizer</li> </ul>	<p><b>Setting reaction</b></p> <ul style="list-style-type: none"> <li>• Ring-opening polymerization of aziridine rings, which are at the end of branched polyether molecules</li> <li>• Acid-catalyzed condensation</li> <li>• polymerization of polyether prepolymer with alkoxy silane terminal groups</li> </ul>
<p><b>By product:</b> No by product</p>	

Consistency	Mixing systems
<ul style="list-style-type: none"> <li>• Putty</li> <li>• High</li> <li>• Medium</li> <li>• Low</li> <li>• Extra low</li> </ul>	<ul style="list-style-type: none"> <li>• Hand mixing</li> <li>• Static auto mixing</li> <li>• Dynamic mechanical mixing</li> </ul>

## PROPERTIES OF ELASTOMERIC IMPRESSION MATERIALS

Property	Polysulfide	Condensation Silicone	Addition Silicone	Polyether
Working time (min)	4–7	2.5–4	2–4	3
Setting time (min)	7–10	6–8	4–6.5	6
Tear strength (N/m)	2500–7000	2300–2600	1500–4300	1800–4800
Percent contraction (at 24 h)	0.40–0.45	0.38–0.60	0.14–0.17	0.19–0.24
Contact angle between set material and water (°)	82	98	98/53*	49
Hydrogen gas evolution (Y/N)**	N	N	Y†	N
Automatic mixing (Y/N)**	N	N	Y	Y
Custom tray (Y/N)**	Y	N	N	N
Unpleasant odor (Y/N)**	Y	N	N	N
Multiple casts (Y/N)**	N	N	Y	Y
Stiffness (value of 1 indicates greatest stiffness)‡	3	2 (1)	2 (1)	1 (2)
Distortion on removal (value of 1 indicates the greatest and 4 the least potential distortion)	1	2	4	3

Y/N - Yes or No

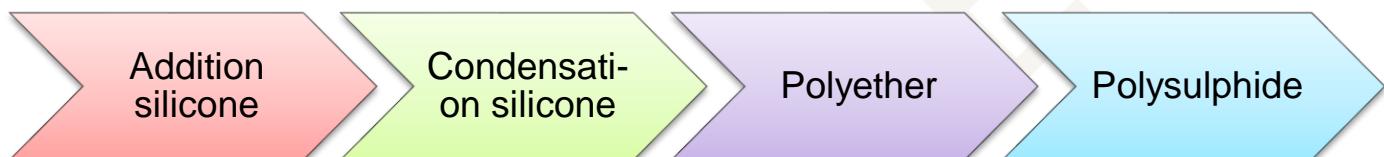
## I. Working and setting time

### Factors affecting working and setting time

- An increase in temperature, viscosity and humidity, decreases working time and setting time
- Polyether is less sensitive to temperature

## II. Elasticity

- Elasticity improves with an increase in curing time in the mouth
- An additional 1 or 2 minutes inside the mouth before removal of impression is beneficial
- Amount of **permanent deformation** under stress followed by strain induced during removal of impression



## III. Stiffness



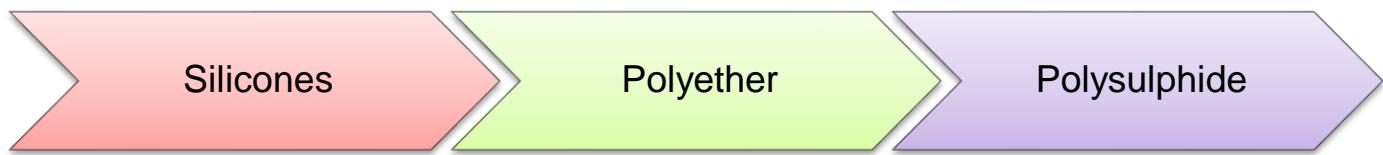
## IV. Flow

- Ideally, they should freely flow and wet the tissues while low medium is injected onto the surface to be recorded, followed by resisting flow by spreading heavy bodied on the impression tray to retain the impression.
- This phenomenon is called shear thinning
- Because of its highest rigidity, polyether is contraindicated in periodontally compromised tooth regions

## V. Dimensional stability

- Stability of elastomeric impressions are dependent on the following factors
- Formation of by product
- Polymerization shrinkage
- Contraction due to difference between oral and room temperature
- Incomplete recovery of deformation

## VI. Tear strength



## VII. Biocompatibility

- Allergic reactions are less for elastomeric impression materials
- Polysulphide has the least cell death count, whereas polyether has the highest cell death and toxicity

## Comparison of properties of elastomeric impression materials

Property	Polysulphi -de	Condesati o-n silicone	Addition silicone	Polyether
Tear strength	Highest	Good	Good	Good
Dimensional stability	Least	Less	Best	Good
Casting shrinkage	Highest	High	Lowest	Low
Permanent deformation	Highest	High	Lowest	Low
Flexibility	Good	Good	Low	Least
Hardness	Lowest	Harder than polysulp h-ide	Harder than polysulp h-ide	Harder than polysulp h-ide
Flow setting under forces	Very low	Very low	Low	Moderat e- high

## FAILURES OF ELASTOMERIC IMPRESSION MATERIALS

Types of failures	Causes
1. Rough/ uneven surfaces	<ul style="list-style-type: none"> <li>Incomplete polymerization due to premature removal of impression from mouth</li> <li>Presence of organic materials on teeth</li> <li>Latex contamination</li> <li>Polymerization is too rapid due to high humidity and temperature</li> <li>Higher ratio of accelerator to base in condensation silicone</li> </ul>
2. Bubbles	<ul style="list-style-type: none"> <li>Incorporation of air during mixing</li> </ul>
3. Irregularly shaped voids	<ul style="list-style-type: none"> <li>Presence of moisture or debris on the teeth surface</li> </ul>
4. Rough/ chalky stone cast	<ul style="list-style-type: none"> <li>Improperly cleaned impression</li> <li>Presence of excessive water after washing the impression</li> <li>Excessive wetting agents on impression</li> <li>Premature removal of cast</li> <li>Improper water/ powder ratio of gypsum product</li> <li>Delayed pouring of cast</li> </ul>
5. Distortion	<ul style="list-style-type: none"> <li>Shrinkage of custom tray</li> <li>Lack of adhesion of elastomers to the tray</li> <li>Poor mechanical retention</li> <li>Bulky material</li> <li>Material is partly set before seating the impression</li> <li>Premature removal of impression</li> <li>Mobility of tray during polymerization</li> <li>Delayed pouring of polysulphide and condensation silicone</li> </ul>

**RECENT ADVANCES**

<b>I. Hydrophilized addition silicones</b>	<b>II. Monophase impression material</b>
<ul style="list-style-type: none"> <li>Hydrophobic nature of elastomers is a major drawback. Addition of surfactants (micelles) reduces the contact angle of the materials, increases wettability, pouring of gypsum models.</li> <li>These surfactants consist of a hydrophilized part and a hydrophilic compatible silicone.</li> <li>According to Miller et al on adding modified polydimethyl siloxane, quality of impression surface is increased with an increase in wettability and reduction in number of voids.</li> <li>Usage of radiofrequency glow discharge to disinfect polyvinyl siloxane impressions.</li> </ul>	<ul style="list-style-type: none"> <li>Available as single viscosity</li> <li>Viscosity is determined based on the amount of pressure given while manipulating the material,</li> <li>Greater the shear - acts as light bodied material</li> <li>Lesser the pressure - acts as heavy bodied material</li> </ul>

### III. Visible light cured polyether urethane

Introduced in 1988 with ADA no 19  
Similar to light cured composite

#### **Composition:**

Polyether urethane dimethacrylate  
diketone - photoinitiator

Transparent silica - acts as filler (40-60%)

Available as light and  
heavy bodied

#### **Manipulation**

Transparent stock trays  
are used with heavy  
body and light body  
syringed onto it.

Curing is done using  
blue light (30seconds)

#### **Advantages**

1. Working time is longer
2. Impressions can be corrected
3. Good dimensional stability, accuracy and flow1.

#### **Disadvantages**

1. Expensive
2. Technique sensitive
3. Setting time is short

### CONCLUSION

- The recent modifications in impression materials led to improved characteristics, handling properties and clinical performances compared to unmodified materials.

## REFERENCE

1. William J. O'Brien. Dental materials and their selection. 4th edition
2. Sakaguchi R, Ferracane J, Powers J. Craig's Restorative Dental Materials, 14<sup>th</sup> edition
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*Please Give Your Feedback on this Answer*

**Q. 04: Hardness tests (10M)**

**CONTENTS/SYNOPSIS**

Introduction

Hardness

- Definition
- Classification of hardness tests
- Types of hardness tests
  - Brinell hardness test
  - Rockwell hardness test
  - Vickers hardness test
  - Knoop's hardness test
  - Barcol hardness test
  - Shore A hardness test
- Nanoindentation

Conclusion

Reference

## INTRODUCTION

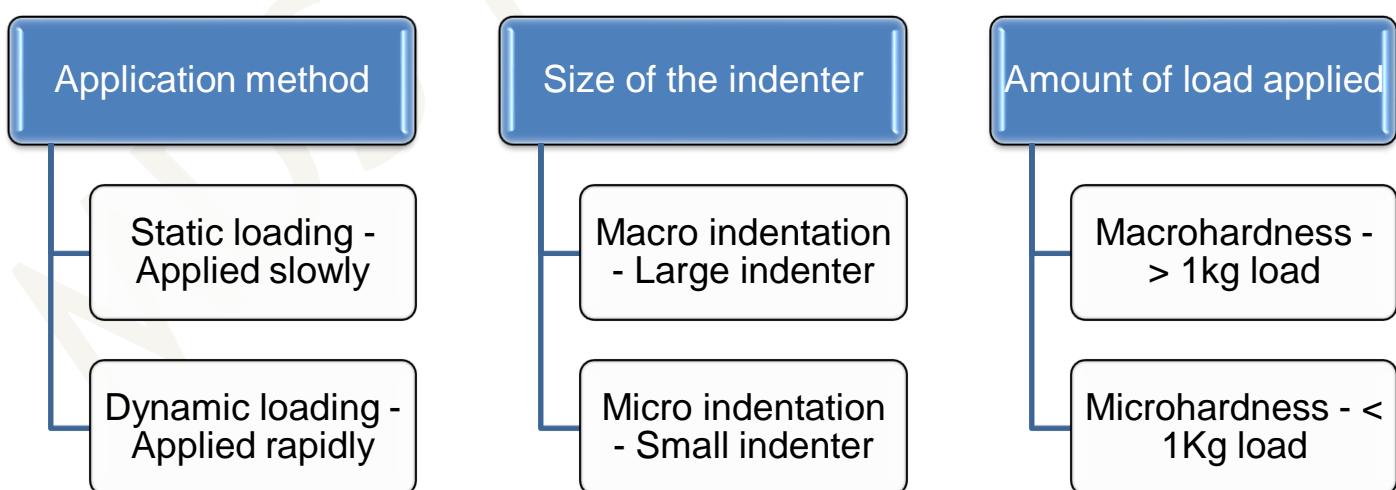
- Restorative materials and prosthesis are constantly exposed to chemical, thermal and mechanical challenges in oral environment
- These challenges may lead to deformation of materials
- Mechanical properties deal with law of mechanics, defining how a material responds to these mechanical challenges
- They are measured as elastic and plastic responses under an applied force

## HARDNESS

### Definition

- Hardness is defined as resistance of a material to undergo plastic deformation under indentation force
- Surface hardness is a parameter used to evaluate resistance of a material surface to plastic deformation by penetration
- It is an intrinsic property of a material, in terms of units of mass, length and time
- According to Mineralogy it is also defined as hardness of a material based on its ability to resist scratching
- The mechanical properties that are related to hardness of a dental material are proportional limit, ductility, compressive stress, elastic stiffness, viscoelasticity, toughness

### Classification of Hardness Tests



## Micro hardness tests

- Knoop hardness test
- Vickers hardness test

## Macrohardness tests

- Brinell hardness test
- Rockwell hardness test

**Types of tests based on the materials****1. Brinell Hardness Test**

- It is one of the oldest tests used to test metals and alloys in dentistry
- Example: Dental gold alloys
- In this test a hard-spherical steel or tungsten carbide ball with 1.6mm diameter and a load of 123N load is applied onto the polished surface of the material
- The load is applied for 30 seconds followed by measuring the diameter of indentation

$$\text{Brinell Hardness Number (BHN)} = \frac{\text{Load applied}}{\text{Area of projected surface of the indentation}}$$

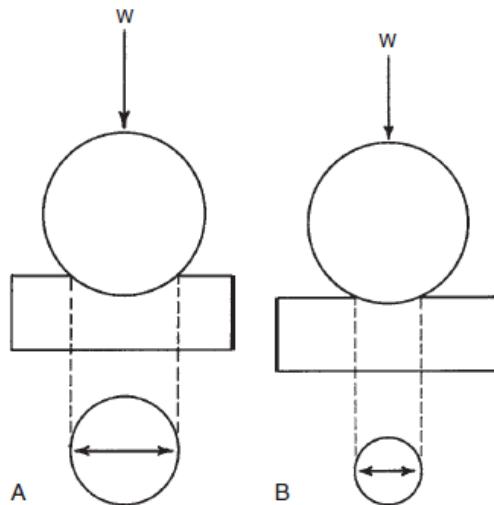
Smaller the indentation

Greater the number

Harder is the material

- Brinell Hardness Tests
  - i. Indentation on softer material
  - ii. Indentation on harder materials
  - iii. Microscopic view

<b>Advantages</b>	<b>Disadvantages</b>
1. Very simple test 2. Best suited for ductile materials 3. Large indentation area makes the test very good to determine hardness values	1. Poor in determining localized values 2. Not suitable for brittle materials

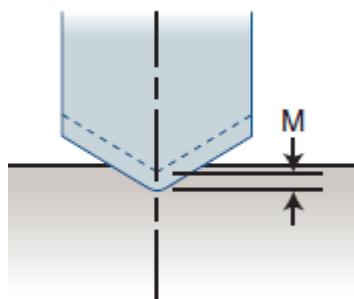


## 2. Rockwell Hardness Test

- It is a rapid method to check hardness, almost like Brinell test
- A steel ball or conical diamond point is used to test
- Depth of penetration is measured using a sensitive micrometer dial

Hardness is determined by the amount of depth of penetration under the load on comparison with the penetration of small preload

- Based on the type of material, various indenting points with different sizes and loads are available
- Plastics which are used in dentistry are tested using a revised version of superficial Rockwell test method
- *Disadvantage*: cannot be used for brittle materials



## 3. Vickers Hardness Test

- Uses similar principle of Brinell hardness test.
- Instead of a steel ball, a square based  $136^{\circ}$  pyramid/ diamond indenter is used.

- The computation method of Vickers hardness number is like BHN, where load is divided by area of indentation.

- This test is used in employing ADA specification number for casting gold alloys
- Suitable for testing brittle materials
- Used to measure hardness of tooth structure.

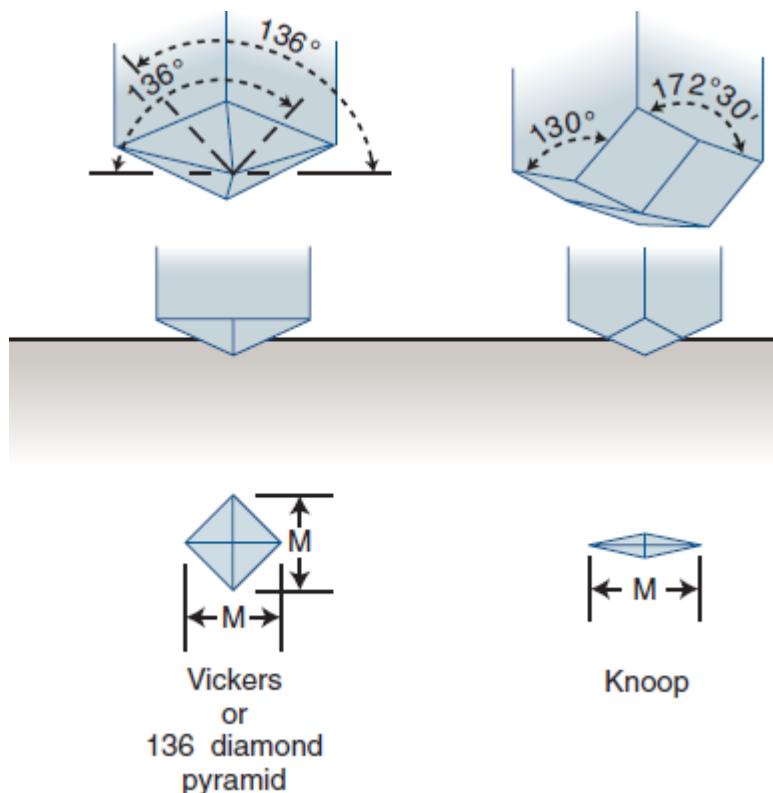
#### 4. Knoop Hardness Test

- It is also called a micro indentation test as lighter loads are applied to produce delicate micro indentations

Suitable for brittle materials like thin plastics and metal sheets

- Consists of a geometrically configured diamond tip indenter.
- The outline of the indentation is rhomboid in shape.
- To measure the hardness number the length of the largest diagonal (projected area) is divided by load applied (Maximum 35 N)
- Requires highly polished specimens (flat shaped) and the time required to complete the test is greater

Both Knoop and Vickers hardness tests applies load  $< 9.8\text{N}$  and depth of indentation  $< 19\mu\text{m}$ , making them capable of measuring smaller areas of thin and brittle materials



5. Barcol hardness test	6. Shore A hardness test
<ul style="list-style-type: none"> <li>Uses a 1mm diameter Barcol impressor (spring loaded) which is pressed against the surface of dental material to be tested.</li> <li>Example: Curing depth of resin composites can be tested</li> </ul>	<ul style="list-style-type: none"> <li>Used to check the hardness of rubber based materials.</li> <li>Consists of a 0.8mm diameter indenter which is blunt and pointed</li> <li>Example: Elastomeric impression materials, soft denture lines, mouth gaurs, maxillofacial elastomers</li> </ul>
<p><b>Principle:</b> Based on the resistance to indentation</p>	

## NANOINDENTATIONS

- Conventional hardness tests uses higher loads resulting indentation as large as 100µm.
- These tests are used to determine hardness values on comparison with other materials, whereas they cannot detect the hardness of the materials which has phases or components smaller than the size of the indenter.

**Example:** Resin composites with micro fillers

- To measure hardness of such materials, technique called **Nanoindentation** is introduced.
- Load applied in nanoindentation is in the range of 0.1 - 5000 mg- f, leading to an indentation of 1  $\mu\text{m}$

**Used to measure**

Hardness of micro sized phases

Elastic modulus

Yield strength and fracture toughness of brittle materials

Measure storage and modulus of viscoelastic materials

**Tooth tissue properties obtained from Nanoindnetation tests**

Tissue	Nanohardness		Dynamic Hardness		Elastic Modulus
	GPa	kg/mm <sup>2</sup>	GPa	kg/mm <sup>2</sup>	GPa
Enamel	4.48 (0.44) <sup>a</sup>	457 (45)	2.90 (0.23)	295 (23)	87.7 (5.9)
Dentin-enamel junction	2.37	242			53.2
Dentin	0.70 (0.12)	71 (12)	0.55 (0.09)	56 (9)	24.0 (3.9)

<sup>a</sup>Numbers in parentheses represent standard deviations.

Modified from Urabe I, Nakajima M, Sano H, Tagami J. Physical properties of the dentin-enamel junction region. Am J Dent. 2000;13:129–135.

**CONCLUSION**

- Mechanical tests represents an improtant parameter of analyses. The knowledge on the principles of these tests is essential to evaluate dental materials.

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3. Powers, Wataha. Dental materials foundation and applications. 11th edition
4. Urabe I, Nakajima M, Sano H, Tagami J. Physical properties of the dentin-enamel junction region. Am J Dent. 2000;13:129–135.
5. Wang L, D' Alpino PHP, Lopes LG, Pererira JC. Mechanical properties of dental materials restorative materials: Relative contribution of laboratory tests. J Appl Oral Sci 2003;1(3):162-71

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*Please Give Your Feedback on this Answer*

**Q. 02: Write in detail about implant biomaterials used in dentistry (15M, 20M),**

**Titanium (10M, 7M, 6M)**

**Titanium used in dental implants (7M)**

**CONTENTS/SYNOPSIS**

**Introduction**

**History & evolution of implant materials**

**Classification of implant biomaterials**

- Based on type of biomaterial
- Based on biodynamic activity
- Properties of implant materials
  - Physical and Mechanical properties
  - Corrosion and Biodegradation of implant material

**Biomaterials used in dentistry**

- Metallic implants
  - Cobalt - Chromium alloys
  - Iron - Chromium - Nickel based alloys
  - Titanium and Titanium alloys
    - Composition
    - Structural forms
    - Titanium alloys
    - Properties
    - Mechanical properties of pure titanium and its alloys
    - Advantages
    - Disadvantages
    - Factors affecting titanium implant failure
    - Recent developments
- Ceramic implants
  - Zirconia
    - Yttrium stabilized zirconia polycrystals (Y-TZP)
    - Glass infiltrated zirconia toughened alumina (ZTA)
    - Alumina toughened zirconia (ATZ)
- Polymers and composites
- Carbon and carbon compounds

**Conclusion**

**References**

## INTRODUCTION

- According to European Society of Biomaterials, a biomaterial is defined as a nonviable material used in medical appliances, fabricated to interact with biological system.
- The behavior of an implant biomaterial and its performance is affected based on its biomechanical aspects like type of material, shape of the implant, surface chemistry and topography, its ability to transfer the stresses and strain on to the bone interface.
- Dental implants are fixtures that acts as replacement of missing tooth, which can be placed either on maxilla or mandible.
- On following proper protocols for the placement of implant clinically, dental implants bonds to the bone (Osseointegration) over time and provides anchorage to the prosthesis.
- Currently there are two classes of implant biomaterials in manufacturing either alone or in a hybrid fashion
  - Metals
  - Ceramics
- Metallic implants are either CP Ti (Commercial Titanium) or Ti 6-Al-4V (Titanium alloy)

## HISTORY & EVOLUTION OF IMPLANT BIOMATERIALS

Ancient Era (1000 AD)	
Implants are originated in the early Egyptians and south American cultures.	
Earliest dental implants are made of ivory and stones in China Egypt	
Albucasis de condue is an Arabian surgeon who wrote paper on transplants	
Foundational period (1800 - 1910)	
16 <sup>th</sup> Century	Gold and Ivory implants
1809	Maggiolo used gold as tooth root
1887	Harris used teeth made of porcelain using lead coated platinum posts
1890	Zamenski has made a report on implantation of teeth using porcelain, gutta percha and rubber
1898	R.E Payne placed capsules of silver into tooth sockets
Early 1900's	Lambotte made implants using aluminium, Silver, copper, brass, magnesium, gold, soft steel with gold and nickel plating
Premodern era (1901 - 1930)	

1901	R. E. Payne presented capsule implantation in 3rd international dental congress
1903	Sholl implanted porcelain tooth with corrugated porcelain root
1913	Dr Edward J Greenfield introduced iridium and 24K gold into the alveoli as a submerged implant
<b>Modern era (1935 - 1978)</b>	
Early 20th century	Gold, Lead, Iridium, Tantalum, Stainless steel and cobalt alloys were used as implant materials
1940's	Cobalt-chromium, molybdenum sub-periosteal and Titanium blade implants are introduced
1957	Branemark discovered the process of osseointegration with Titanium implants
1970's	Non metal biomaterials like vitreous & pyrolytic carbon, aluminium oxide, hydroxyapatite were introduced
1982	United states Food and Drug Administration recommended Titanium as dental implant bio material
Currently with the newer developments in the field of ceramics, newer materials like zirconia, roxolid, modified titanium implants are introduced.	

## CLASSIFICATION OF IMPLANT BIOMATERIALS

Based on the type of material used and its biodynamic activity

Type of material	Biodynamic activity		
	Biotolerant	Bioinert	Bioactive
Metals	Gold Co-Cr alloys Stainless steel Zirconium Niobium Tantalum	Titanium Titanium alloys	-
Ceramics	-	-	$\text{Al}_2\text{O}_3$ Zirconium oxide HA Tri & tetra $\text{Ca}_3\text{PO}_4$ Calcium pyrophosphate

			Fluorapatite Carbon silicon Brushite Bioglass
Polymers	Polyamide Polyethylene PMMA Polytetrafluoro ethylene Polyurethane	-	-

## PROPERTIES OF IMPLANT MATERIALS

### I. Corrosion and Biodegradation of implant material

- Corrosion is defined as loss of ions from surface of the metal into the surrounding environment
- Types of corrosion are

Crevice Corrosion	Pitting Corrosion	Galvanic Corrosion	Electrochemical Corrosion
<ul style="list-style-type: none"> <li>Seen in implant bone interface. Ions from implant metal is released into the surrounding local environment creating a positive charge</li> </ul>	<ul style="list-style-type: none"> <li>Occurs in implants with small surface</li> <li>Metallic ions dissolve and combine with chloride ions leading to formation of rough surface and pits over the implant surface</li> </ul>	<ul style="list-style-type: none"> <li>Occurs due to electrical gradient differences</li> <li>Ions (Ni, Cr) from implant may enter soft tissues surrounding due to saliva leakage between the prosthesis and its superstructure</li> <li>Leads to reabsorption of bone, affects implant stability, implant failure</li> </ul>	<ul style="list-style-type: none"> <li>Metal deterioration takes place due to anodic oxidation and cathodic reduction</li> <li>Can be prevented by giving a passive oxide layer over the implant surface</li> </ul>

### Clinical significance of corrosion

- Implant biomaterials should be corrosion resistant.
- Effects of corrosion on implants are:
  - Surface roughness
  - Weakened restoration
  - Release of metallic ions
  - Discoloration of surrounding soft tissue
  - Allergic and toxic reactions (Local and systemic)

## II. Physical and Mechanical properties

Modulus of Elasticity	<ul style="list-style-type: none"><li>• Elastic modulus of implants should be like that of bone to ensure uniform stress distribution at implant bone interface</li></ul>
Compressive, Tensile, Shear strength	<ul style="list-style-type: none"><li>• Should have higher tensile and compressive strength to prevent fracture of implant, reduce the stresses</li></ul>
Yield strength Fatigue strength	<ul style="list-style-type: none"><li>• Should have high yield strength and fatigue strength</li><li>• Prevents fracture under load</li></ul>
Ductility	<ul style="list-style-type: none"><li>• According to ADA, implant should have a minimum of 8 % ductility to contour and shape the implant</li></ul>
Hardness Toughness	<ul style="list-style-type: none"><li>• Harder the implant, lesser the incidence of its wear</li><li>• Toughness avoids the fracture of implants</li></ul>
Surface energy and Surface tension	<ul style="list-style-type: none"><li>• Wettability of implant, cleanliness, osseointegration and adsorption of proteins depends on surface energy of the implant</li></ul>
Surface roughness	<ul style="list-style-type: none"><li>• Modification (Roughness) on the surface of the implants increases the surface area thereby improving the osteoblasts adhesion</li></ul>
Biocompatibility	<ul style="list-style-type: none"><li>• Most important property of an implant material considering its long-term placement in oral cavity</li><li>• Depends upon the corrosion resistance of the material</li></ul>

Material	Nominal Surface Analysis (w/o)	Modulus of Elasticity, GN/m <sup>2</sup> (psi $\mu$ 10 <sup>6</sup> )	Ultimate Tensile Strength, MN/m <sup>2</sup> (ksi)	Elongation to Fracture (%)	
Titanium oxide	99+Ti	97 (14)	240–550 (25–70)	15	Ti
Titanium oxide aluminum–vanadium	90Ti-6Al-4V	117 (17)	869–896	>12	Ti
Cobalt–oxide chromium–molybdenum (casting)	66Co-27Cr-7Mo	235 (34)	655 (95)	>8	Cr
Stainless oxide steel (316L)	70Fe-18Cr-12Ni	193 (28)	480–1000	>30	Cr
Zirconium oxide		97 (14)	552 (80)	20	Zr
Tantalum oxide		—	690 (100)	11	Ta
Gold	99+Au	97 (14)	207–310 (30–45)	>30	Au
Platinum	99+Pt	166 (24)	131 (19)	40	Pt

## Biomaterials Used in Dentistry

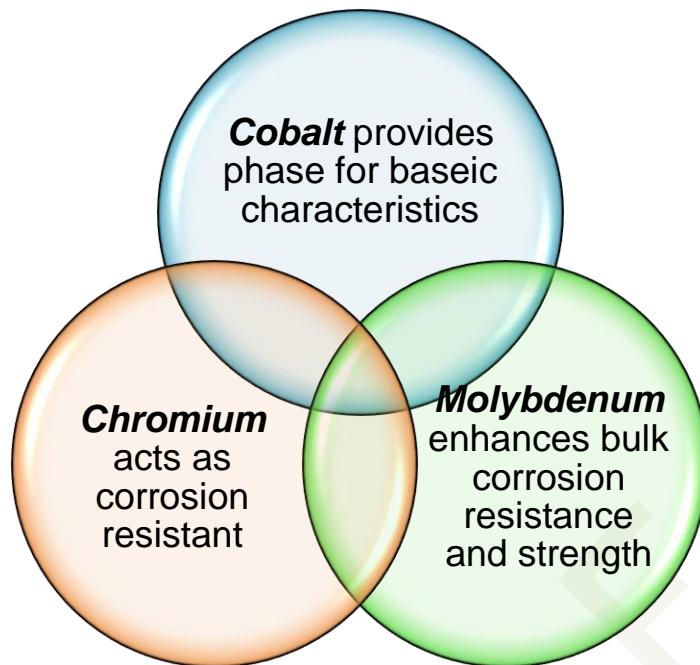
- Various organizations have proposed guidelines to standardize implant materials.
- Eg: ASTM Committee F4 and ISO (ISOTC 106, ISOTR 10541)

### I. Metallic Implants

- Metals have biomechanical properties making them ideal as implant material.
- They are bioinert and bio tolerant with better mechanical properties
- Easy to process and finish
- Can be sterilized by using routine procedures
- The most used metals in implant dentistry are titanium and its alloys, austenitic Fe-Cr-Ni-Mo steel, Co-Cr alloys, tantalum, niobium. with the recent advancements, conventional metals have been outdated and replaced by Ti and its alloys.

#### 1. Cobalt Chromium alloys

- Used to manufacture subperiosteal frames under metallurgic conditions.
- Main constituents of this alloy are cobalt, chromium and molybdenum.
- Acts as a substitute for patients with nickel allergy.



### Disadvantages

1. Melting range of Co-Cr alloy is higher, hence manipulation of the alloy is complex in laboratory.
2. Ductility is less on comparison with Ni-Cr alloys, hence difficult to do casting and finishing

### 2. Iron - Chromium - Nickel based alloys

- Used for orthopedic and implants
- Iron based alloys are used for fabrication of ramus frame, ramus blade, stabilizer pins and mucosal inserts

Advantages	Disadvantages
<ol style="list-style-type: none"> <li>1. High strength and ductility</li> <li>2. Resistance to corrosion</li> <li>3. Higher galvanic potential, may create galvanic coupling and biocorrosion if used along with titanium, zirconium, carbon implants</li> </ol>	<ol style="list-style-type: none"> <li>1. Prone to pitting corrosion, hence care should be taken to retain the passive oxide layer.</li> <li>2. Should be avoided in patients with allergies</li> </ol>

### 3. Titanium and its alloys

- Titanium is the most successful implant biomaterial used in dentistry
- Excellent biocompatibility due to the ability to form a stable oxide layer on its surface.
- Pure titanium exists as dark gray shiny metal.

- Melting point:  $1667^{\circ}\text{C}$  and boiling point:  $3227^{\circ}\text{C}$ .
- It is brittle at cold temperature and can break at room temperatures.
- It is malleable and ductile at higher temperature.

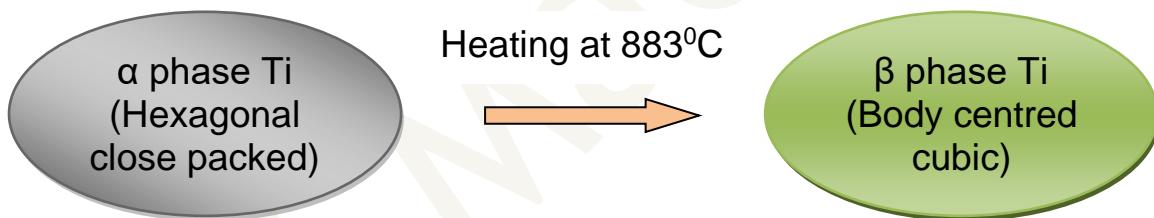
### Composition

- Commercially pure titanium (cpTi) is classified into 4 grades based on their oxygen content and two alloys (Ti-6Al-4V & Ti-6Al-4V-ELI)

Titanium	N	C	H	Fe	O	Al	V	Ti
CP grade I	0.03	0.08	0.015	0.20	0.18	—	—	Balance
CP grade II	0.03	0.08	0.015	0.30	0.25	—	—	Balance
CP grade III	0.05	0.08	0.015	0.30	0.35	—	—	Balance
CP grade IV	0.05	0.08	0.015	0.5	0.4	—	—	Balance
Ti-6Al-4 V alloy	0.05	0.08	0.015	0.3	0.2	5.50–6.75	3.50–4.50	Balance
Ti-6Al-4 V (ELI alloy)	0.05	0.08	0.012	0.25	0.13	5.50–6.50	3.50–4.50	Balance

### Structural forms

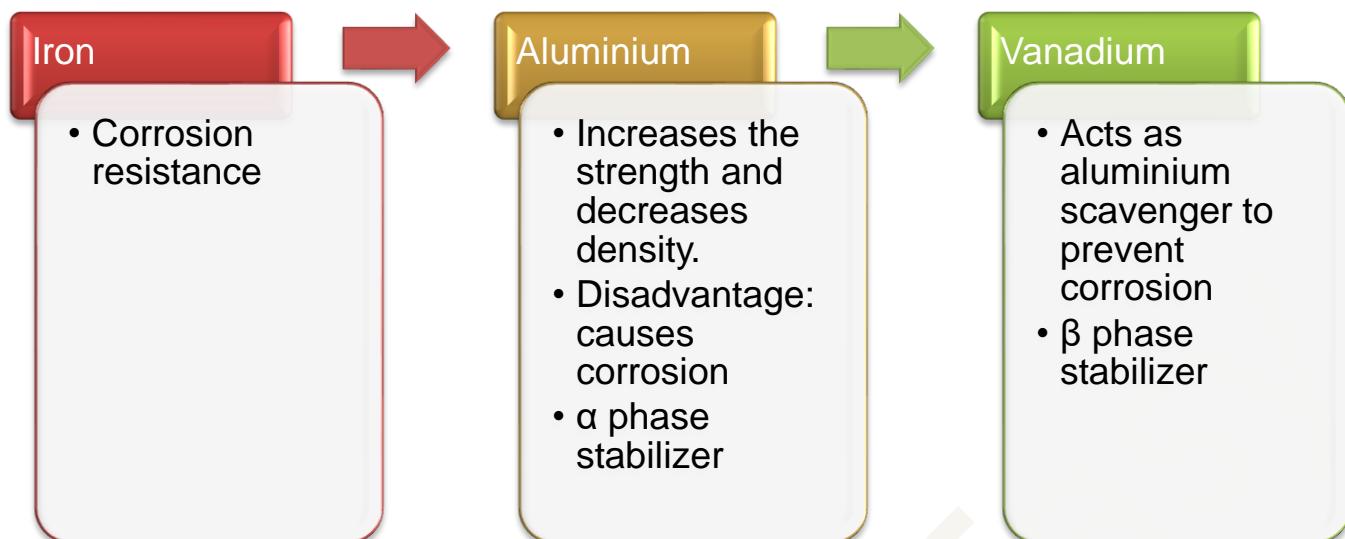
- Available as 3 forms based on their stabilizers
  1. Alpha form ( $\alpha$ )
  2. Beta form ( $\beta$ )
  3. Alpha-beta form ( $\alpha + \beta$ )



- Titanium is a dimorphic metal at the temperature point of  $882.5^{\circ}\text{C}$ , as it exists in  $\alpha$  phase at this temperature and changes to  $\beta$  phase above this temperature
- It is very reactive and forms oxide layer spontaneously on its surface

### Titanium Alloys

- Titanium alloys also exist in three forms based on added elements which acts like **phase condition stabilizers** to pure form of titanium
- Both  $\alpha$  and  $\beta$  forms can coexist based on their composition and heat treatment.
- Combination of  $\alpha + \beta$  alloys (6% Aluminium, 4% Vanadium) is most used for fabrication of dental implants (Ti-6Al-4V)



### Properties

- The presence of trace elements carbon, iron, oxygen and nitrogen improves the mechanical properties of cpTi
- Concentration of trace elements are in an increasing manner from Grade I to IV
- Based on the residue of oxygen in the metal the mechanical and physical properties of pure titanium differs from each other.
- The modulus of elasticity of pure titanium has a range of 102 - 104 GPa from grade I to IV, which is 5 times higher than the compact bone. Hence it aids in proper distribution of stress
- **Elastic modulus** of titanium alloys is slightly higher on comparison with Cp Titanium
- **Yield strength** of Ti alloys has increased upto 60 % when compared with Cp Ti

### Mechanical properties of pure titanium and its alloys

Material	Modulus (GPa)	Ultimate tensile strength (MPa)	Yield strength (MPa)	Elongation (%)	Density (g/cc)	Type of alloy
Cp Ti Grade I	102	240	170	24	4.5	A
Cp Ti Grade II	102	345	275	20	4.5	A
Cp Ti Grade III	102	450	380	18	4.5	A
Cp Ti Grade IV	104	550	483	15	4.5	A
Ti-6Al-4V- ELI	113	860	795	10	4.4	α+β
Ti-6Al-4V	113	930	860	10	4.4	α+β
Ti-6Al-7Nb	114	900-1050	880-950	8-15	4.4	α+β
Ti-5Al-2.5Fe	112	1020	895	15	4.4	α+β
Ti-15Zr-4Nb-2Ta-0.2Pd	94-99	715-919	693-806	18-28	4.4	α+β
Ti-29Nb-13Ta-4.6Zr	80	911	864	13.2	4.4	B

Adopted from: A critical review of dental implant materials with an emphasis on titanium versus zirconia, Materials 2015, 8, 932-958; Reham B. Osman and Michael V. Swain

Advantages	Disadvantages
<ol style="list-style-type: none"> <li>1. Highly passive</li> <li>2. Thickness can be controlled</li> <li>3. Rapid formation</li> <li>4. Ability to repair instantaneously during damage</li> <li>5. Resistance to chemical attacks</li> <li>6. Catalytic</li> <li>7. Modulus of elasticity compatible with bone</li> </ol>	<ol style="list-style-type: none"> <li>1. Esthetics due to its grayish colour, which is more pronounced when soft tissue is thin.</li> <li>2. Perimplant tissue discoloration has been documented with Ti concentration of 100 - 300 ppm due to galvanic corrosion</li> </ol>

### Factors affecting titanium implant failure

1. Design of the implant
2. Treatment planning including number of implants, position, dimensions
3. Occlusion and parafunctional habits
4. Fatigue, fracture and bending of implant on cyclic overload
5. Imperfections during manufacturing
6. Design of prosthetic restoration
7. Inaccurate fit of restorations
8. Marginal bone loss due to improper transfer of stress and inflammatory response
9. Allergy to metal
10. Chemical degradation due to galvanic corrosion (due to dissimilar metal for restoration)

### Recent Developments

- Development of new titanium alloys with properties like nontoxic, non-allergic, better mechanical properties and workability is in research.
- Replacement of elements like aluminium and vanadium with other nontoxic elements like Neobium, Iron, Molybdenum, Palladium, Zirconium.
- Alloys ( $\beta$  forms) with lesser modulus of elasticity closer to the bone is more desirable, with higher strength and toughness than  $\alpha + \beta$  alloys.

Straumann (Roxolid) has released titanium - zirconium alloy (TiZr1317) implants with narrow diameter.

It is a binary combination of titanium (83 - 87%) and zirconium (13 - 17%).

Better mechanical properties on comparison with CpTi and Ti-6Al-4V  
Tensile strength: 953 MPa  
fracture strength is 40% higher

Improved osseointegration due to addition of zirconia

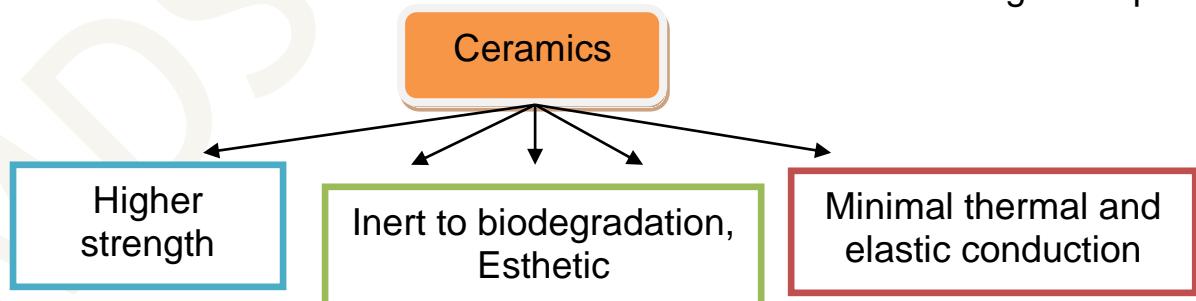
More biocompatible than pure titanium due to sandblasting and acid etching

#### Ti12.5Zr2.5Nb2.5Ta (TZNT) - $\alpha$ Ti alloy

- Used as surgical implant
- Modulus of elasticity is closer to human bone when compared to conventional alloys
- Admission of strain (0.65%) is equivalent to human bones (0.67%)
- No toxicity or adverse reactions due to addition of zirconia, neobium.
- Better corrosion resistance

## II. Ceramics

- Ceramics are nonmetallic, inorganic, nonpolymeric materials which are divided into metallic oxides and other elements.
- Oxide ceramics have been introduced for the fabrication of surgical implants.



Ceramic Coating	Ceramic Implants
<ul style="list-style-type: none"> <li>Can be either coated or plasma sprayed onto the metallic implants, creating a bioactive surface</li> <li><i>Properties:</i> brittle, high elastic modulus, tensile strength is low</li> </ul>	<ul style="list-style-type: none"> <li>Materials used: Alumina, Zirconia</li> <li><i>Properties:</i> Low tensile strength, can tolerate higher compressive stress, wettability is higher than all the implant materials</li> </ul>

## Zirconia

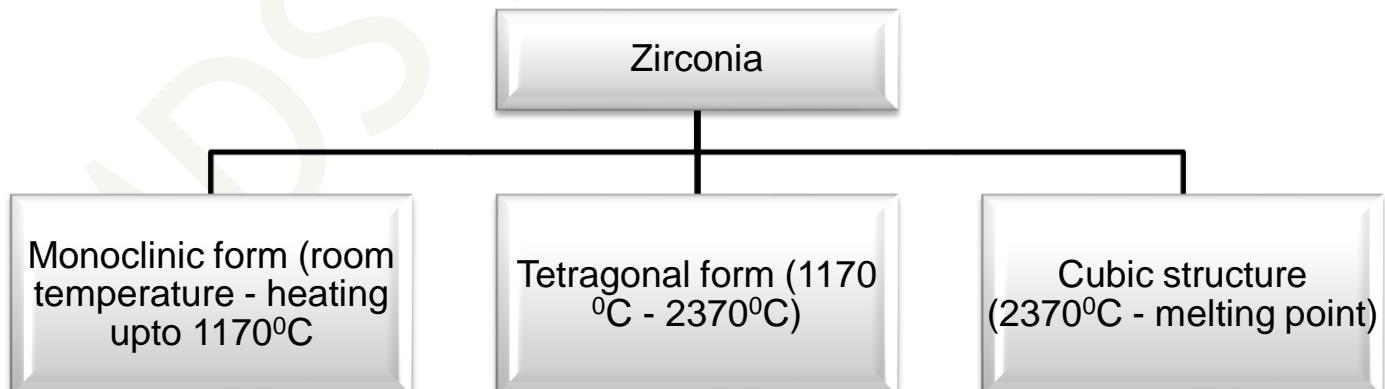
- Zirconium oxide was introduced in 1990's as framework for all ceramic prosthesis

## Properties

- It is grayish white in colour, soft material.
- It is both ductile and malleable.
- Solid at room temperatures, but in the presence of impurities it becomes brittle and hard.
- Powder form is highly flammable whereas solid form is not.
- Resistant to corrosion

## Structure

- Pure zirconia may exist as any of the three crystal form at room temperature after heating



- The cubic form of unalloyed zirconia can be stabilized by CaO, MgO,  $Y_2O_3$  resulting into a multiple phased material - **Partially stabilized zirconia (PSZ)**
- Tetragonal phase alone can also be obtained by adding yttrium at room temperature. It has low porosity, higher density, bending and compressive strength. Can be used for biomedical application
- Currently there are only three types of zirconia containing ceramics are been used in dentistry
  1. 3Y - TZP (Yttrium stabilized tetragonal zirconia polycrystals)
  2. Mg-PSZ (Magnesium stabilized transformation toughened PSZ)
  3. ZTA (Alumina stabilized dispersion toughened zirconia)

Yttrium stabilized zirconia polycrystals (Y-TZP)	Glass infiltrated zirconia toughened alumina (ZTA)	Alumina toughened zirconia (ATZ)
<ul style="list-style-type: none"> <li>• Ivory colour</li> <li>• Density of material: 6.0g/cc</li> <li>• Maximum working temperature is 2000°C</li> <li>• Porosity is 0%</li> <li>• Superior mechanical properties like fracture strength, fracture toughness is due to transformation toughening.</li> <li>• Light weight, resistant to corrosion and wear.</li> <li>• Susceptible to low temperature degradation (LTD)</li> </ul> <p>Advances:</p> <ul style="list-style-type: none"> <li>• 3Y-TZP is used as a substrate for single piece endosseous implants.</li> </ul>	<ul style="list-style-type: none"> <li>• ZTA is manufactured by adding 33 vol% of 12 mo% ceria stabilized zirconia (12Ce- TZP) to In-ceram alumina.</li> <li>• Processed by using slip casting or soft machining</li> <li>• Exhibits lesser mechanical properties when compared to 3Y-TZP</li> <li>• Residual porosity is seen</li> </ul>	<ul style="list-style-type: none"> <li>• ATZ is a combination of 20 wt% alumina and 80 wt% zirconia with 3 mo% yttria.</li> <li>• By adding alumina (0.25wt%), has improved resistance to low temperature degradation.</li> <li>• Highest bending strength of all ceramics (both at room temperatures and elevated higher temperatures)</li> </ul>

### Comparison of mechanical properties of zirconia

Material	Chemical composition	Modulus (GPa)	Fracture toughness (MPa m <sup>1/2</sup> )	Flexural strength (MPa)	Density (g/cc)	Color
3Y-TZP	98% small equiaxed tetragonal grains of zirconia ( $ZrO_2$ )+3 mol% yttria ( $Y_2O_3$ )	210 GPa	7-10 MPa m <sup>1/2</sup>	800 to 1,000 MPa	6 g/cc	Ivory
ZTA	33 vol% of 12 mol% ceria-stabilized zirconia ( $12Ce-TZP$ ) to In-Ceram alumina	285 GPa	5-6 MPa m <sup>1/2</sup>	1422±60 MPa	5 g/cc	White
ATZ	20 wt% alumina+80 wt% zirconia containing 3 mol% yttria	260 GPa	5-6 MPa m <sup>1/2</sup>	1800-2,400 MPa	5.45±0.02 g/cc	White/off-white

### Failures of zirconia implants

#### Mechanical failures

- Manufacturing defects (porosities, cracks) initiates crack propagation leading to failure
- Functional overloading
- Over torquing during surgical placement
- Because of the brittle nature stress concentration causes failure

#### Chemical failures

- LTD (low temperature degradation) due to aging, exposure to moist environment in oral cavity leads to roughening, development of microcracks and loss of strength

### Recent developments

- To improve durability and stability alumina is added to 3Y-TZP in smaller amounts.
- To minimize LTD (low temperature degradation) of 3Y-TZP, silica is added.
- Recently introduced zirconia material BMG (zirconia based bulk metallic glass) ( $Zr61Ti2Cu25Al12ZT1$ ), exhibits higher strength, fracture resistance, toughness and low elastic modulus

### III. Polymers and Composites

- Implants fabricated using polymethylmethacrylate and polytetrafluoroethylene were introduced earlier in 1930's.
- There are other polymer materials which have been used as implant biomaterial; polyamide, polyurethane, polyethylene, polypropylene, polysulphone, silicone rubber.

## Properties

- Lesser strength and modulus of elasticity (closer to soft tissue)
- Higher elongation to fracture

Advantages	Disadvantages
<ol style="list-style-type: none"> <li>1. Physical properties can be altered easily based on changes in composition</li> <li>2. Manipulation is easy</li> <li>3. Better reproduction of the details</li> <li>4. Do not generate current or microwaves like metals</li> <li>5. Tissue attachment is fibrous in nature</li> <li>6. Can be evaluated easily under microscope</li> <li>7. More esthetic</li> </ol>	<ol style="list-style-type: none"> <li>1. Mechanical properties are inferior on comparison to other biomaterials</li> <li>2. Poor adhesion to tissues</li> <li>3. May have allergic reactions which are adverse in nature</li> <li>4. Few polymers have very less creep, flow, fatigue strength</li> <li>5. Sensitive to sterilization and handling.</li> <li>6. Main disadvantage is implant cannot be sterilized using steam or ethylene oxide</li> </ol>

## IV. Carbon and Carbon Compound

- Carbon as biomaterial for implant has been introduced in 1960's.
- They also have been used as coating on metallic implants
- It is one of the most biocompatible materials.
- It is highly inert
- Has modulus of elasticity almost like bone and dentine, hence effective transmission of biomechanical forces at the implant bone interface.

### Disadvantages

1. Susceptible to fracture
2. Brittle

## CONCLUSION

- Several implant biomaterials have been introduced in the past few decades ranging from pure titanium to Hydroxyapatite coatings.
- Hence selection of an ideal biomaterial based on the type of available bone, clinical condition, prosthetic planning will give an effective result.

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Please Give Your Feedback on this Answer

**Q. 10: Phosphate bonded investments (10M, 6M)**

**CONTENTS/SYNOPSIS**

Introduction

Definition of investment material

Ideal requirements

General composition

Classification of investment material

- Based on processing temperature
- Based on the Binder

Phosphate bonded investment

- Composition
- Setting reaction
- Properties
- Setting and thermal expansion
- Working and setting time
- Advantages and disadvantages

Conclusion

References

## INTRODUCTION

- Investment is defined as a process of making a mold into which metals or ceramics can be casted

## DEFINITION

- According to GPT 8, a material which consists of an allotrope of silica and bonding agent is called a dental casting investment.
- The bonding substance may be gypsum or phosphates or silica

## IDEAL REQUIREMENTS

Should be

1. Manipulated easily
2. Have enough strength at room temperature
3. Stable at higher temperatures
4. Expansion
5. Have beneficial casting temperatures
6. Porous adequately
7. Smooth surface
8. Inexpensive

## COMPOSITION

- In general, an investment is a mixture of three distinct types of materials, i.e.

### Refractory material

It can withstand at high temperatures and regulates thermal expansion

Available as oxides of silica: quartz, tridymite, cristobalite

### Binder material

Binds together the particles of refractory substance

Calcium sulfate hemihydrate, Phosphate ethyl sulphate

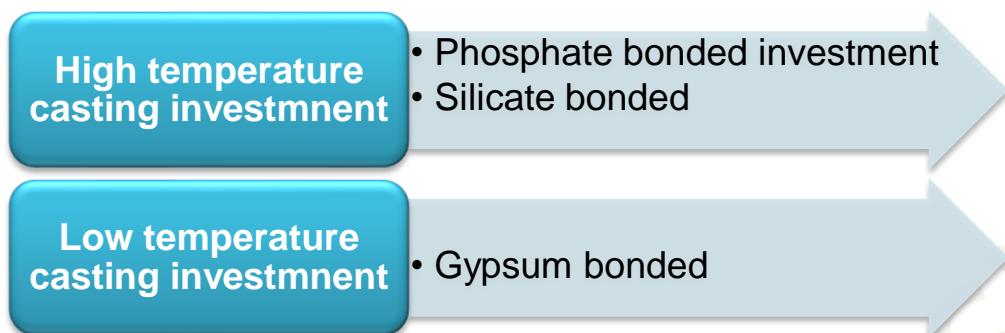
### Other chemicals

Added in small quantities to modify various physical properties

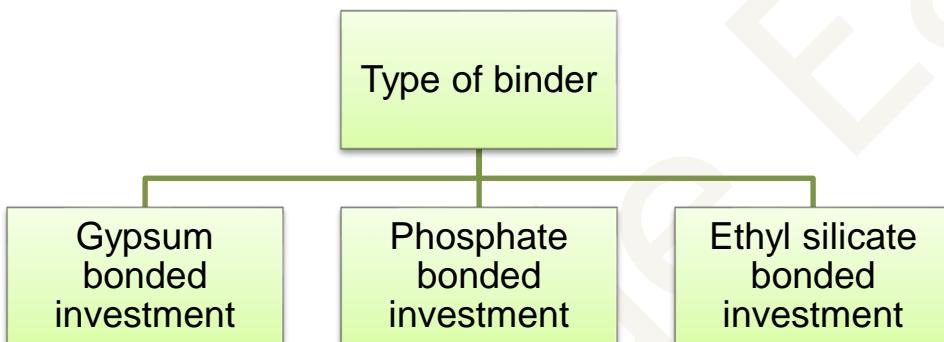
NaCl, boric acid,  $K_2SO_4$ , graphite, copper powder, MgO

## CLASSIFICATION OF INVESTMENT MATERIALS

### I. Based on Processing Temperature



### II. Based on the Binder



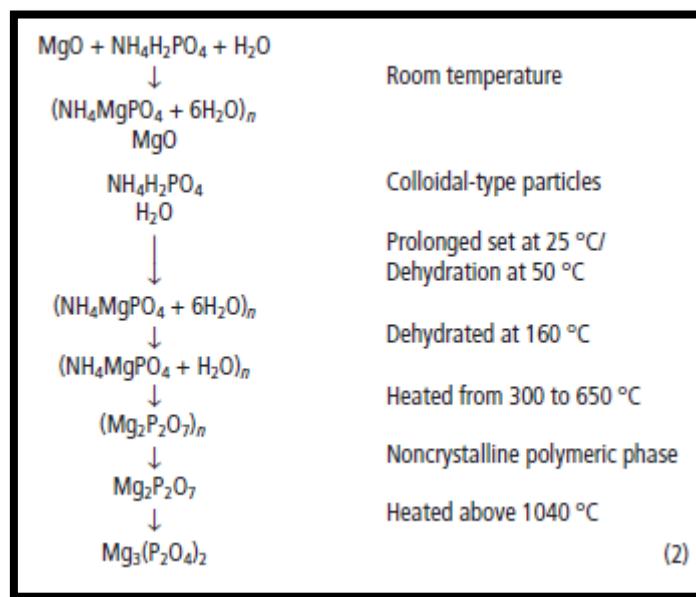
## PHOSPHATE BONDED INVESTMENTS (PBI)

- These are high temperature investment materials
- Used for investment of metal ceramic alloys
- Example: High gold, palladium-based alloys

Temperature Range	<ul style="list-style-type: none"> <li>• 1000 – 1100°C</li> </ul>
Types	<ul style="list-style-type: none"> <li>• Carbon containing PBI → for gold alloys</li> <li>• Carbon free PBI → for base metal alloys</li> </ul>
Composition	<ul style="list-style-type: none"> <li>• Refractory → Silica (80% by wt)</li> <li>• Binder → 20% MgO and ammonium dihydrogen phosphate</li> <li>• Modifier → Carbon</li> <li>• Liquid → Aqueous colloidal silica suspension</li> </ul>
Setting Reaction	$\text{NH}_4\text{H}_2\text{PO}_4 + \text{MgO} + 5\text{H}_2\text{O} \longrightarrow \text{NH}_4\text{MgPO}_4 + 6\text{H}_2\text{O}$ <ul style="list-style-type: none"> <li>• The final products also contain excess of magnesia along with unchanged silica and crystalline <math>\text{Mg}_2\text{P}_2\text{O}_7</math></li> </ul>
Working and setting	<ul style="list-style-type: none"> <li>• Warmer the mix, faster it sets</li> </ul>

time	<ul style="list-style-type: none"> <li>Increased mixing time and efficiency resulting in a faster set, smoother and accurate casting</li> <li>Mechanical mixing under vacuum is preferred</li> <li>Increase in liquid powder ration increases the working time</li> </ul>
Compressive Strength	<ul style="list-style-type: none"> <li>2.5 MPa → for type I (Crown &amp; inlays)</li> <li>3.0 MPa → for type II (RPD)</li> </ul>
Setting Expansion	<ul style="list-style-type: none"> <li>0.4% (linear)</li> <li>0.6-0.8% (hygroscopic)</li> <li>Slight expansion occurs when compared to gypsum bonded</li> <li>0.8% with 50:50 liquid &amp; water mixture</li> <li>thermal expansion is increased by using 1-1.2% of undiluted liquid of colloidal silica</li> <li>Early thermal shrinkage leads to decomposition of the binder</li> </ul>
Advantages	<ul style="list-style-type: none"> <li>Green and fired strength</li> <li>Setting and thermal expansion are high enough to compensate thermal contraction of metals or porcelains during cooling</li> <li>Withstand temperature upto 1000°C for short period of time</li> </ul>
Disadvantages	<ul style="list-style-type: none"> <li>Above 1375°C causes breakdown of mold and roughens the surface of castings</li> <li>Difficult to divest</li> <li>When higher expansion – release of trapped gas</li> </ul>
Wax burn out temperatures	<ul style="list-style-type: none"> <li>Gold: 700-750°C</li> <li>Palladium: 730-815°C</li> <li>Base metal: 815-900°C</li> </ul>

## Thermal reaction of set Phosphate bonded investment



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2. Sakaguchi R, Ferracane J, Powers J. Craig's Restorative Dental Materials, 14<sup>th</sup> Edition
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**Please Give Your Feedback on this Answer**

## Q. 12: Physical properties of dental materials (7M)

### CONTENTS/SYNOPSIS

#### Introduction

#### Mechanical Properties

- Force
  - Stress
  - Strain
  - Stress Strain Curve

#### Mechanical Properties Based on Elastic Deformation

- Young's Modulus/ Elastic Modulus
- Hooke's Law
- Poisson's Ratio
- Resilience & Toughness
- Yield Strength & Ultimate Strength

#### Mechanical Properties Based on Plastic Deformation

- Cold Working
- Flexural Strength & Impact Strength
- Ductility & Malleability
- Hardness
- Surface Concentration Effects

#### Physical and Chemical Properties

- Rheology
- Creep & Flow

#### Colour And Optical Effects

- Dimensions of Colour
- Colour Perception

#### Thermal Properties

- Thermal Conductivity
- Thermal Diffusivity
- Coefficient of Thermal Expansion

#### Electrochemical Properties

- Tarnish
- Corrosion

#### Conclusion

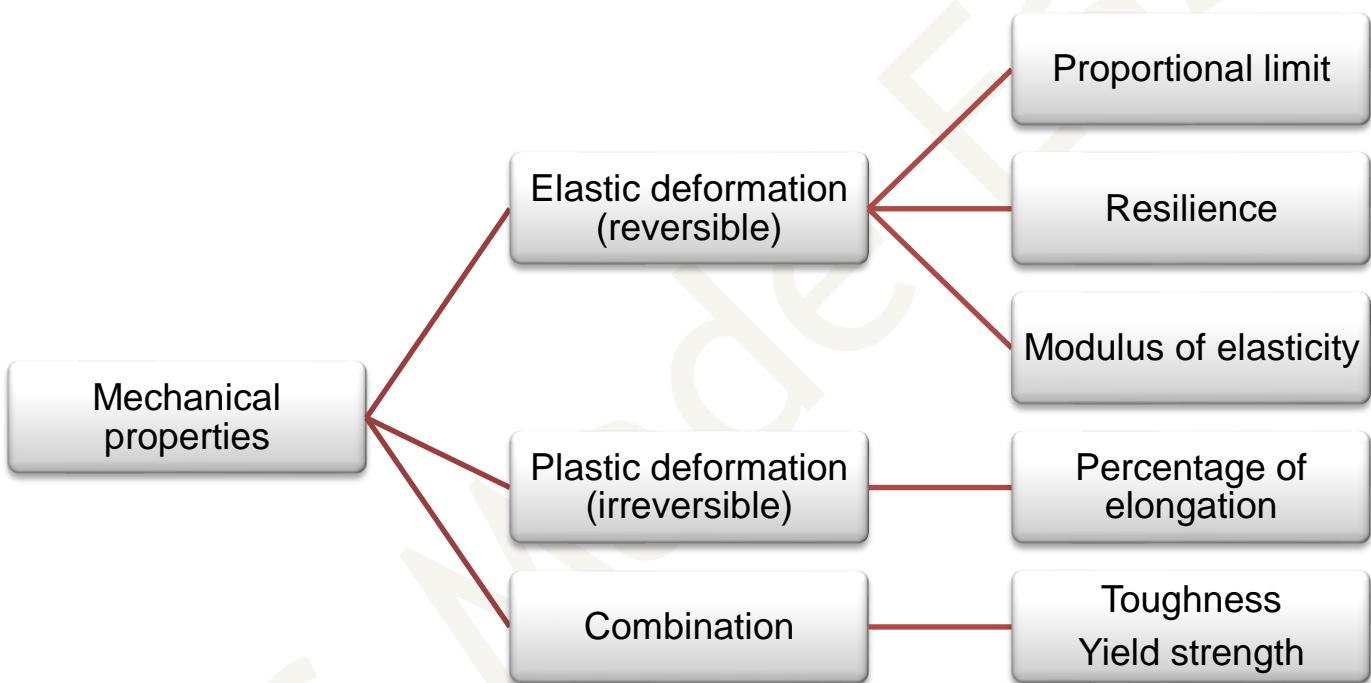
#### References

## INTRODUCTION

- Dental materials present in the oral cavity are constantly exposed to mechanical, thermal, chemical challenges which can lead to deformation of materials

## MECHANICAL PROPERTIES

- Mechanical properties are generally measured when the material is under force either applied or distributed (Elastic & Plastic)
- These forces are expressed in units of stress and strain
- Represented in the measurements of



## Force

- Force is an interaction of one body with another resulting in either a bodily translation or deformation based on the rigidity of the body.
- It has three characters
  - Point of application
  - Direction
  - Magnitude
- The SI unit of force in Newton (N)

## Occlusal Forces

- Maximum acceptable occlusal forces are 200 - 3500 N
- Highest in posterior teeth region

Forces of natural dentition	Occlusal forces on restorations
<ul style="list-style-type: none"> <li>• 1st &amp; 2nd molars: 400 - 800N</li> <li>• Premolars: 300N</li> <li>• Cuspid: 200N</li> <li>• Incisors: 150N</li> </ul>	<ul style="list-style-type: none"> <li>• Forces generated by RPD: 65 - 235N</li> <li>• Forces generated by CD: 100N on posterior teeth, 40N on incisors region</li> </ul>

### 1. Stress

- It is defined as the force acting per unit area in each plane of a material (or)
- An internal resistance within the material due to a load applied externally
- Measured in units of Megapascal (Mpa)

$$\text{Stress } (\sigma) = \frac{F \text{ (N)}}{A \text{ (m}^2\text{)}}$$

### Types of Stresses

Type Of Stress	Produced By	Examples
<b>Residual Stress</b>	Stress caused within the material during the manufacturing process	During welding
<b>Structural Stress</b>	Stresses produced in the structure during function. Weights they support provide the loadings	In abutments of fixed partial denture
<b>Pressure Stress</b>	Induced in vessels containing pressurized materials	In dentures during processing under pressure and heat
<b>Flow Stress</b>	Force of liquid striking against the wall acts as the load	Molten metal alloy striking the walls of the mould during casting
<b>Thermal Stress</b>	Material is subjected to internal stress due to different temperatures causing varying expansions in the material	Materials that undergo thermal stress such as inlay wax, soldering and welding alloys
<b>Fatigue Stress</b>	Stress caused due to cyclic rotation of a material	Rotary instruments undergo rotational or cyclic fatigue

## Type of stress based on forces applied



Tensile stress	Compressive stress	Shear stress
<ul style="list-style-type: none"> <li>Seen due to a load that either stretches or elongates the body with the forces directed away from each other.</li> <li><b>Clinical aspect:</b> A sticky toffee in between a crown and opposing teeth produces tensile forces and may dislodge the crown</li> </ul>	<ul style="list-style-type: none"> <li>Caused when a load compresses the body with the forces directed towards each other.</li> </ul>	<ul style="list-style-type: none"> <li>It is the tendency of a body to slide over another with the forces parallel to each other.</li> <li><b>Clinical aspect:</b> Debonding of orthodontic bracket luted on the tooth enamel due to shear stress</li> </ul>
<b>Torsion</b>		
<ul style="list-style-type: none"> <li>It is due twisting of the body</li> </ul>		
<b>Flexural stress</b>		
<ul style="list-style-type: none"> <li>It is due to the bending of the body. It can be produced with a combination of forces.</li> <li><b>Clinical aspect:</b> Tensile and compressive stress produced in a two-unit cantilever prosthesis</li> </ul>		

## 2. Strain

- It is defined as change in length when compared to the original length due to an applied load.
- Measured in the units of length/ length and reported as percentage values

$$\text{Strain } (\varepsilon) = \frac{\text{Change in length } (\Delta l)}{\text{Unit original length } (l_0)}$$

- The amount of strain always differs based on the material, magnitude and forces.

### Clinical aspect

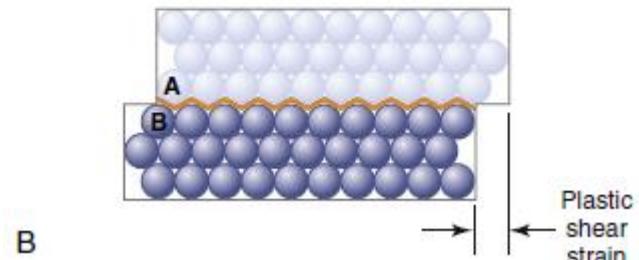
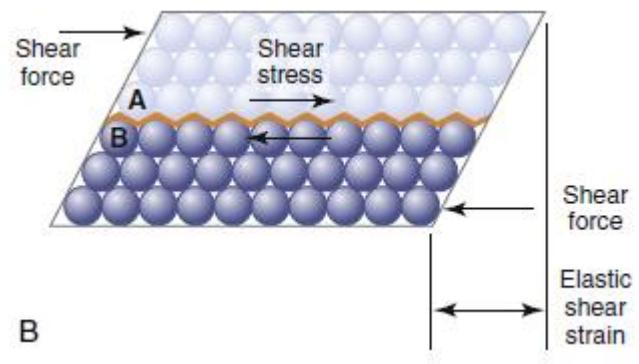
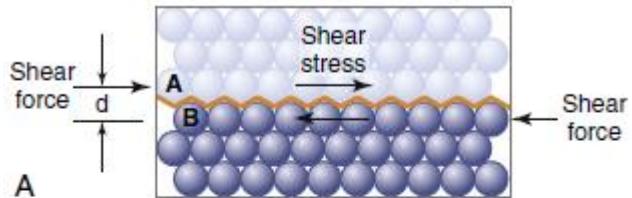
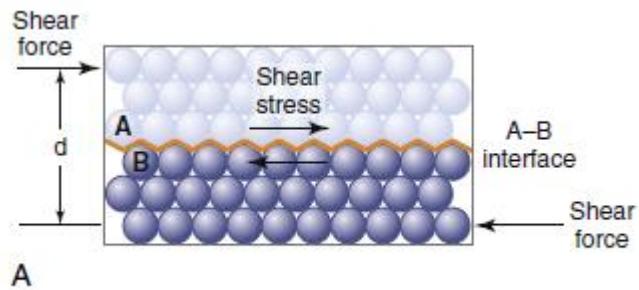
- Bending and adjusting the orthodontic wires without fracturing is due to strain
- Recovery of impression materials without permanent distortion from retentive areas of mouth
- Failure of orthodontic treatments, implants could be due to long term strain

### Elastic strain

- Reversible
- Disappears on removal of force

### Plastic strain

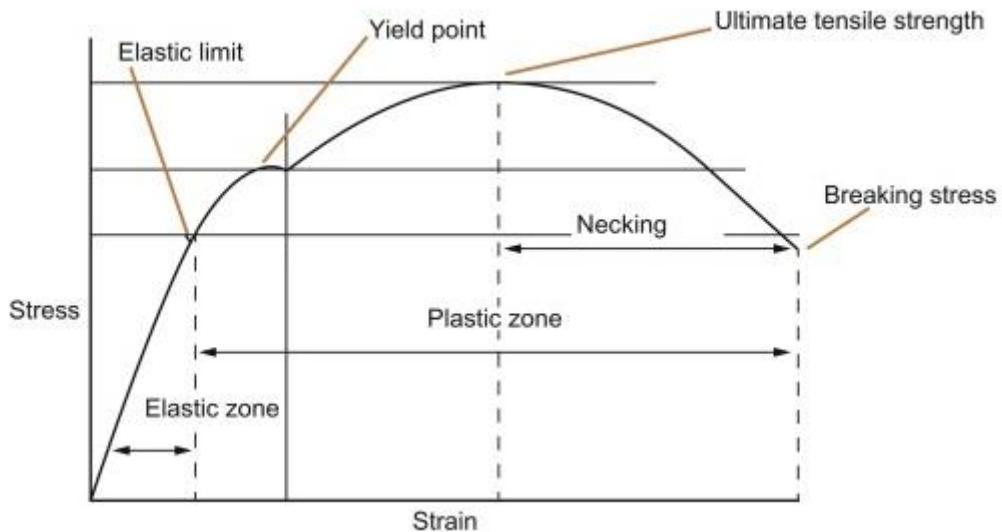
- Irreversible
- Causes permanent damage on removal of force



Schematic representation of atoms in original positions (A), and after elastic and plastic deformation (B)

### 3. Stress Strain Curve

- It is the association between stress and strain of that material



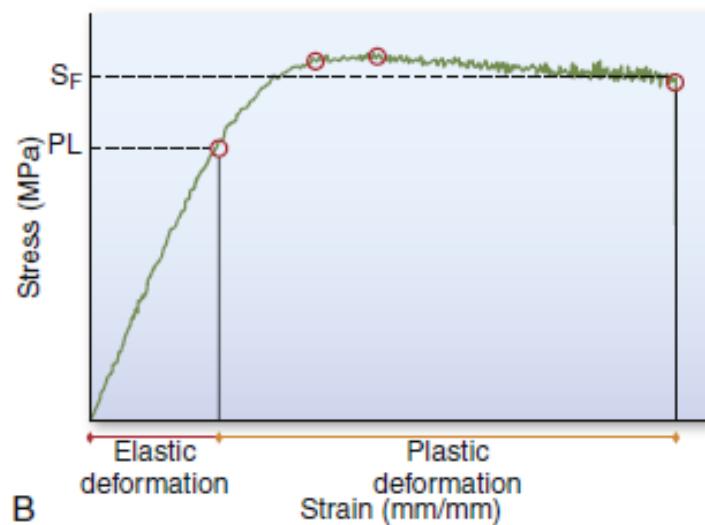
Example of stress - strain curve of a fibre model

## MECHANICAL PROPERTIES BASED ON ELASTIC DEFORMATION

### I. Young's Modulus/ Elastic Modulus

- It is defined as the relative stiffness of a material measured in the elastic region of the stress strain curve.
- Calculated as ratio of elastic stress/elastic strain
- Stiffer the material higher the modulus of elasticity

$$E = \frac{\text{Stress}}{\text{Strain}} = \frac{\sigma}{\epsilon} = \frac{F/A}{\Delta l/l_0}$$



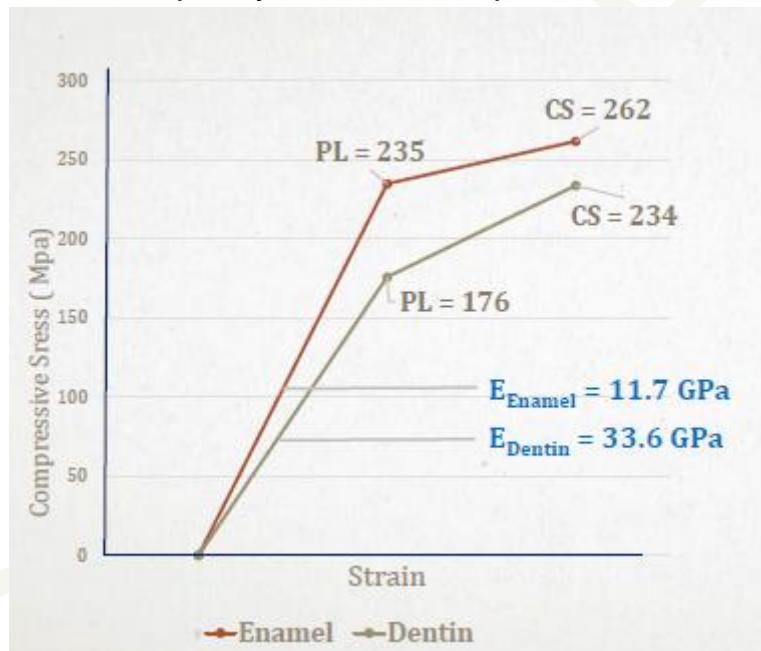
Stress strain curves showing elastic and plastic deformation under tensile stress

## II. Hooke's Law

- According to **Hooke's law**, stress will be proportional to the strain within the elastic limit of the material
- Maximum stress a material can withstand without deforming permanently is called **Elastic limit**
- The limit at which the stress and strain are not proportional any more is called as **Proportional limit**

### Clinical Aspect

- Enamel is more brittle and stiffer than dentin, whereas dentin is more tough and flexible.
- Hence dentin has capacity to withstand plastic deformation under load



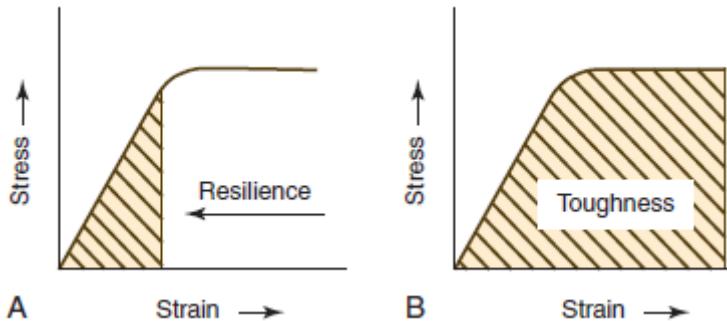
Stress strain curve of enamel and dentin. E: Elastic limit, PL: Proportional limit, CS: compressive stress

## III. Poisson's Ratio

- It is the ratio of transverse to axial strain.
- Poisson's ratio of an ideal isotropic material is 0.5
- Examples: Enamel, dentin, composite have a Poisson's ratio of 0.3

#### IV. Resilience & Toughness

Resilience	Toughness
The amount of energy required to permanently deform a material is called resilience	The amount of energy required to fracture a material is called toughness



Stress strain curve giving a measure of resilience & toughness

#### V. Yield Strength & Ultimate Strength

Yield strength	Ultimate strength
<ul style="list-style-type: none"> <li>It is the amount of stress needed to produce a plastic strain</li> <li>Also called as proof stress</li> <li>Amount of plastic strain is referred as percent offset</li> </ul>	<ul style="list-style-type: none"> <li>Ultimate tensile strength is the maximum stress a material can withstand before permanent failure</li> <li>Ultimate compressive strength is the maximum stress a material can withstand under compressive stress</li> </ul>

- Elastic limit, proportional limit and yield strength are important to evaluate dental materials.
- They are determined differently, but their values are relatively like each other

## MECHANICAL PROPERTIES BASED ON PLASTIC DEFORMATION

- It is the force with which a material is subjected leading to permanent deformation (plastic strain) even after the removal of the force is referred.
- The object will remain either bent or stretched and will not return to its original shape

### I. Cold working

- Also called as strain/ work hardening
- It is defined as application of constant stress beyond its limit of proportionality, the strength and hardness of the material increases with a decrease in its ductility

#### *Clinical aspect*

- Constant bending of orthodontic wires, adjustments of clasps in RPD lead to fracture or deformity

#### *How to minimize the risk?*

- Apply forces smaller increments to avoid plastic deformation

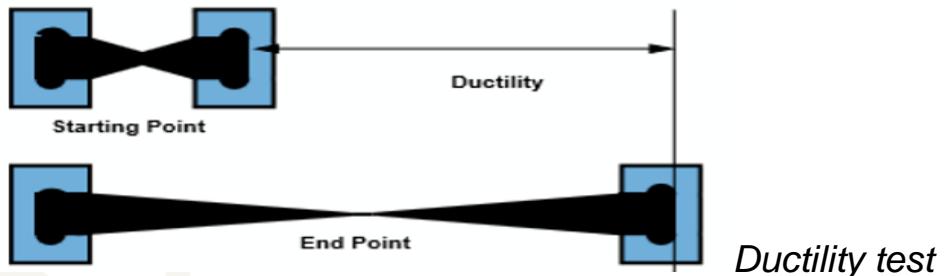
### II. Flexural Strength & Impact Strength

<i>Flexural Strength</i>	<i>Impact Strength</i>
<ul style="list-style-type: none"> <li>• It is the force applied in a test specimen at the fracture point when subjected to flexural load</li> <li>• Also called modulus of rupture <i>Clinical aspect:</i> Development of fracture points and its progression over repeated stress cycles in amalgam restorations (Fatigue failure)</li> </ul>	<ul style="list-style-type: none"> <li>• It is the amount of energy required to break or fracture a material under impact force</li> <li>• Commonly measured with Charpy Impact tester</li> <li>• Materials with low modulus of elasticity and high tensile strength - higher resistance to impact</li> <li>• Materials with low modulus of elasticity and low tensile strength - Lower resistance to impact</li> </ul>

Material	Elastic Modulus (Gpa)	Tensile Strength (Mpa)
Composite	17	30 – 90
Porcelain	40	50 – 100
Amalgam	21	27 – 55
Alumina ceramic	350 – 418	120
Acrylic	3.5	60

### III. Ductility & Malleability

Ductility	Malleability
<ul style="list-style-type: none"> <li>It is the ability of the material to withstand permanent deformation <b>under tensile stress</b> until the point of fracture</li> <li>Examples: It is the capacity of the metal to be able to draw into thin wires (Gold)</li> <li>Measured using bend test</li> <li>Grain size affects the property</li> </ul>	<ul style="list-style-type: none"> <li>It is the ability of the material to withstand permanent deformation <b>under compressive stress</b></li> <li>Example: It is the capacity of the metal to be able to draw into thin sheets (Gold, silver)</li> <li>Measured by the capacity to withstand pressure</li> <li>Crystal structure affects the property</li> </ul>



#### IV. Hardness

- It is defined as the ability of a material to resist plastic deformation produced due to indentation force

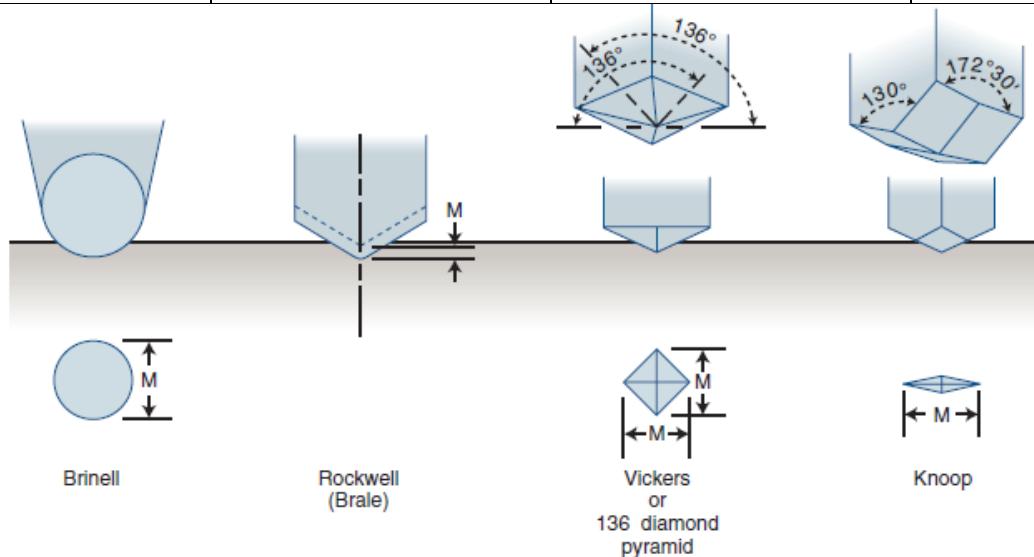
#### Classification of Hardness Test

Method of Application	Size of the indenter	Amount of load applied to the indenter
Static Loading - slowly applied	Macro-indentation - Large indenter tip	Macrohardness - $> 1\text{ kg load}$
Dynamic Loading - rapidly applied	Micro-indentation - Small indenter tip	Microhardness - $< 1\text{ kg load}$

- Various types of hardness tests used in dentistry are

i. Brinell Test	ii. Rockwell Test	iii. Vicker's Test	iv. Knoop's Test
Used for determination of hardness of metals Hardness is determined based on proportional limit and ultimate tensile strength	It is a rapid method	Used for casting alloys, tooth structure	Developed to do micro indentation test Used for testing metal sheets or thin plastics
<b>Method:</b> Steel ball of 1.6mm diameter is used to subject the material to penetration load Brinell hardness number is achieved	<b>Method:</b> A conical diamond point is used to determine hardness Dial gauge is used to measure the depth of penetration	<b>Method:</b> Uses a pyramidal square based indenter to get Vicker's hardness number (VHN) Method is similar to Knoop's and Brinell test	<b>Method:</b> Micro indentation needle is used, and the rhomboid outline is measured to get Knoop's hardness number
<b>Advantages:</b> Best to test ductile materials	<b>Advantages:</b> Rapid and direct testing	<b>Advantages:</b> Can be used for brittle materials	<b>Advantages:</b> Used for brittle and thin materials
<b>Disadvantages:</b> Difficult to measure the hardness of cold	<b>Disadvantages:</b> Cannot be used for brittle materials	<b>Disadvantages:</b> Surface of the material should be	<b>Disadvantages:</b> Material should be highly

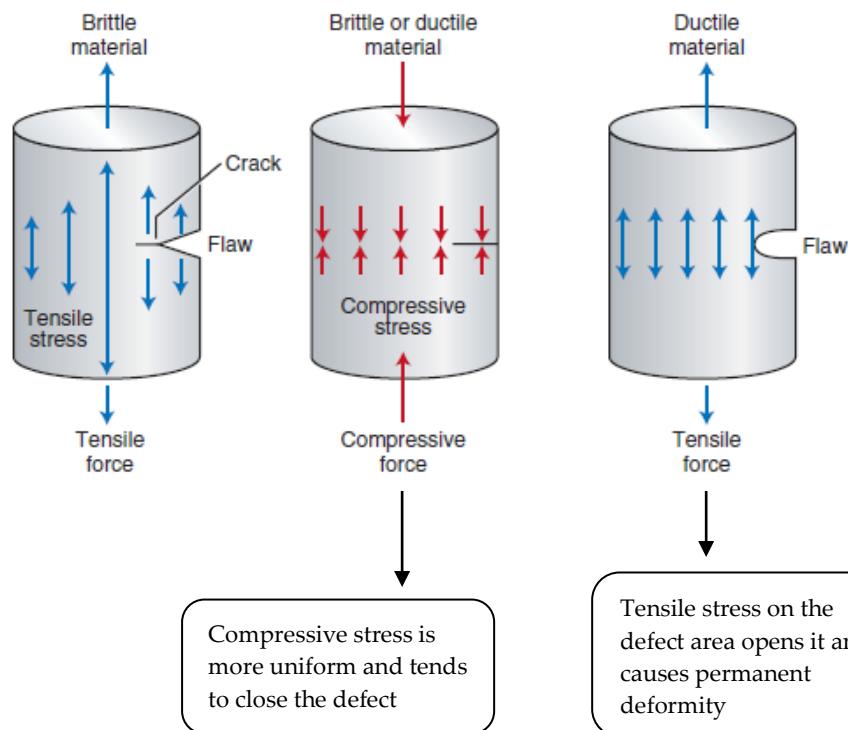
worked materials Cannot be for brittle materials		highly polished Longer time needed to test	polished
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## V. Surface concentration effects

- Presence of microscopic defects on the external or internal surface of the material leads to reduction of strength.
- These defects are very critical in brittle materials which are under tensile stress, as it leads to opening of cracks and breakage of bonds.

### *Affect of stress on the flaws in brittle materials*



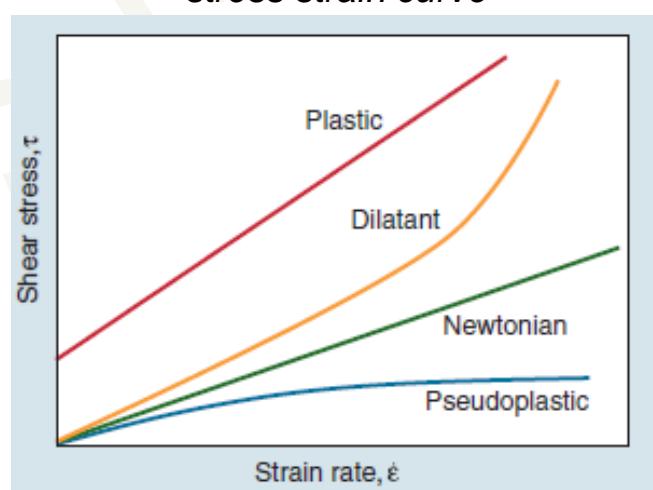
Causes for the defects	Methods to minimize the defects
• Defects on the surface like roughness, porosity	• Polishing the surface and reducing
• Internal voids	• Use high quality, increase the object size
• Sharp line angles (axio pulpal angle)	• Proper designing of the prosthesis, rounded line angles
• Dissimilarity in CET or elastic moduli on the bonded surfaces	• CET and elastic moduli of two materials should be close
• Hertzian load (Point of fracture)	• Cusp tips should be well rounded that are opposing brittle materials

## PHYSICAL AND CHEMICAL PROPERTIES

### I. Rheology

- Defined as study of deformity and flow of the matter
- Viscosity is resistance to the flow
- Most of the dental materials are available initially in fluid phase which can be manipulated and shaped accordingly
- Example:** Dental cements, impression materials, gypsum products, waxes

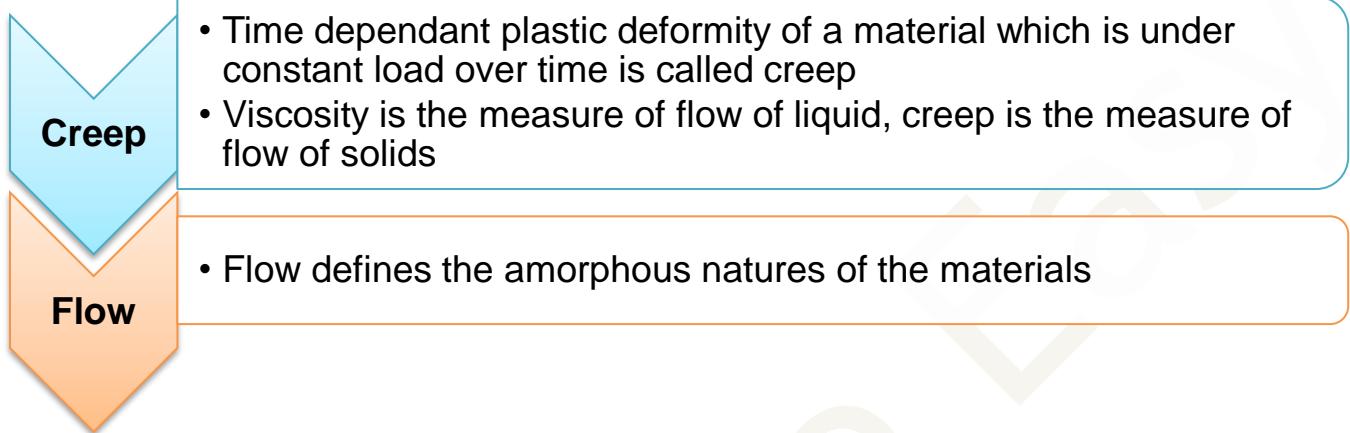
*Types of rheological behaviors of materials can be understood according to their stress strain curve*



- For an ideal fluid shear stress is proportional to its strain, hence greater the forces applied faster the flow. This is called **Newtonian viscosity**
- With an increase in strain, viscosity of the material decreases until it reaches constant value nearly. **Pseudoplastic viscosity**

- With an increase in strain, the fluid becomes more rigid. Also called **dilatant**
- The fluids which are rigid initially and becomes viscous are called **plastic**
- Fluids that are under repeated pressure becomes less viscous and obtains more flow are called **thixotropic**

## II. Creep & Flow



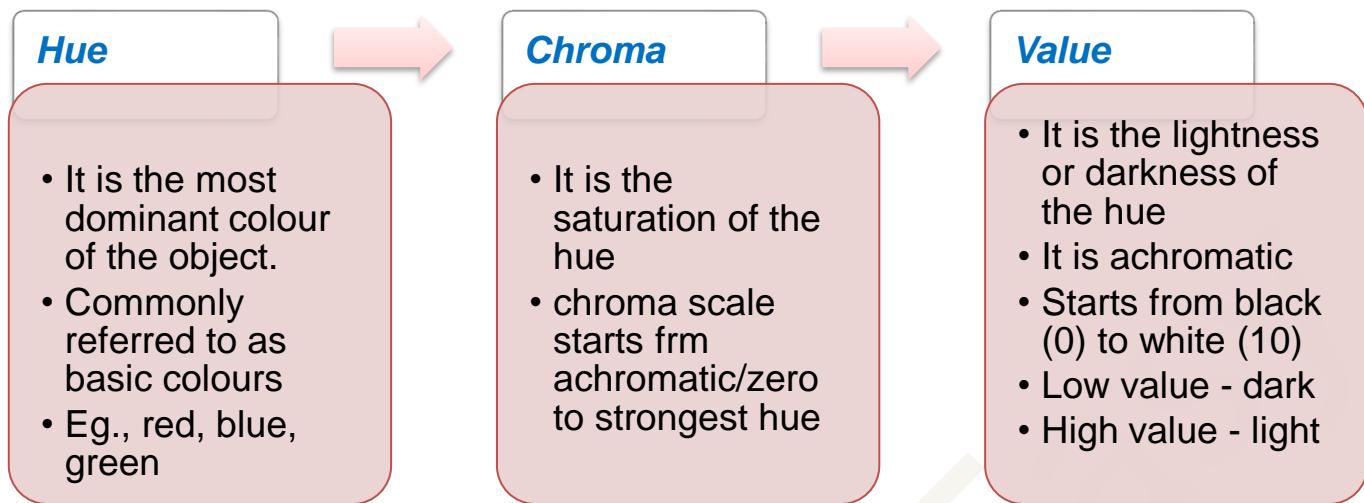
### Clinical aspect

- During amalgam restoration, creep causes the unsupported amalgam to come out of the margins of the cavity which are weak and may cause corrosion and ditches in the margins

## COLOUR AND OPTICAL EFFECTS

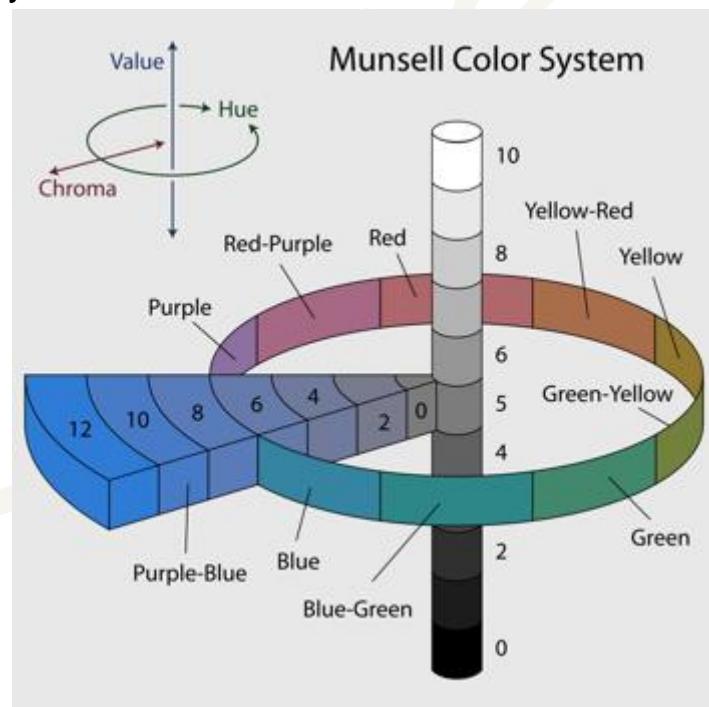
- Colour plays an important role in esthetic dentistry.
- Colour of an object depends on the type of light that enters the eye through the object
- An object is visible when a light from external source is either reflected or transmitted.

## Dimensions of Colour



Colour systems to describe and measure the colors:

- Munsell colour system
- Cielab colour system



## Colour perception

Observer	Object	Light source
<ul style="list-style-type: none"> <li>• Identifying a colour is subjective and varies with individual</li> <li>• Depends on age, exposed duration,</li> </ul>	<ul style="list-style-type: none"> <li>• Colour of an object depends on its light transmitting ability</li> <li>• Depends on light scattering onto the</li> </ul>	<ul style="list-style-type: none"> <li>• Commonly available light sources are natural sunlight, incandescent and fluorescent lights.</li> <li>• Colour corrected lights</li> </ul>

fatigue etc.,	surrounding walls, furniture etc. • Hence it is advisable to maintain neutral colours	are also available.
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## THERMAL PROPERTIES

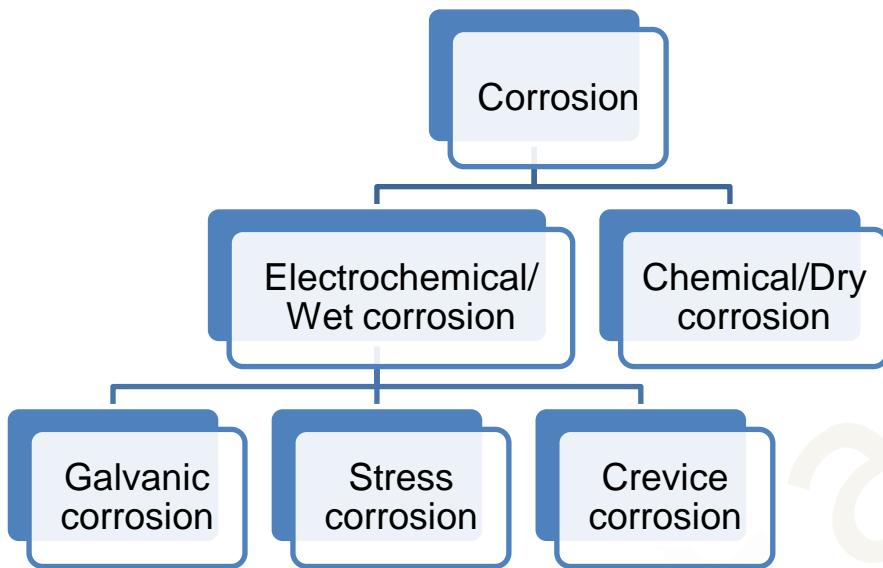
I. Thermal conductivity	II. Thermal diffusivity	III. Coefficient of thermal expansion
<ul style="list-style-type: none"> <li>It is a physical property that controls the transfer of heat through a material</li> <li>The international system unit is watts per meter per kelvin</li> <li>The order of thermal conductivity is</li> <li>Enamel &lt; Dentin &lt; Polymers &lt; Ceramics &lt; Metals</li> <li>↑ Thermal conductivity = ↑ Transmission of thermal energy</li> </ul>	<ul style="list-style-type: none"> <li>It is the measure of speed of temperature through an object on heating one surface.</li> <li>Thermal diffusivity = Thermal conductivity / Density × heat capacity</li> <li>It is important in the oral cavity due to constant discrepancy in intraoral temperature due to food intake</li> </ul>	<ul style="list-style-type: none"> <li>It is defined as change in length of a material with an increase in temperature for 1 °C</li> <li><math display="block">\alpha = \frac{\Delta L}{L \times \Delta T}</math></li> <li>Proximity of CTE between tooth and restoration prevents marginal leakage, debonding.</li> </ul>

## ELECTROCHEMICAL PROPERTIES

Tarnish
<ul style="list-style-type: none"> <li>It defined as discoloration of the surface of the metal</li> <li>Loss of luster over the surface is seen</li> <li>Forms a thin oxide layer due to reaction with sulphur, chlorine etc.,</li> <li><b>Causes:</b> Soft and hard deposits on restoration, discolortaion due to medication, food, bacteria, oxide layer</li> </ul>

Corrosion
<ul style="list-style-type: none"> <li>It is a chemical or electrochemical process by which a metal undergoes partial or complete dissolution</li> <li>Metals are most commonly affected with corrosion</li> <li>Causes: Acidic action of phosphoric, acetic acids, alkaline solutions, water &amp; saliva in the oral environment</li> </ul>

## Classification of Corrosion



### i. Dry corrosion

- It occurs in the absence of the water with combination of metal and nonmetallic elements.
- Eg., Discoloration of silver by sulphur

### ii. Wet corrosion

- It is an electrochemical reaction which occurs in the presence of the water
- Eg., Corrosion with an amalgam (anode) and gold alloy restoration (cathode) intraorally with saliva as electrolyte

<i>iii. Galvanic corrosion</i>	<i>iv. Stress corrosion</i>	<i>v. Concentration cell corrosion</i>
<ul style="list-style-type: none"> <li>• Contact of dissimilar metals leading to galvanic shock</li> <li>• Intensity of this current reduces with an increase in the age of restoration</li> <li>• Varnish coating on the restoration eliminates galvanic shock</li> </ul>	<ul style="list-style-type: none"> <li>• Caused by the combination of mechanical stress and corrosive oral environment (surface irregularities)</li> <li>• Excessive burnishing around the margins of restoration is to be avoided</li> </ul>	<ul style="list-style-type: none"> <li>• Occurs due to variation in electrolytes in the environment or due to micrroleakage</li> <li>• Eg., Difference in O<sub>2</sub> concentration, food debris,</li> <li>• Maintenance of oral hygiene is indicated</li> </ul>

## CONCLUSION

- It is very important to know properties of dental materials we use in dentistry, which will enable us to choose the right material with closer properties similar to natural tooth substrate

## REFERENCES

1. William J. O'Brien. Dental materials and their selection. 4th edition
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*Please Give Your Feedback on this Answer*

**Q. 06: Discuss in detail polymers and their applications in prosthetic dentistry (15M).**

**Reinforced polymethylmethacrylate denture base resins (6M)**

**Recent advances in denture-based materials (7M)**

## CONTENTS/SYNOPSIS

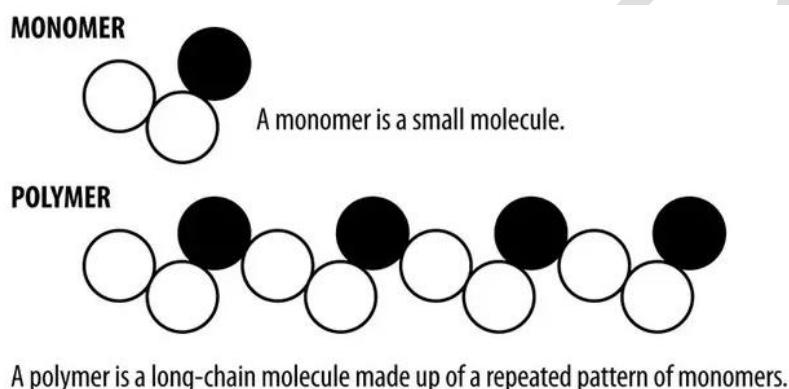
- Introduction
- Terminology
- Applications of resins in prosthetic dentistry
- Classification
- Components and composition
- Properties of polymers
  - Biological compatibility
  - Physical properties of polymers
    - Deformation and Recovery
    - Elastic recovery
    - Viscoelastic recovery
    - Solvation & dissolution properties
  - Thermal properties
  - Aesthetic properties
  - Chemical stability
- Chain configurations
- Chemistry of polymerization
  - Addition polymerization
  - Condensation or step growth polymerization
  - Ring open polymerization
- Denture base resins
  - PMMA
  - Ideal requirements of denture base resin
  - Composition of denture base resins
  - Different types of denture base resins
- Recent advances
- Conclusion
- References

## INTRODUCTION

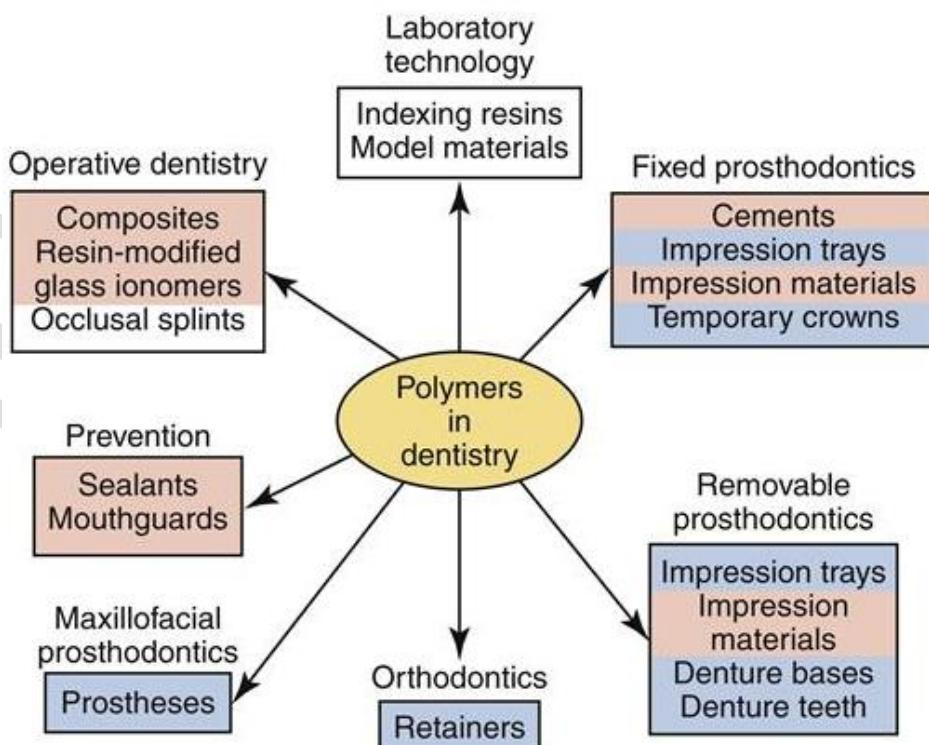
- Polymer is a chemical compound consisting of large organic molecules formed by the union of many repeating smaller monomer units

## TERMINOLOGY

- In Greek "poly" means many and "mer" means part or a unit.
- **Resins** are either monomers or molecules mixed with other components to produce a material with useful properties.
- **Polymerization** is the process of joining of monomers or small molecules to form a polymer
- **Degree of polymerization** is the number of units repeated in a polymer chain.



## APPLICATIONS OF RESINS IN DENTISTRY



## CLASSIFICATION

<b>Based on origin</b>	<b>Based on thermal behaviour</b>	<b>Based on units</b>
<ul style="list-style-type: none"> <li>• Natural resin</li> <li>• Synthetic resin: Thermoplastic, Thermoset, Synthetic elastomer</li> </ul>	<ul style="list-style-type: none"> <li>• Thermoplastic</li> <li>• Thermosetting</li> </ul>	<ul style="list-style-type: none"> <li>• Homopolymer</li> <li>• Co polymer: Block, Graft, Alternating</li> </ul>
<b>Based on polymerization</b>	<b>Based on Industrial use</b>	<b>Based on Architecture</b>
<ul style="list-style-type: none"> <li>• Additional polymers: by repeated addition of monomers</li> <li>• Condensation polymers: by repeated reaction of condensation between different monomer units</li> </ul>	<ul style="list-style-type: none"> <li>• Adhesives</li> <li>• Fibres</li> <li>• Elastomers</li> <li>• Paints</li> <li>• Plastics</li> </ul>	<ul style="list-style-type: none"> <li>• Linear</li> <li>• Branched</li> <li>• Cross linked</li> </ul>

## COMPONENTS & COMPOSITION

### Basic Nature of Polymers

- Polymers consists of large molecules that are linked together to form a limitless chain like configurations

#### 1. Factors that determine properties of polymers are

- Chain length
- Extent of branching or cross linking of chains
- Organization of polymers within

#### 2. Structure of Polymers (Spatial Structure)

##### Linear

- The linear homopolymer has mer units of the same type, and the random copolymer of the linear type has the two mer units randomly distributed along the chain.

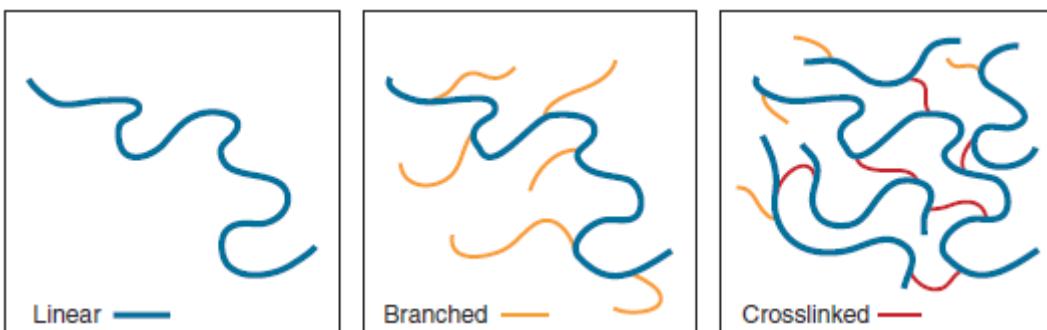
- The linear block copolymer has segments, or blocks, along the chain where the mer units are the same

### Branched

- Branched homopolymer consists of the same mer units, whereas the graft-branched copolymer consists of one type of mer unit on the main chain and another mer for the branches

### Cross-Linked

- The cross-linked polymer shown is made up of a homopolymer cross-linked with a single cross-linking agent
- Ex: Denture base materials, Occlusal surfaces of acrylic teeth
- Cross-linked polymers flow at higher temperatures than linear or branched polymers
- Some cross-linked polymers do not absorb liquids as readily as either the linear or branched materials



### 3. Copolymers

- Polymers that have only one type of repeating unit (*mer*) are *Homopolymers*, those with two or more types of mer units are known as *Copolymers*
- To improve the physical properties, it is advantageous to use two or more chemically different monomers

Random/Statistical	Block	Graft/Branched
<ul style="list-style-type: none"> <li>Order is non sequential among the two (or more) mer units along the polymer chain</li> <li>Ex: A-B-A-B-B-B-A-</li> </ul>	<ul style="list-style-type: none"> <li>Identical monomer units occur in relatively long sequences along the main polymer</li> <li>Ex: A-A-A-B-B-B-B-A-A-</li> </ul>	<ul style="list-style-type: none"> <li>Copolymer- sequences of one type of mer unit are attached as a graft (branched) onto a backbone of a second type of mer unit.</li> </ul>

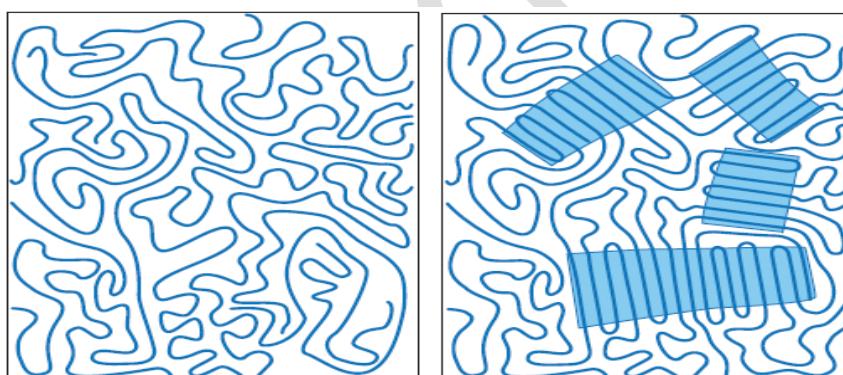
- |  |  |  |
|--|--|--|
|  |  | <ul style="list-style-type: none"><li>• Ex: -A-A-A-A-A-<br/>-B-B-B-B-B</li></ul> |
|--|--|--|

#### 4. Molecular Organization

- In polymers with chains either coiled or entangled in a disorderly fashion, called as amorphous structure
- Whereas in some polymers, the chains are aligned in a orderly or crystalline fashion which increases the properties like strength, hardness, rigidity, melting point
- Most of the polymer materials consists of either or both combinations

#### Factors affecting

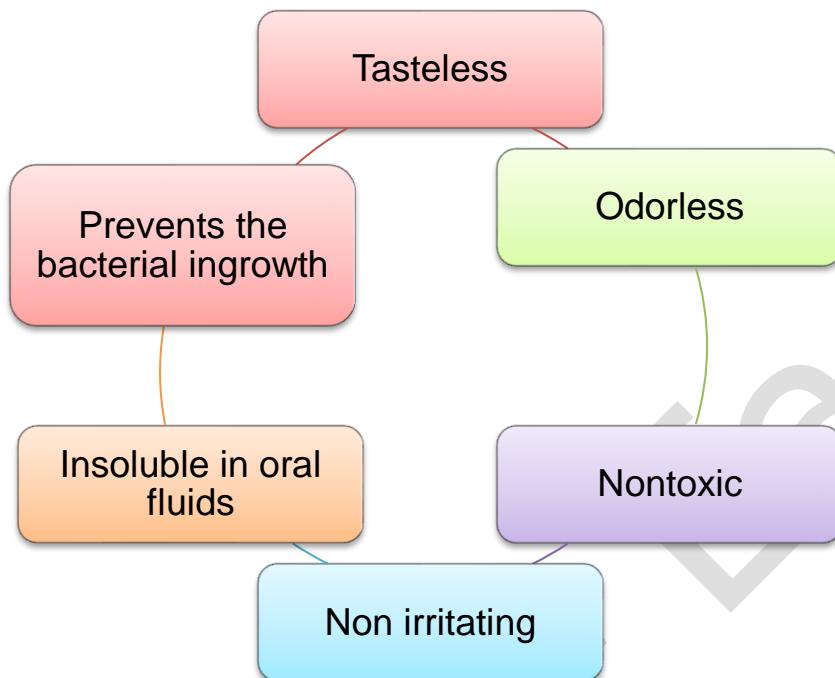
- Copolymerization, which decreases the ability of polymer chains to align themselves
- Long branched polymers, which inhibit polymer chains from becoming aligned
- Arrangement of substituent groups randomly
- Plasticizers



Schematic representation of polymers with amorphous inter and intramolecular organization and combination of both amorphous and crystalline polymers

## PROPERTIES OF POLYMERS

### I. Biological Compatibility

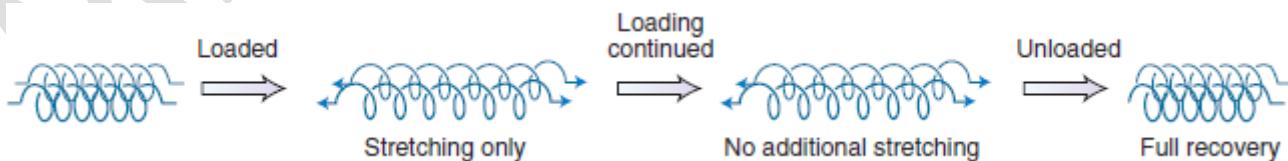


### II. Physical properties of Polymers

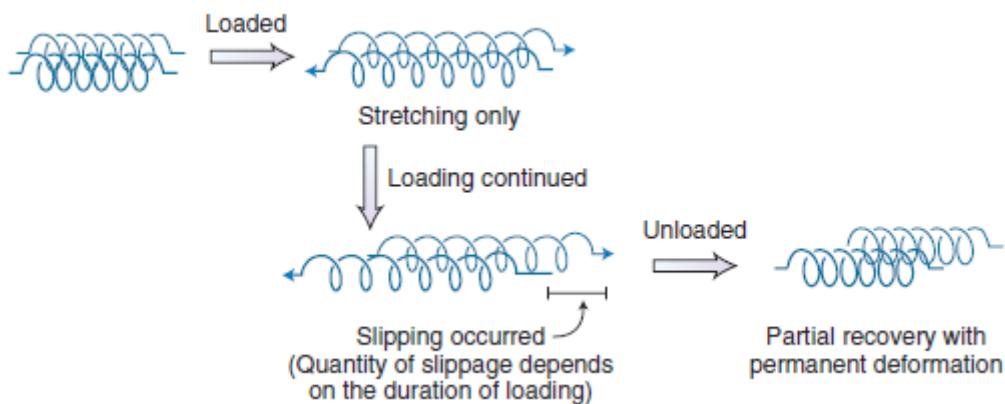
#### 1. Deformation and Recovery

- Forces applied leads to development of stress within the polymers  
Elastic plastic strain or both
- **Elastic deformation** is a reversible strain and recovers on elimination of stress
- **Plastic deformation** is an irreversible strain and forms a new shape permanently
- Combination of both plastic & elastic strains is called **viscoelastic deformation**, in which only elastic strain will be recovered

#### 2. Elastic recovery



### 3. Viscoelastic recovery



### 4. Solvation & dissolution properties

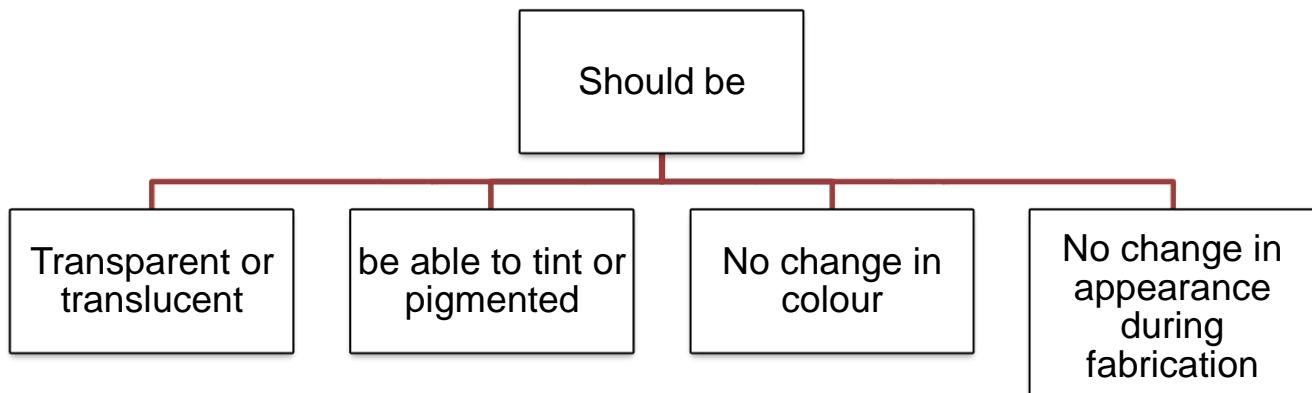
- The dissolution of polymer is  $\alpha$  the length of the chain
- Polymers instead of dissolving absorb the solvent and swell
- Dissolution is prevented by cross linking polymer chains
- Elastomers swell greater than plastics
- Molecules absorbed by polymer chains tend to spread and form slip between them, called as plasticization
- Hence a minimum amount of swelling in dental polymers may cause undesirable fit of the prosthesis

## III. Thermal properties

- Adequate thermal conductivity should be present to simulate oral temperature to the prosthesis

<b>Thermoset</b>	<b>Thermoplastic</b>
<ul style="list-style-type: none"> <li>▪ Chemical change during setting reaction</li> <li>▪ Not softened on exposure to heat</li> <li>▪ Does not melt, instead undergoes decomposition</li> <li>▪ Crosslinked and insoluble</li> </ul>	<ul style="list-style-type: none"> <li>▪ Soften on exposure to temperature and harden on cooling</li> <li>▪ Reversible</li> <li>▪ Can be reproduced by either heating or cooling</li> </ul>

#### IV. Aesthetic Properties



#### V. Chemical Stability

- Should be inert and stable chemically
- Should not deteriorate in oral environment

#### CHAIN CONFIGURATIONS

- Polymer chains are generally held by
  - Chain entanglements
  - Weaker Vander wall forces or secondary bonds
- With an increase in molecular weight, entanglements in polymer chains will increase leading to a stronger polymer
- Eg., Glass transition temperature

#### CHEMISTRY OF POLYMERIZATION

- Monomers are always held either by addition or condensation reactions

I. Addition polymerization	II. Condensation or step growth polymerization
<ul style="list-style-type: none"> <li>• Monomers are initiated one at a time into a sequence to form growing chains</li> <li>• Polymerization is activated from centre unit and continuous until the entire monomer is exhausted</li> <li>• Simple and fast process</li> <li>• Produces larger size molecules</li> <li>• There will not be any change in the composition</li> </ul>	<ul style="list-style-type: none"> <li>• Monomers are activated by a chemical reaction by linking to multiple monomer units</li> <li>• Byproducts are produced (water, alcohol, ammonia etc.,)</li> <li>• Polymerization is activated simultaneously in all monomer units</li> <li>• Slow process</li> <li>• Example: Proteins, carbohydrates</li> </ul>

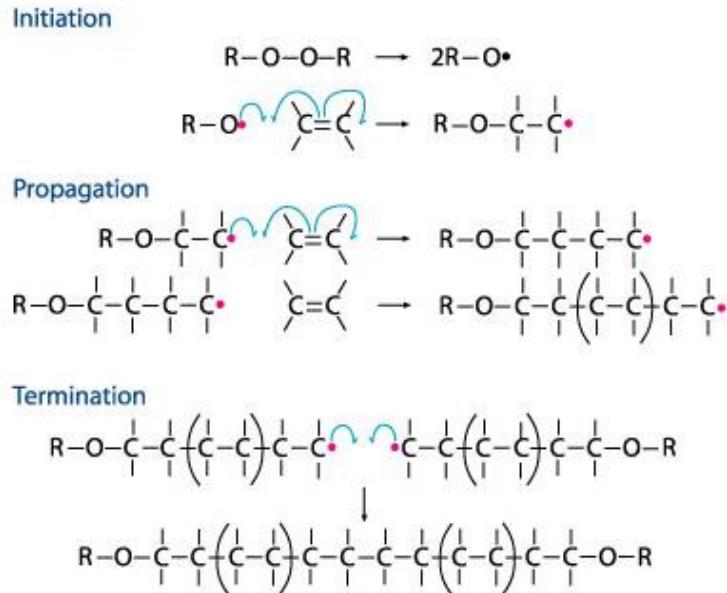
<ul style="list-style-type: none"> <li>Control is not easy</li> <li>Types           <ol style="list-style-type: none"> <li>Free radical</li> <li>Ring opening</li> <li>Ionic polymerization</li> </ol> </li> <li>Example: PMMA (Heat or self cure)</li> </ul>	
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### Stages in Addition Polymerization

Induction	<ul style="list-style-type: none"> <li>To initiate the additional polymerization a source for free radical "R" is required</li> <li>The process of releasing or producing free radicals is called <b>activation</b></li> <li>Example for sources: Heat, UV light, chemical agents (Eg., benzoyl peroxide), energy from one compound to another</li> <li>Polymerization is <b>initiated</b> by free radicals reacting with monomer leading to a cycle of release of free radicals</li> </ul>
Propagation	<ul style="list-style-type: none"> <li>After initiation the production of free radicals starts generating the growth of polymer chains until all the free radicals are reacted</li> </ul>
Chain transfer	<ul style="list-style-type: none"> <li>In this step, the free radical is transferred to another monomer to produce a new free radical for further growth</li> </ul>
Termination	<ul style="list-style-type: none"> <li>Chain reaction can be terminated by following reasons</li> <li>Coupling of two chain ends of free radicals</li> <li>Exchange of H<sub>2</sub> atom from one chain to another</li> <li>Collision of initiation free radical with a growing chain</li> <li>Collision of growing chain with an inhibitor</li> </ul>
Inhibition	<ul style="list-style-type: none"> <li>An impurity reacting with any monomer may inhibit polymerization</li> <li>Example: Hydroquinone, eugenol, oxygen</li> </ul>

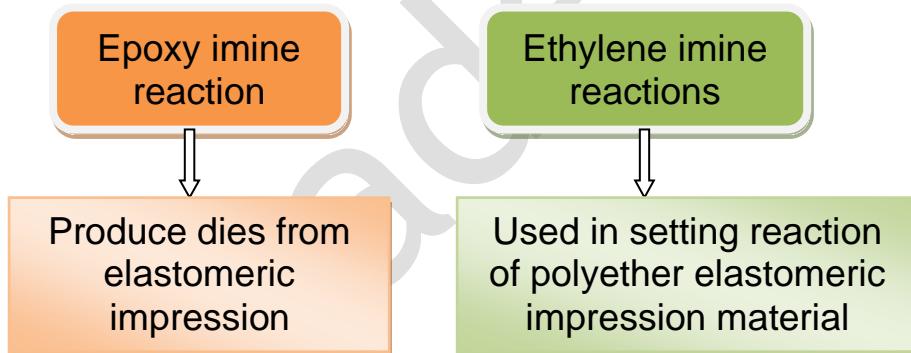
### Functions

- Prevents polymerization in storage
- Provides adequate time for mixing and working



### III. Ring open polymerization

- There are two ring opening polymerization in dentistry



- Epoxy system consists of epoxide oligomer (difunctional) and an amine (difunctional)
- The amine opens the ring forming a rigid polymer due to cross linking
- Presence of water interferes with the setting as it reacts with epoxide, hence hydrocolloid impression materials like alginate and agar are incompatible with die materials

### DENTURE BASE RESINS

- ADA/ ANSI specification no denture base resins is 12
- Acrylic resins are derived from ethylene and contain vinyl group.
- Polymethylmethacrylate (PMMA) resin is commonly used in dentistry
- PMMA is not used directly, rather the monomer methyl methacrylate in liquid consistency is proportioned with polymer and is supplied in powder form

## Methylmethacrylate

- It is transparent and in liquid consistency at room temperature
- Polymerization can be initiated by chemical substance, light, heat, ultraviolet light

Properties	Value
Molecular weight	100
Melting point	- 48 <sup>0</sup> C
Boiling point	100.8 <sup>0</sup> C
Density	0.945 g/ml at 20 <sup>0</sup> C
Heat of polymerization	12.9 Kcal/mol
Volume shrinkage	21%

## Poly (Methyl Methacrylate) PMMA

- Dr Walter Wright introduced PMMA in 1937 as a denture base material
- It is a transparent and extremely stable material
- It has all the ideal properties of a denture base material except for mechanical properties
- PMMA is not only used for denture bases, but also for denture reliners, rebases, orthodontic prostheses, maxillofacial prostheses, temporary crowns, splints
- Transmits UV light (250 nm)
- It is divided based on the method of activation

Properties	Value
Knoop hardness	18 - 20
Tensile strength	60 MPa
Density	1.019 g/cm <sup>3</sup>
Elastic modulus	2.4 GPa

## Classification

### 1. According to ISO 1567

Type 1	<ul style="list-style-type: none"> <li>• Class 1, Heat processing polymers (powder &amp; liquid)</li> <li>• Class 2, Heat processed (plastic)</li> </ul>
Type 2	<ul style="list-style-type: none"> <li>• Class 1, autopolymerized polymers (powder &amp; liquid)</li> <li>• Class 2, autopolymerized polymers (powder &amp; liquid pour type)</li> </ul>
Type 3	<ul style="list-style-type: none"> <li>• Thermoplastic blank/ powder</li> </ul>
Type 4	<ul style="list-style-type: none"> <li>• Light activated materials</li> </ul>
Type 5	<ul style="list-style-type: none"> <li>• Microwave cured resins</li> </ul>

<b>2. Based on use</b>	<b>3. Based on methods of activation</b>
<ul style="list-style-type: none"> <li>• Temporary: Eg. Self cure denture base resins</li> <li>• Permanent: Eg. Heat cure denture base resins, Light cure resins</li> </ul>	<ul style="list-style-type: none"> <li>• Chemically activated</li> <li>• Heat activated</li> <li>• Light activated</li> </ul>

### Ideal requirements of denture base resins

- Nontoxic, non allergic, non carcinogenic
- Compatible with oral mucosa and adjacent soft tissues
- Simulate the oral tissues
- Should have wide selection of colour to provide esthetics
- Tasteless, odorless, lighter in weight
- Should be rigid
- No interference with oral functions
- Fluid sorption is less
- Resistant to stain, calculus deposits
- Wettable
- Self cleansable

- Adequate bond between resin and teeth
- Resistant to acids, alkalis, wear, abrasion
- Resistant to strain
- Easy to polish, repair, relined
- Manipulation and processing are simple
- Cost effective
- Good shelf life

## COMPOSITION AND TYPES OF DENTURE BASE RESINS

### I. Heat Activated PMMA

- Available as powder and liquid form

Powder	Liquid
<ul style="list-style-type: none"> <li>• Beads or granules of polymethylmethacrylate</li> <li>• <b>Initiator (benzoyl peroxide) (PGI-99)</b></li> <li>• Pigments/dyes (colour vitality as cadmium, iron, organic dyes)</li> <li>• Optical Opacifiers (<math>TiO_2/ZnO</math>)</li> <li>• Plasticizers (ethyl acrylate (internal), dibutylphthalate (external) to make dough easier)</li> <li>• Synthetic fibres (nylon)</li> <li>• Coloured fibres (blood vessels)</li> <li>• Shelf life is limitless</li> </ul>	<ul style="list-style-type: none"> <li>• Methyl methacrylate monomer</li> <li>• <b>Inhibitor (hydroquinone)</b></li> <li>• <b>Cross linking agent (glycol dimethacrylate)</b></li> <li>• Preserved in dark or amber bottle to avoid contamination by light or powder</li> </ul>

- Processing of heat cure denture base resins are done using two techniques
  - Compression molding technique
  - Injection molding technique

### II. Chemically Activated Denture Base Resin (Auto Polymer, Self-Cure, Cold-Cure)

Powder	Liquid
<ul style="list-style-type: none"> <li>• Poly (Methyl Methacrylate)</li> <li>• Other copolymers - 5%</li> <li>• <b>Benzoyl Peroxide → Initiator</b></li> </ul>	<ul style="list-style-type: none"> <li>• Methyl Methacrylate</li> <li>• <b>Dimethyl-p-toluidine → Activator</b></li> <li>• Dibutyl phthalate → Plasticizer</li> </ul>

- |  |  |
|--|--|
| <ul style="list-style-type: none"><li>• Compounds of mercuric sulphide, Cadmium → Dyes</li><li>• Zinc / Titanium Oxide → Opacifiers</li><li>• Dibutyl phthalate → Plasticizer</li><li>• Dyed organic fillers</li><li>• Inorganic particles like glass fibers / beads</li></ul> | <ul style="list-style-type: none"><li>• Glycol dimethacrylate → Cross linking agent</li><li>• Hydroquinone → Inhibitor</li></ul> |
|--|--|

### **Clinical Applications**

- Custom trays
- Repair of denture
- Relining & rebasing
- Removable orthodontic appliances

### **Advantages**

1. Initial fit is good
2. Thermal contraction is less
3. Can be used for denture repairs as it avoids warpage

### **Disadvantages**

1. Colour stability is inferior
2. Degree of polymerization is less
3. Inferior physical properties

### **Manipulation**

- Sprinkle – On technique
- Adapting technique
- Fluid resin technique
- Compression moulding technique
- Injection moulding technique

### III. Light Activated Denture Base Resin

- Available as pre-mixed sheets
- Clay-like consistency

#### Composition

- Urethane dimethacrylate matrix
- Acrylic copolymer
- Microfine silica fillers
- Photo initiator system – Camphoroquinone amine
- Provided in opaque light packages – to avoid premature polymerization
- Adapted to cast when in plastic form
- Polymerized in light chamber with light of 400-500 nm from high intensity quartz halogen bulbs

### IV. Microwavable acrylic resin

- GC lab technologies have introduced a processing system with a combination of molding and microwave activation.
- This process accelerated the polymerization

Advantage	Disadvantage
<ul style="list-style-type: none"><li>• Eliminates the need for handling the resin during packing process as we use injection technique</li></ul>	<ul style="list-style-type: none"><li>• Costly due to the addition of pneumatic press and flask components</li></ul>

### RECENT ADVANCES

- Several studies have been done to improve the mechanical properties of PMMA
- Reinforced PMMA results in improved flexural strength, impact strength and increased resistance to fatigue

### I. Reinforced PMMA's

- Materials used to reinforce PMMA are
  1. **Air abrasion with alumina:** improved flexural strength
  2. **Reinforcement with zirconium oxide:** increased flexural strength, thermal conductivity

3. **Addition of salinized zirconium oxide nanoparticles** improve the mechanical properties of PMMA like impact strength, surface hardness, but is disadvantageous for solubility and water sorption
4. **Reinforced acrylic with glass fibers:** Increases toughness, flexural strength and impact strength, resistance to deformation
5. **Titanium oxide nanoparticles:** It depends on the number of nanoparticles used. Concentration less than 1% gives improves impact strength. Higher the concentration will lead to adverse effects on strength
6. **Silanated propyl propylene:** On addition to heat cure acrylic resin improves the mechanical strength
7. **ZnO nanoparticles:** Synthesized by microwave solvothermal method. ZnO -NPs have higher hydrophobicity, hardness, absorption, prevents microbial colonization
8. **Addition of silver nanoparticles:**  
Ag- NP Acrylic resins have improved antifungal properties than conventional acrylics. Also improves the viscoelastic properties

## II. BPS (Biofunctional Prosthetic System)

- It is a system that designs with biological harmony, improvising the function, comfort and appearance to the patient

## CONCLUSION

- Acrylic resins have been in use from a long time.
- It has almost become a founding pillars in the prosthetic treatment phase.
- A thorough knowledge in the basic properties and updates about the recent developments can improve the idea of treatment plan for a long-term outcome

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5. Skinner EW. Acrylic denture base material: Physical properties and manipulation. JPD 1951 (1) 161 - 3

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*Please Give Your Feedback on this Answer*

**Q. 13: Recent advances in impression material (7M)**

**CONTENTS/SYNOPSIS**

Introduction

Impression materials

Classification

- Based on setting mechanism and material properties
- Based on clinical condition
- Based on the use
- Based on the pressure applied

Ideal requirement of an impression material

Recent advances in impression materials

- Recent advances of hydrocolloids
  - Dust free alginates
  - Siliconised alginate
  - Low dust alginate impression material
  - Antiseptic alginate
  - Chromatic alginate
  - Alginate available as paste system
  - Polyacrylamide incorporated alginate
- Recent advances of agar hydrocolloids
  - Wet field technique
- Recent advances of elastomeric impression materials
  - Hydrophilized addition silicones
  - Monophase impression material
  - Visible light cured polyether urethane

Conclusion

References

## INTRODUCTION

- The main goal of dentistry is to maintain and improve the life of the patient.
- This can be achieved by preventing diseases, eliminating pain, improving masticatory efficiency, speech and esthetics.
- The main challenge is the development and selection of a long lasting, biocompatible, which can withstand adverse oral conditions
- Dental materials are generally classified as
- Preventive materials: Eg. Pit and fissure sealants, liners and bases
- Restorative materials: Eg. Direct and Indirect restorative materials
- Auxiliary materials: Eg. Etchants, impression materials, gypsum products, finishing and polishing abrasives

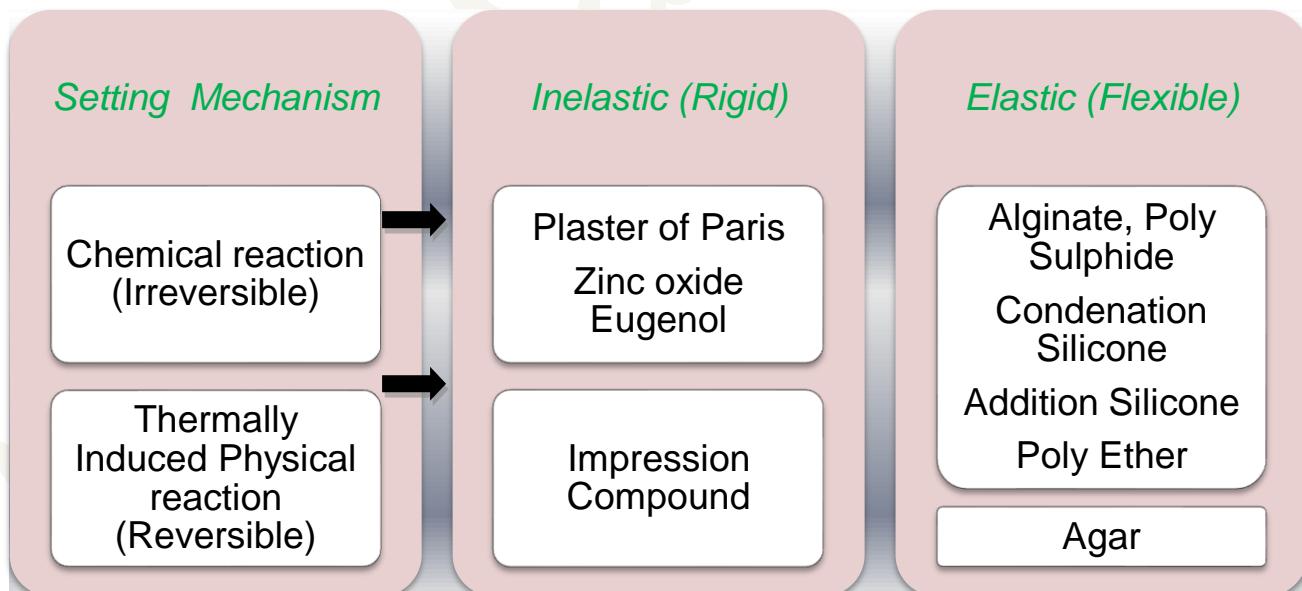
## IMPRESSION MATERIALS

- Impression materials are used to replicate and represent the form of the tooth and their relationship with the remaining oral structures.

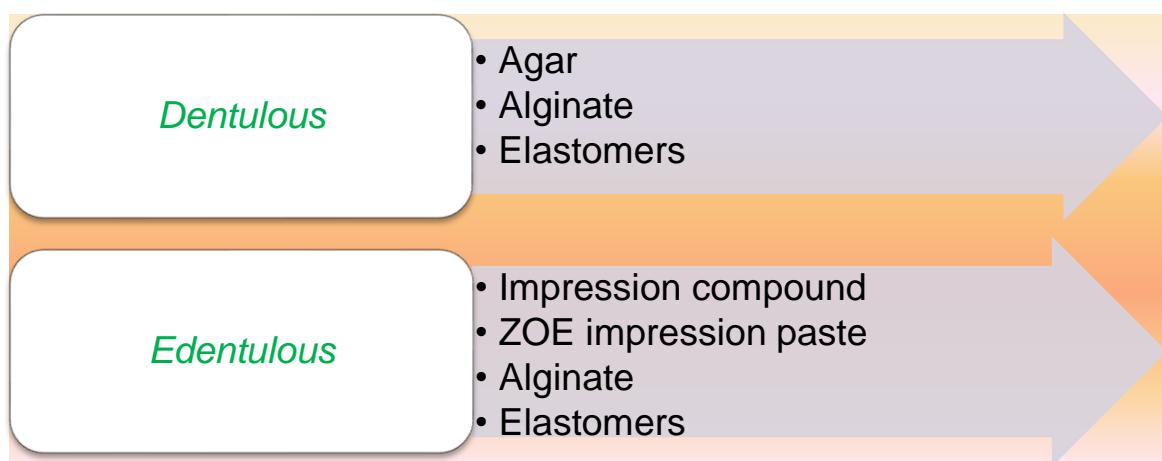
## CLASSIFICATION

According to Philips' Science of dental materials, 12th Ed

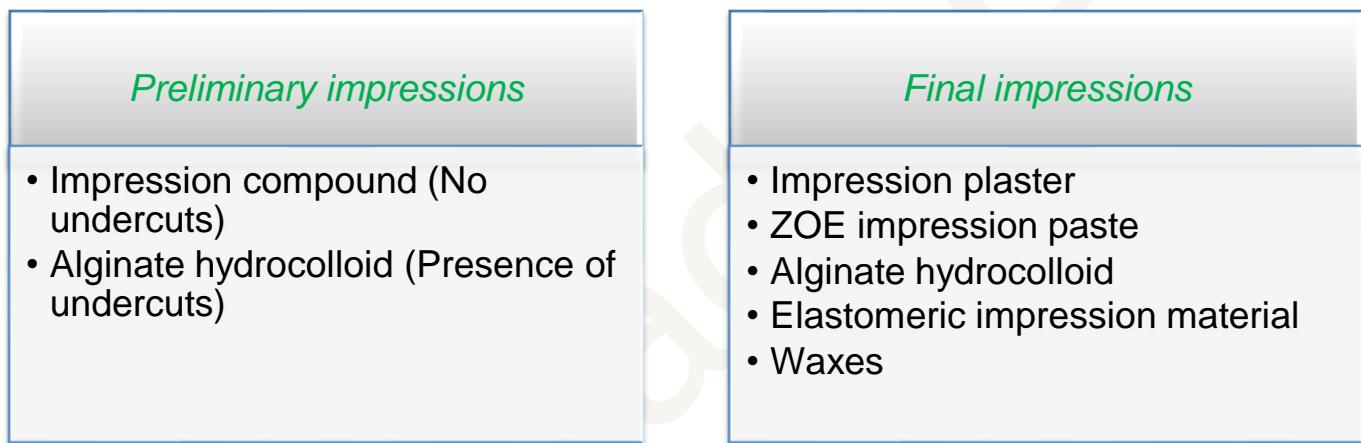
### 1. Based on Mechanism Of Setting and Mechanical Properties



## 2. Based on the Clinical Condition



## 3. Based on the Uses



## 4. Based on the Amount of Pressure Applied

<i>Mucocompressive</i>	<i>Mucostatic</i>	<i>Selective Pressure</i>
<ul style="list-style-type: none"> <li>• Example: Impression compound</li> </ul>	<ul style="list-style-type: none"> <li>• Example: Impression plaster</li> </ul>	<ul style="list-style-type: none"> <li>• Example: Zinc oxide eugenol impression paste</li> </ul>

## IDEAL REQUIREMENTS OF AN IMPRESSION MATERIAL

1. Pleasant taste and odour
2. Nontoxic or non-irritant
3. Good shelf life
4. Adequate flow
5. Enough viscosity to be held in a tray
6. Wettability to the oral structures
7. Should be able to set either physically or chemically within in the mouth
8. Tear strength to protect the impression from distortion
9. Dimensional stability to be able to pour casts
10. Compatible biologically
11. Economical

## RECENT ADVANCES IN IMPRESSION MATERIALS

### I. Hydrocolloids

- Hydrocolloids are true solutions that exist as a single phase (Colloid and suspension).
- They undergo sol gel transformation

#### 1. Agar Hydrocolloid

- It is a reversible hydrocolloid, undergo transformation by a change of temperature
- Available a syringe or tray material

<i>Classification</i>	<i>Clinical applications</i>
1. Type 1 high consistency	
2. Type 2 medium consistency	
3. Type 3 low consistency	<ul style="list-style-type: none"><li>• Best material for duplicating casts</li><li>• Primary impression in dentulous patients (crown and bridges)</li></ul>

#### Recent Advances

##### *Wet field technique*

- Oral tissues are flushed with warm water followed by injection of material
- The hydraulic pressure of the tray material (viscous in nature)

forces the syringe material into the oral cavity where the areas are to be recorded

- These forces push the syringe material throughout the sulcus along with blood and debris

## 2. *Alginate Hydrocolloid*

- It is an irreversible hydrocolloid impression material which sets by chemical reaction
- Available as bulk powders and pre weighed packages

<i>Classification</i>	<i>Clinical applications</i>
1. Type I (fast setting) 2. Type II (normal setting)	<ul style="list-style-type: none"><li>• To make preliminary impression of edentulous patients with undercuts.</li><li>• To make impressions of dentulous patients.</li><li>• Prepare study models.</li><li>• Used as duplicating materials</li></ul>

### Recent Advances

<i>Dust Free Alginates</i>
<ul style="list-style-type: none"><li>• Airborne particles in fine alginate impression material may cause lung problems like silicosis, pulmonary hypersensitivity on inhalation</li><li>• Hence dustless alginates were introduced by coating the material with glycerin or glycol.</li><li>• This makes the powder denser than the uncoated conventional alginate powder</li></ul>
<i>Siliconized alginate</i>
<ul style="list-style-type: none"><li>• Consists of a two-component system</li><li>• Available as paste form, one with alginate sol and second is a calcium reactor</li><li>• Silicone polymer has been introduced into these components to make the material tear resistant compared with unmodified alginate.</li><li>• Disadvantage: Poor dimensional stability</li></ul>
<i>Low Dust Alginate Impression Material</i>

- Introduced in 1997 by Schunichi and Nobutakatanate
- Comprises of a gelation regulator and a filler to control the release of dust
- Particle size varies from 1 - 40 $\mu$

#### Antiseptic Alginate

- Introduced in 1990 by Tameyuki Yamamoto, Maso Abinu
- This material consists 0.01 - 7 parts by weight of antiseptic to 100 parts by weight of alginate material which is cured
- Antiseptic used are glutaraldehyde and chlorhexidine gluconate
- Antiseptic may be incorporated in the form of microcapsules

#### Chromatic Alginate

- Alginate with colour changing markers indicates the setting time, which play a major role in impression making
- It indicates two colour changes
- End of the mixing time: Violet to pink
- End of the setting time: Pink to White
- Advantages: Improved dimensional stability, tear and deformation resistance is good, surface details are smooth, compatibility with gypsum and dust free
- Examples: CAVEX colour change, Extend a Pour (Dux dental products)

#### Alginate available as paste system

- To prevent the contamination of powder two paste system of alginate has been introduced.
- Consists of a base and a catalyst paste.
- Base: Soluble alginate, fillers, water
- Catalyst: Calcium salts as reactors, paraffin liquid, magnesium hydroxide as pH stabilizer

#### Polyacrylamide incorporated alginate

- To prevent grainy mix of alginate on exposure to water, a stabilizing and thickening agent is added to conventional alginate.
- 0.01 - 0.25 wt% Polyacrylamide is incorporated
- It improves mixing capacity resulting in a smooth alginate mix

## II. Elastomeric Impression Materials

- Elastomers are referred to as rubbery polymers which sets chemically
- There are four types of elastomers commonly used in dentistry
  1. Polyether
  2. Polysulphide
  3. Addition silicone
  4. Condensation silicone

Consistency	Mixing systems
<ul style="list-style-type: none"> <li>• Putty</li> <li>• High</li> <li>• Medium</li> <li>• Low</li> <li>• Extra low</li> </ul>	<ul style="list-style-type: none"> <li>• Hand mixing</li> <li>• Static auto mixing</li> <li>• Dynamic mechanical mixing</li> </ul>

### Recent Advances

i. Hydrophilized Addition Silicones	ii. Monophase Impression Material
<ul style="list-style-type: none"> <li>• Hydrophobic nature of elastomers is a major drawback. Addition of surfactants (micelles) reduces the contact angle of the materials, increases wettability, pouring of gypsum models.</li> <li>• These surfactants consist of a hydrophilized part and a hydrophilic compatible silicone.</li> <li>• According to Miller et al on adding modified polydimethyl siloxane, quality of impression surface is increased with an increase in wettability and reduction in number of voids.</li> <li>• Usage of radiofrequency glow discharge to disinfect polyvinyl siloxane impressions.</li> </ul>	<ul style="list-style-type: none"> <li>• Available as single viscosity</li> <li>• Viscosity is determined based on the amount of pressure given while manipulating the material,</li> <li>• Greater the shear - acts as light bodied material</li> <li>• Lesser the pressure - acts as heavy bodied material</li> </ul>

### iii. *Visible light cured polyether urethane*

Introduced in 1988 with ADA no 19  
Similar to light cured composite

#### **Composition**

Polyether urethane dimethacrylate  
diketone - photoinitiator

Transparent silica - acts as filler (40-60%)

Available as light and  
heavy bodied

#### **Manipulation**

Transparent stock trays  
are used with heavy  
body and light body  
syringed onto it.

Curing is done using  
blue light (30seconds)

#### **Advantages**

1. Working time is longer.
2. Impressions can be corrected.
3. Good dimensional stability, accuracy and flow.

#### **Disadvantages**

1. Expensive
2. Technique sensitive
3. Setting time is short

## **CONCLUSION**

- The recent modifications in impression materials led to improved characteristics, handling properties and clinical performances compared to unmodified materials.

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1. William J. O'Brien. Dental materials and their selection. 4th edition
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*Please Give Your Feedback on this Answer*

**Q.19: Resilient liners - Types, properties and their applications in prosthodontics (15M)**

**Tissue conditioners (7M, 6M)**

**CONTENTS/SYNOPSIS**

Introduction of Resilient liners

Soft term reliners/ Tissue conditioners

Composition and Chemistry

- Factors affecting the process of gelation
  - Size of the polymer powder
  - Molecular weight of polymer
  - Powder and liquid ratio
  - Content of plasticizer
  - Temperature

Physical properties of tissue conditioners

Clinical applications of tissue conditions

- Adjunct to tissue healing
- Temporary Obturator
- Stabilization of base plate and surgical splints
- Adjunct to a final impression material

Application of tissue conditioners

- Preparation of dentures
- Manipulation and application of tissue conditioner

Care and maintenance

Limitations of tissue conditioner

Long term resilient reliners

- Clinical applications
- Classification
- Composition
- Properties

Conclusion

References

## INTRODUCTION

- Resilient liners are soft and elastic materials which are proven to be excellent clinical adjunct in the management of sore dentures, maxillofacial prosthesis.
- Several studies and clinical trials have established that use of dentures with resilient liners in edentulous patients resulting a great comfort, improved speech, reduced soreness, improved ability to chew, enhanced retention and stability.
- Resilient lines are of two types
  1. Short term resilient liners (Tissue conditioners)
  2. Long term resilient liners

## SHORT TERM LINERS/ TISSUE CONDITIONERS

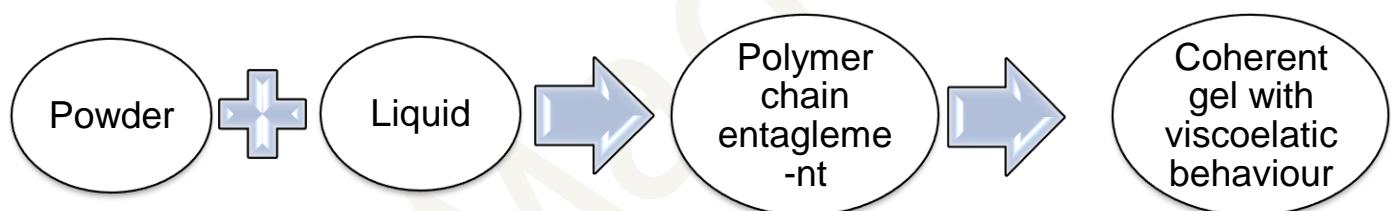
According to Kydd and Mandley (1967), tissue lining materials are essential in dentistry as they permit distribution of forces throughout the denture base to the alveolar bone.

- They aid to reduce the transmission of stress to the supporting tissues.
- For practical purposes, denture base materials are fabricated using rigid materials
- Hence there will be a prolonged contact of these denture bases with the underlying supporting tissues which may lead to physiological or pathological changes in the tissues.
- Mucosal health is achieved by following proper hygiene and therapeutic measures and tissue conditioning whenever needed

## COMPOSITION & CHEMISTRY

- Tissue conditioners are also known as short term reliners
- They are made insitu from a combination of polymer powder and liquid form of plasticizer

Polymer Powder	Liquid Plasticizer
<ul style="list-style-type: none"> <li>• Polyethyl methacrylate (PEMA) - Molecular weight ranging between <math>1.79 \times 10^5</math> - <math>3.25 \times 10^5</math></li> <li>• Polymethyl methacrylate (PMMA) which is a commonly used acrylic polymer, is unsuitable for this application as it is insoluble in ethanol</li> </ul>	<ul style="list-style-type: none"> <li>• It is an ethyl alcohol solution (ester based) without an acrylic monomer.</li> <li>• Plasticizers used are generally low molecular weight aromatic esters</li> <li>• Their role is to reduce the polymer glass transition temperature</li> <li>• Example: dibutyl phthalate, butyl benzyl phthalate, butyl phthalyl butyl glucolate and benzyl benzoate</li> </ul>



### Factors affecting the process of gelation:

1. Size of the polymer powder	$\downarrow$ Polymer weight - $\uparrow$ Gelation time
2. Molecular weight of polymer	$\uparrow$ Polymer weight - $\downarrow$ Gelation time
3. Powder and liquid ratio	$\uparrow$ P/ Water ratio - $\downarrow$ Gelation time
4. Content of plasticizer	Depends on type and amount of plasticizer
5. Temperature	$\uparrow$ Temperature - $\downarrow$ Gelation time

Commercially available as: GC Soft-Liner (GC Europe NV)Coe-Comfort (GC America), Visco-gel (De Try), FITT (Kerr), Tissue conditioner (Shofu), SR-Ivoseal (Ivoclar).

## PHYSICAL PROPERTIES OF TISSUE CONDITIONERS

Oral environment plays a major role on physical properties of tissue conditioners

### I. Water sorption and solubility

- Water sorption - 0.2 to 5.6 mg/cm
- Solubility - 0.03 to 0.4 mg/cm
- Polymer with higher water sorption capacity lead to increase in volume of tissue conditioner
- Loss of ethanol plasticizers leads to shrinkage of tissue conditioner
- These factors also affect the physical properties like flexibility, roughness, dimensional stability of material

### II. Adhesion/ Bonding with denture base

Studies have reported that silicone based tissue conditioners have shown failure of bonding with denture base



Potential space for the formation of dental plaque and calculus



Microleakage

#### Methods to improve bonding

- Mechanical retention: Creating roughness using trimmers, air abrasion, laser on the surface of denture base enhances the retention
- Available space: Ideally 2mm of thickness space is recommended

### III. Viscoelastic behavior

- An ideal resilient denture liner should have greater elasticity during mastication, with a viscous behavior to distribute functional and nonfunctional masticatory forces
- Material should be dimensionally stable while using it as interim relining, to prevent changes in VDO (Vertical dimension of occlusion)

## CLINICAL APPLICATIONS

- Tissue conditioners are soft and resilient. Hence this nature facilitates a wide range of diagnostic and treatment modalities

### Adjunct for healing tissues

- They prepare the oral tissue to withstand masticatory forces from the dentures
- Preserves the residual ridges
- Healing of irritated tissue before delivering a new prosthesis
- Restores the inflamed supporting tissues

### As a temporary obturator

- To obturate or protect the surgical area, tissue conditioners are applied as temporary obturator on previously existing complete or partial removable dentures
- Used to modify dentures post implant surgery

### Base plate stabilization

- In cases with undercuts, fabricating temporary denture bases is not ideal as they tend to lock and break the cast.
- Application of tissue conditioners in these cases stabilizes the denture bases and prevents breakage of cast

### Adjunct as a final impression material

- They are used in cases with movable tissue to record the full extension of sulcus in final impressions
- They record the impression in dynamic form
- Used a provisional liners to enhance the fit of dentures

## APPLICATION OF TISSUE CONDITIONERS

The following steps are to be followed while applying tissue conditioners

### Preparing the dentures

- Reduction of tissue surface of denture base by 1mm near undercuts and crest of the ridge to allow room for tissue conditioner.

### Mixing and placement of the tissue conditioner

- Based on the consistency required, the mixing ratio varies.
- Ideal ratio is 1.25 parts of polymer + (1 part monomer + 0.5cc plasticizer)
- All the ingredients are mixed forming into a gel followed by application onto the tissue surface of denture
- Then denture is inserted into the mouth and border movements are performed to mold the material until set

## CARE AND MAINTAINENCE

- Should be cleaned under running water gently with a cotton cloth or gauze.
- Avoid scrubbing using hard brushes which might lead to tear of the material.
- Disinfect with 0.2% of chlorhexidine
- Longevity is limited (due to loss of plasticizer) as they tend to harden and roughen within 4 - 8 weeks. Hence requires observation

## LIMITATIONS OF TISSUE CONDITIONER

1. Rough surfaces of denture base lead to bacterial and fungal growth onto the relining material exposing the patients to infections
2. Example: Candida associated denture stomatitis
3. Long term usage is contraindicated as tissue conditioners tend to leach out plasticizers and harden traumatizing supporting tissues.

## LONG TERM RESILIENT LINERS

### I. Clinical applications

- Used to prevent soreness of denture
- As preventive measure:
  - In edentulous patients with sharp ridges,
  - Thin atrophied mucosa with very less tolerance of load transmission by denture prosthesis,
  - Dentures with poor retention and recurrent sore spots.

### II. Classification

#### *Based on Composition*

- Plasticized acrylics
- Silicone elastomers

### III. Composition

#### 1. *Acrylic Resilient Liners*

- Commercially available as auto and heat polymerized systems

<i>Powder</i>	<i>Liquid</i>
<ul style="list-style-type: none"><li>Consists of poly ethyl methacrylate or poly butyl methacrylate and few peroxide initiator</li></ul>	<p>For autopolymerized liner</p> <ul style="list-style-type: none"><li>Consists of 2 - ethylhexyl methacrylate, tertiary amine and plasticizer</li></ul> <p>For heat polymerized liner</p> <ul style="list-style-type: none"><li>Consists of methacrylate and plasticizer</li></ul>

#### 2. *Silicone Elastomers*

##### *Heat Cured*

- Available as single paste system with polydimethyl siloxane with terminal vinyl group and benzoyl peroxide as initiator.

##### *Chemical Cured*

- Available as two paste cartridges with base paste and liquid catalyst
- Catalyst: Consists of divinylpolysiloxane and platinum salt
- Base: Polymethyl - hydrosiloxane and divinylpolysiloxane

#### IV. Properties

- Similar to that of tissue conditioners
- Longevity: 4 Weeks to several months

Masticatory function: Acrylic permanent soft liner > Silicone permanent soft liner > tissue conditioner > Acrylic resin

#### CONCLUSION

- Resilient liners are biological materials used for tissue regeneration in a short period of time. Prolonged use of these materials may cause mechanical irritation to the mucosa. Following proper protocols and maintenance will be effective.

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1. William J. O'Brien. Dental materials and their selection. 4th edition
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*Please Give Your Feedback on this Answer*

**Q. No 11: Resin cements (7M)**

**Resins used in dentistry (7M)**

**Resin bonded cements (7M)**

**Elaborate on various luting cements used in prosthodontics (20M)**

**Recent advances in luting cements (7M)**

**How do you select different luting agents for various direct and indirect restorations in Prosthodontics practice (20M)**

## CONTENTS/SYNOPSIS

Introduction

History of luting agents

Classification of dental cements

- Based on applications
- Based on bonding mechanism
- Based on major composition
- Based on setting reaction

Cavity varnish

Cavity liners

Cavity bases

Luting cements

- Ideal requirements of luting cements
- Types of luting cements
  - Silicates
  - Zinc silico phosphates
  - Zinc oxide eugenol
    - Modifications of ZOE
      - ZOE reinforced with alumina (Super EBA)
      - ZOE reinforced with Polymer
      - ZOE reinforced with Resin
      - Cements with vanillate esters
      - ZOE-Fast setting & Non setting ZOE
      - Non eugenol ZOE

- Zinc Phosphate Cement
- Polycarboxylate Cement
- Glass Ionomer Cement
  - Modification of GIC
    - Metal Modified GIC
    - Resin - Modified GIC/ Hybrid Ionomer Cement
    - Calcium Aluminate GIC
    - Compomer/ Polyacid Modified Composite Resin
  - Resin cements

### Selection of luting agents

- Generalized indications and contraindications
- Generalized properties

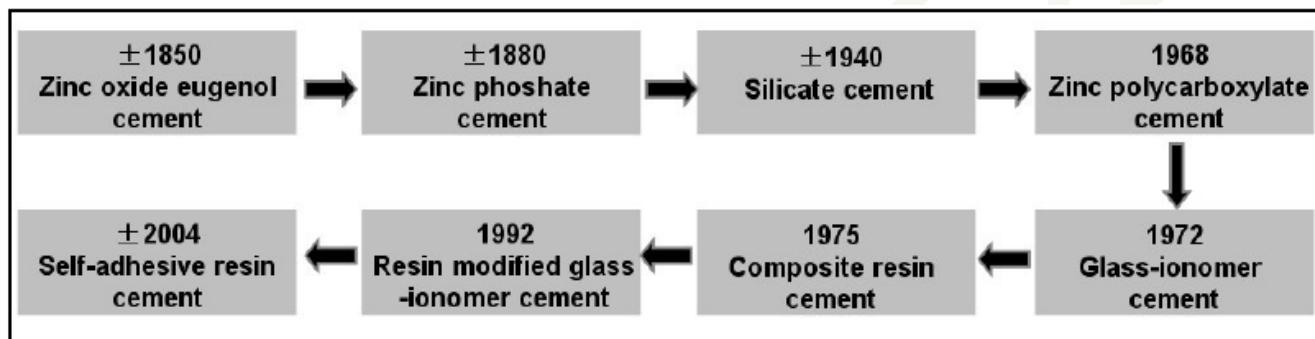
### Conclusion

### Reference

## INTRODUCTION

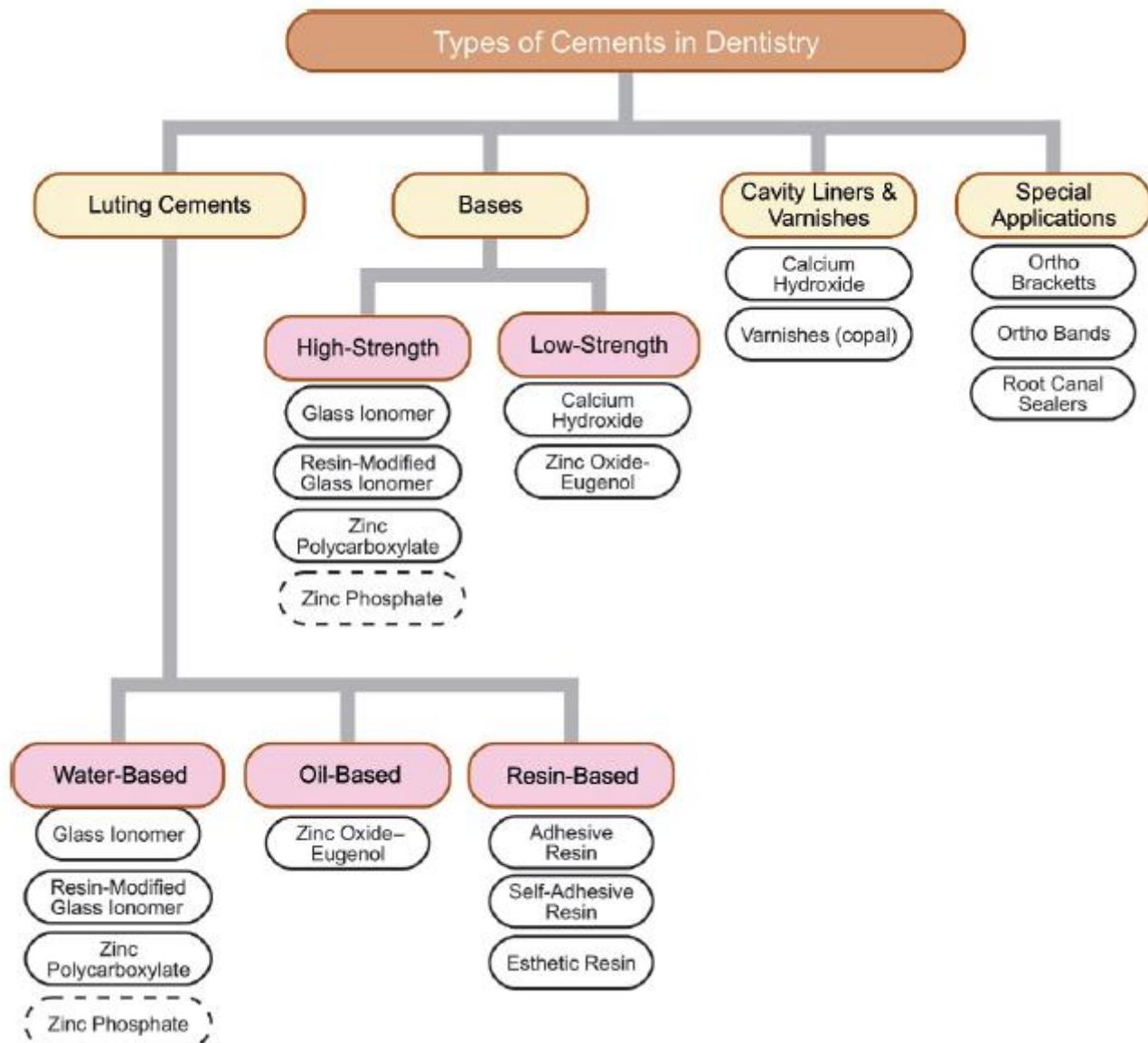
- Dental cements are one of the most important material in the field of clinical dentistry.
- They act as
  - Luting agents to bond fixed restorations to natural tooth or tooth substrate,
  - Cavity liners and bases to protect the underlying pulp,
  - Restorative cements.
- With an increasing demand in fixed restorations, development of new cements is desired with better physical properties and compatibility.

## HISTORY

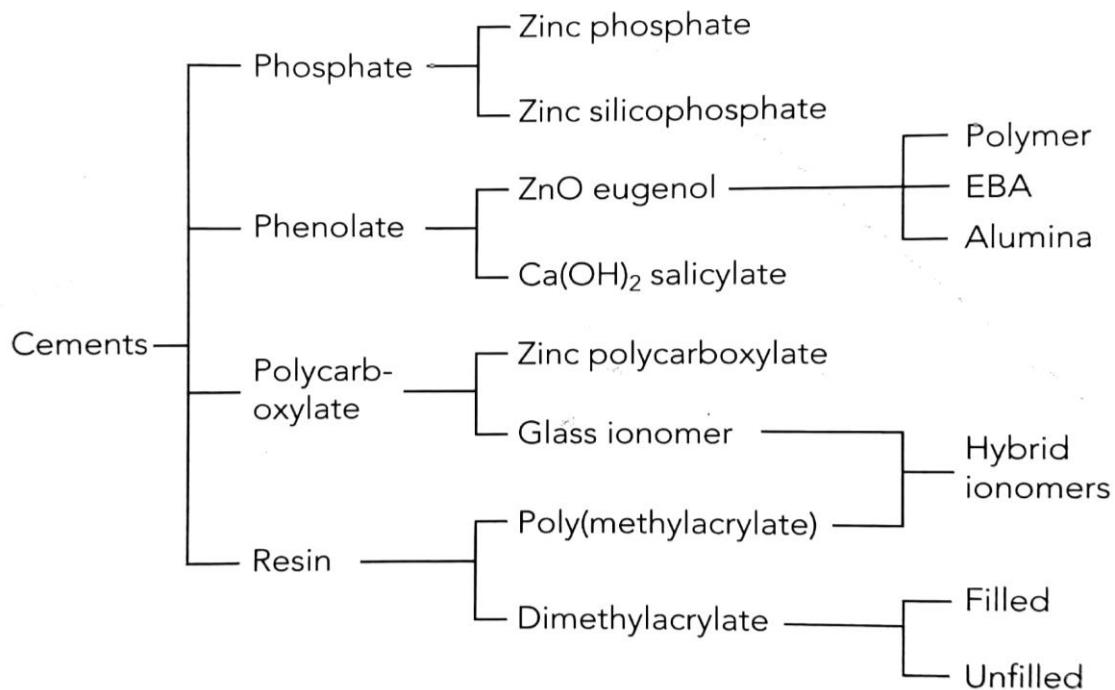


## CLASSIFICATION

### I. Based on Applications



## II. Based on their Bonding Mechanism (William J. O' Brien)



## III. Based on Major Composition (Craig)

- Zinc Phosphate cement
- Zinc oxide eugenol cement
- Zinc polyacrylate cement
- Glass ionomer cement
- Resin cement

## IV. Based on Setting Reaction (Wilson)

1. Acid-base cements
2. Polymerized cements

### CAVITY LINERS

- Cavity liners are thin (0.5mm) protective barriers with therapeutic effects and no mechanical strength and thermal insulating properties
- **Uses:** Prevents marginal leakage, secondary dentin formation, neutralizing acids of luting agents
- **Examples:** Calcium hydroxide (for direct & indirect pulp capping), Zinc oxide eugenol (Low viscous), Glass ionomer cement, MTA.

## CAVITY VARNISHES

- A varnish acts as a protective layer between prepared tooth and restoration.

### Uses

Seals the dentinal tubules and pulp from irritants of either restoration or luting agent, Prevents marginal leakage

### Composition

Natural gums (Copal rosins, synthetic resins) dispersed in solvents (Alcohol, chloroform)

### Application

Applied as two or three layers on the surface of prepared tooth (1-40 $\mu$ m) with a break of 5 to 15 seconds

### Contraindicated

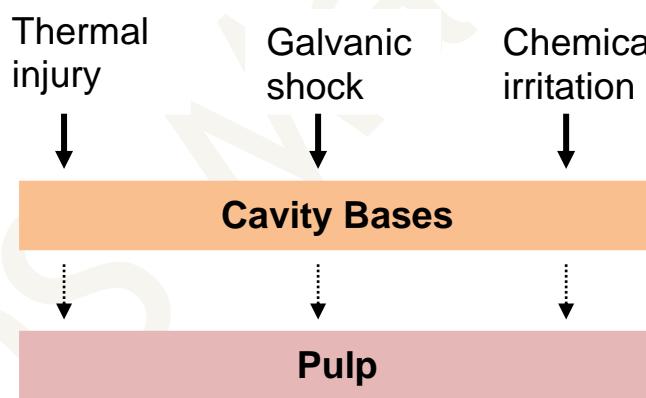
In adhesive bonding agents (GIC, composites)

### Examples

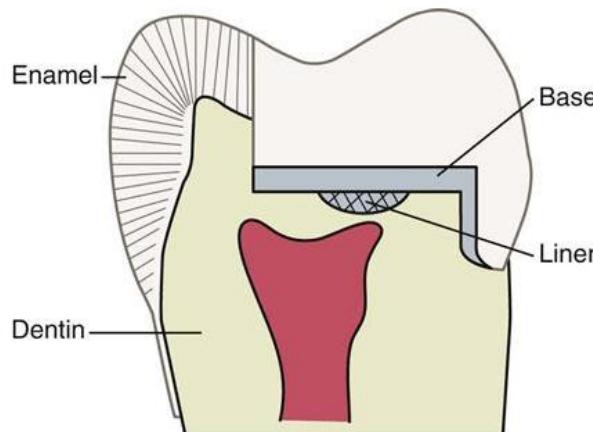
Fluoride varnish, desensitizers, tooth whitening varnishes

## CAVITY BASES

- Bases are thick layers (> 0.75mm) applied below the restorations
- **Uses:** Protects the pulp against galvanic shocks, thermal and chemical irritation



- **Examples:** Calcium hydroxide, Zinc phosphate, Zinc oxide eugenol, Polycarboxylate, Glass ionomer cements



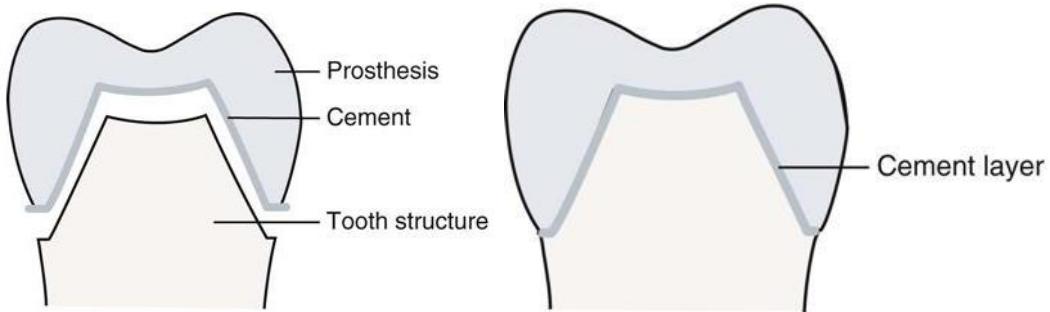
## Comparison of cement bases with other materials

Material	Thermal Conductivity (W/m·K)
Zinc phosphate cement (dry)	1.26
Zinc phosphate cement (wet)	1.63
Zinc oxide–eugenol	1.67
Corkboard	0.04
Gypsum plaster board	0.17
Portland cement	0.29
Glass	1.01
Zirconia ceramic	1.7
Ice	2.18
Stainless steel	15.9
Alumina	30
Pure gold	297

## LUTING CEMENTS

### Ideal characteristics of Luting Agents

1. Should be biocompatible and protect the dentine and pulpal tissues of the teeth
2. Sealing at the interface of tooth or restoration should be perfect to avoid bacterial entry
3. Adequate bonding (physical, chemical, micromechanical)
4. Have higher strength, fracture and wear resistance
5. Good handling properties
6. Radio opaque (to assist in diagnosis)
7. Film thickness should be less to allow placement of restoration
8. Solubility should be less to avoid disintegration of cement
9. Good esthetics



## Types of Luting Cements

### 1. Silicates

#### Composition

- Powder: Silica ( $\text{SiO}_2$ ), Alumina ( $\text{Al}_2\text{O}_3$ ),  $\text{NaF}$ ,  $\text{CaF}_2$ , Flux,  $\text{CaO}$
- Liquid: Phosphoric acid, Buffer salts,  $\text{AlPO}_4$ ,  $\text{ZnPO}_4$ , Water

#### Setting reaction

- Type: Acid base reaction with release of fluoride ions
- Powder/Liquid ratio: 1.6gm/ 4ml

#### Advantages

- Prevents secondary caries, proximarl caries due to fluoride release

#### Disadvantages

- Highly soluble leading to loss of cement
- Marginal leakage
- Pulpal irritation

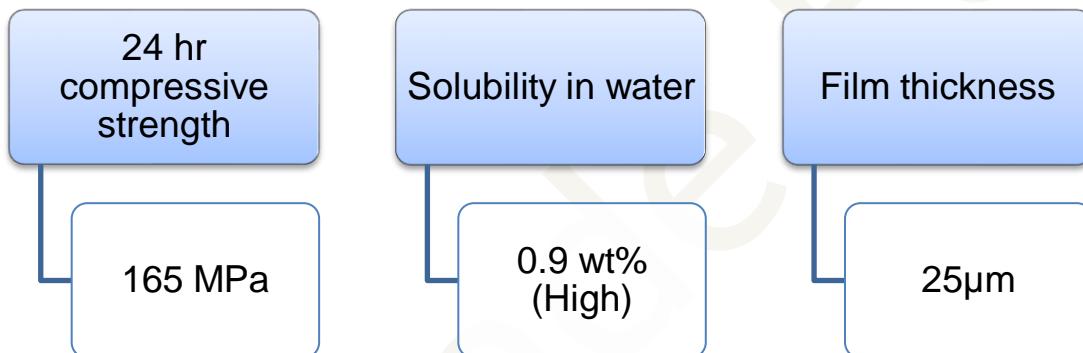
#### Physical & biological properties

24 hr Compressive strength	108 MPa
24 hr Diametral tensile strength	3.5 MPa (Weak)
Hardness	70KHN (dentine)
Solubility of water	0.7 wt% (High)
pH	Insertion < 3, 1 Month < 7

## 2. Zinc Silicophosphate

Applications	Classification	Composition	Setting reaction
<ul style="list-style-type: none"> <li>Luting agent for restorations &amp; orthodontic appliance</li> <li>Interim restoration</li> <li>To make dies</li> </ul>	<ul style="list-style-type: none"> <li>Type I: Cementation</li> <li>Type II: Interim filling material</li> <li>Type III: Both Type I &amp; Type II</li> </ul>	<ul style="list-style-type: none"> <li>Powder: Glass silicate, Zinc oxide, Magnesium oxide</li> <li>Liquid: Phosphoric acid, Water, Zn &amp; Al salts</li> </ul>	<ul style="list-style-type: none"> <li>Type: Acid base reaction with release of fluoride ions</li> <li>Setting time: 3 - 15 mins</li> </ul>

### Physical & Biological properties



### 3. Zinc Oxide Eugenol

#### Classification

- Type I: Temp cement (40µm), Luting agent
- Type II: Long term cement (25µm), Luting agent
  - Type III: Temp restoration
  - Type IV: Interim restoration

#### Composition

- Powder: ZnO (60%), Rosin, Zinc stearate & Zinc acetate (Accelerates and strengthens)
- Liquid: Eugenol (85%), Olive oil

#### Setting reaction

- Type: Acid base reaction (Chelation)
- $ZnO + H_2O \rightarrow Zn(OH)_2 + \text{Eugenol (E)} \rightarrow ZnE_2 + 2H_2O$ 
  - Water is the byproduct

#### Manipulation

- Available either in powder /Liquid or Pastes
- Mixed on a glass slab with a spatula until even consistency is achieved
- Mixing time: 30 - 60 sec, Setting time: 4 - 10 min

Applications	Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Temporary &amp; Permanent cement</li> <li>• Temporary &amp; Interim restoration</li> <li>• Cavity base &amp; Liner</li> <li>• Root canal sealing agent</li> <li>• Periodontal dressing</li> <li>• Impression material</li> <li>• Bite registration</li> </ul>	<ul style="list-style-type: none"> <li>• Least irritating among the dental materials</li> <li>• Excellent seal</li> <li>• Therapeutic effect on pulp</li> </ul>	<ul style="list-style-type: none"> <li>• Low strength and abrasion resistance</li> <li>• Solubility in oral fluids</li> <li>• Little anticariogenic action</li> </ul>

### Characteristic Properties

ZOE (Type I)		ZOE-EBA (Type II)		ZOE plus polymer (Type II)	
Setting time	4 - 10 min	Setting time	9.5 min	Setting time	6 - 10 mins
Maximum film thickness	25 µm	Maximum film thickness	25 µm	Maximum film thickness	32 µm
24 hr Compressive strength	6 - 28 MPa	24 hr Compressive strength	55 MPa	24 hr Compressive strength	48 MPa
24 hr Diametral tensile strength	-	24 hr Diametral tensile strength	4.1 MPa	24 hr Diametral tensile strength	4.1 MPa
Elastic Modulus	-	Elastic Modulus	5.0 GPa	Elastic Modulus	2.5 GPa
Solubility in water	0.04 wt%	Solubility in water	0.05 wt%	Solubility in water	0.08 wt%

### Modifications

ZOE reinforced with alumina (Super EBA)
<ul style="list-style-type: none"> <li>Powder: ZnO (30%), Alumina (30%)</li> <li>Liquid: Ortho EBA(Ethoxy benzoic acid), Eugenol</li> <li>Compressive strength: 55 Mpa</li> <li>Working time: Long</li> <li>Setting time: 9.5 min</li> </ul>

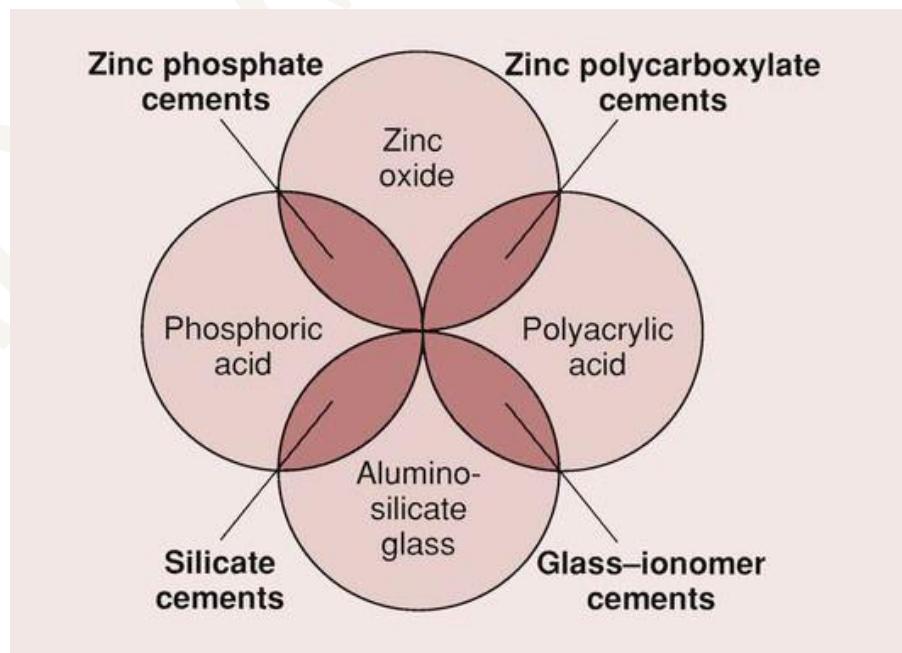
ZOE reinforced with Polymer
<ul style="list-style-type: none"> <li>Powder: ZnO (80%), Polymethylmethacrylate (20%)</li> <li>Liquid: Eugenol, Acetic acid, Thymol</li> <li>Compressive strength: 48 Mpa</li> <li>Working time: Long</li> <li>Setting time: 6-10 min</li> <li>Good abrasion resistance</li> </ul>

ZOE reinforced with Resin
<ul style="list-style-type: none"> <li>Powder: ZnO (88%), Rosin (10%)</li> <li>Liquid: Polystyrene (10%), Eugenol (90%)</li> <li>Compressive strength: 40 Mpa</li> <li>Working time: Long</li> </ul>

Cements with vanillate esters	ZOE-Fast setting & Non setting ZOE	Non eugenol ZOE
<ul style="list-style-type: none"> <li>Pwder: ZnO</li> <li>Liquid: Ortho EBA, Hexyl vanillate</li> <li>Higher strength, lesser solubility</li> </ul>	<ul style="list-style-type: none"> <li>Fast setting is initiated by adding zinc acetate</li> <li>Additives can be adding to reduce the setting time</li> </ul>	<ul style="list-style-type: none"> <li>Zinc oxide, oils (Aromatics, olive), Petroleum jelly, beeswax, oleinic acid.</li> </ul>

	4. Zinc Phosphate Cement	5. Polycarboxylate Cement	6. Glass Ionomer Cement
<i>Classification</i>	<ul style="list-style-type: none"> <li>Oldest <b>gold standard</b> cement</li> <li>Also known as crown &amp; bridge cement</li> <li>Type I: As Luting agent (25 <math>\mu</math>)</li> <li>Type II: For bases &amp; restorations (40 <math>\mu</math>)</li> </ul>	<ul style="list-style-type: none"> <li>It is the first cement to bond chemically to teeth</li> </ul>	<ul style="list-style-type: none"> <li>Also called as Polyalkenoate cements</li> <li>Acc to Philips: <ul style="list-style-type: none"> <li>Type I: Luting</li> <li>Type II: Restorative</li> <li>Type III: Liner &amp; Base</li> </ul> </li> </ul>
<i>Uses</i>	<ul style="list-style-type: none"> <li>Luting agent - restorations, orthodontic appliances</li> <li>Interim restoration, bases</li> </ul>	<ul style="list-style-type: none"> <li>As Permanent cement for restorations, FPD's, inlays &amp; onlays</li> <li>Orthodontic</li> <li>cementation. high strength base</li> </ul>	<ul style="list-style-type: none"> <li>Esthetic restorations, luting, core build up, lamination technique, orthodontic bracket placements</li> </ul>
<i>Composition</i>	<p><i>Powder</i></p> <p>ZnO (90%), MgO (8%), Oxides of bismuth, calcium, barium (0.2%), Silica</p>	<p><i>Powder</i></p> <p>ZnO (major), MgO/SnO (modifier), BiO, Alumina, SnF</p>	<p><i>Powder</i></p> <p>Silica (35-50%), Alumina (20-30%), Aluminium, calcium and sodium fluoride, Alpo4, Barium(traces)</p>

	<p><i>Liquid</i></p> <p>Phosphoric acid (38.2%), water (36%), Alumina (16%), Al &amp; Zn (buffers)</p>	<p><i>Liquid</i></p> <p>Polyacrylic acid (PAA), itaconic acid, tricarboxylic acid, maleic acid</p>	<p><i>Liquid</i></p> <p>Polyacrylic acid (45%), Itaconic acid, maleic acid, tricarboxylic acid, tartaric acid, water (50%)</p>
<i>Setting reaction</i>	$\text{ZnO} + \text{H}_3\text{PO}_4 \rightarrow \text{Zn}_3 (\text{PO}_4)_2$ <p>(Zn Al Phosphate gel) + <math>\text{H}_2\text{O}</math></p> <ul style="list-style-type: none"> <li>Water is the main component for this reaction</li> <li>W/P ratio: 1.4 gm/0.5 ml</li> <li>Manipulated on a cool glass slab to improve WT &amp; ST</li> </ul>	<p>PAA + Glass particles (via carboxyl group)</p> <p>↓</p> <p>Polycarboxylate cement</p>	<ul style="list-style-type: none"> <li><b>Decomposition</b> of glass in acids</li> <li><b>Release</b> of Ca, Fl, Al, Na ions</li> <li><b>Migration</b> of ions into aqueous stage of cement</li> <li><b>Gelation</b> of acid and the ions</li> <li><b>Hardening</b> for 24hrs with the cross link of ions in acid</li> <li><b>Maturation</b> after 24hrs</li> </ul>



## Modifications of Glass Ionomer Cement (GIC)

### 1. Metal Modified GIC

- Developed to improve the fracture toughness of GIC

#### Miracle mix

Mixture of silver amalgam alloys with Glass ionomer powder

**Disadvantage:** Inferior to the properties of amalgam

Adhesion is not strong with alloy particles

#### Cermet

Substituted by **Ag-Pd alloy** which allows chelation with polyacrylic acid

**Advantages:** Adhesion, anticariogenic, wear resistance

**Disadvantages:** Poor esthetics, discoloration of tooth, roughed surface, decreased working and setting time

**Indications:** Core build up, class I restorations, lining

**Contraindication:** Anterior teeth, High occlusal loading areas

Composition	Chemistry	Clinical applications	Advantages & Disadvantages
<ul style="list-style-type: none"> <li>Powder: Conventional powder and camphoroquinone for light or chemical activation</li> <li>Liquid of GIC is modified with methylmethacrylate and HEMA</li> </ul>	<ul style="list-style-type: none"> <li>Acid base reaction along with polymerization</li> <li>Rate of reaction is less because of reduced water content</li> </ul>	<ul style="list-style-type: none"> <li>Pit &amp; fissure sealants</li> <li>Class I, II, V restorations</li> <li>Core build ups</li> <li>Liners and bases</li> <li>Orthodontic bracket placements</li> </ul>	<ul style="list-style-type: none"> <li>Advantages: Improved WT, ST, Strength, adhesive property, anticariogenic, reduced sensitivity to water</li> <li>Disadvantages: Marginal leakage due to shrinkage</li> </ul>

## 2. Calcium Aluminate GIC

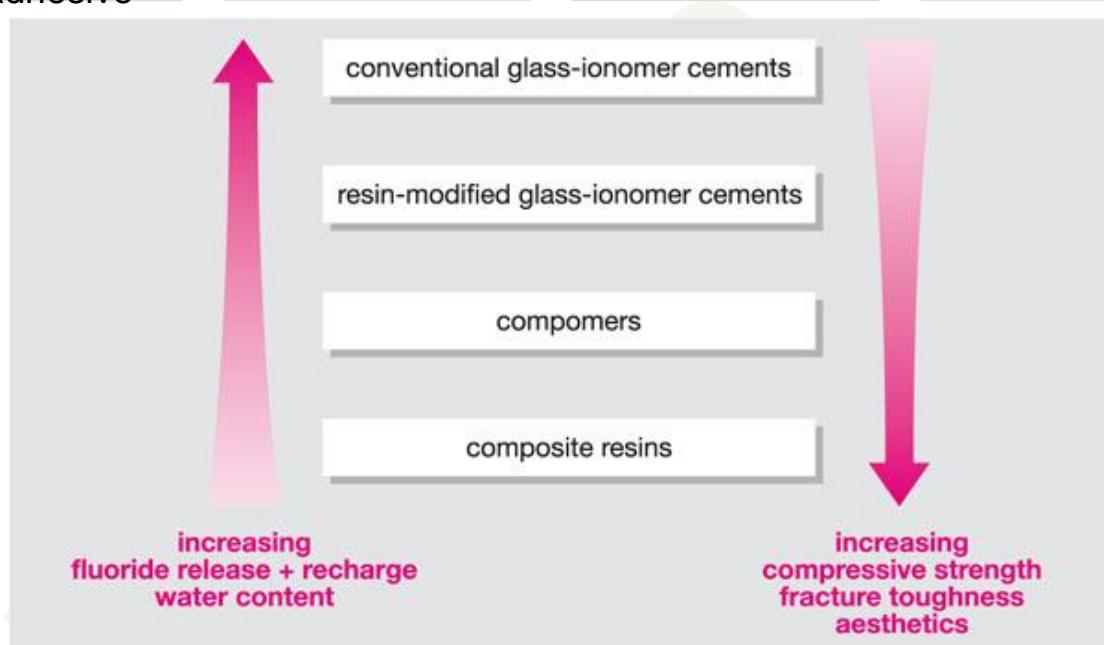
- It is a product of combination of GIC with calcium aluminate ( $\text{Al}_2\text{O}_3:\text{CaO} = 1:1$ )
- Used to lute fixed prostheses

Composition	Properties
<i>Powder</i> Calcium aluminate Tartaric acid Polyacrylic acid St - Fl - Al - glass	Working time - 2 Mins Setting time - 5 Mins Film thickness - 15 +/- 4 $\mu\text{m}$ Setting expansion - 0.4 %
<i>Liquid</i> Water (99.6%) Additives	

## 3. Compomer/ Polyacid Modified Composite Resin

- It is a modification of GIC into water free polyacrylic acid along with added initiators
- Developed to attain fluoride releasing capacity along with composite resin properties
- Uses
  1. Pit & fissure sealants
  2. Restorations for primary teeth, Class III, V lesions
  3. Core build ups
  4. Liners & bases
  5. Cervical abrasion
  6. Retrograde filling materials

Composition & Setting	Properties	Advantages	Contraindications
<ul style="list-style-type: none"> <li>Powder: St - Al - Fluorosilicate glass, Oxides of metals, Initiators</li> <li>Liquid: Methacrylates and water</li> <li>For restorations - need dentin bonding agent</li> <li>For luting - self adhesive</li> </ul>	<ul style="list-style-type: none"> <li>Micromechanical adhesion</li> <li>minimal fluoride release</li> <li>Properties: GIC &gt; Compomer &lt; Composite</li> </ul>	<ul style="list-style-type: none"> <li>Better adaptation to tooth</li> <li>Esthetics</li> <li>WT greater than RMGIC</li> </ul>	<ul style="list-style-type: none"> <li>Cannot be given for Class II, IV cavities</li> <li>Lost tooth surface areas</li> <li>As luting agent under Full coverage restorations</li> </ul>



## 7. Resin Cements

- They are flowable consistency composites with low viscosity used for Cementation of prosthesis, restoration, orthodontic brackets

**Classification:** consists of filled & unfilled matrix

- Class I: Self cure
- Class II: Dual cure
- Class III: Light cure

**Composition**

<i>Chemical cure</i>	<i>Dual cure</i>	<i>Light cure</i>
<b>Powder:</b> Resin (PMMA), Inorganic fillers <b>Liquid:</b> Methyl methacrylate, tertiary amines, organosilanes	<b>Base paste:</b> PMMA, fillers <b>Catalyst:</b> Methylmethacrylate, fillers, initiators	Available in one paste system with methyl methacrylate monomers like HEMA, 4META etc

**Advantages**

- Superior compressive and tensile strength
- Solubility is low
- Available in wide ranges of shades and translucencies

**Disadvantages**

- Severe reaction on exposure to pulp
- Film thickness is high
- Polymerization shrinkage causes marginal leakage
- No anticariogenic property, chemical bonding
- Less modulus of elasticity
- Technique is meticulous

**SELECTION OF LUTING AGENTS**

- Not all the cements have the ideal requirements of a luting agent, hence clinical failures are inevitable.
- This can be minimized by proper selection of luting agents and manipulation.
- Following factors should be kept under review
  - Uniform and reproducible
  - Thorough mixing of cement
  - Following isolation protocol and moisture contamination
  - Setting should be undisturbed
  - Removal of excess cement
  - Avoiding excessive dentin drying

**GENERALIZED INDICATIONS & CONTRAINDICATIONS**

Type of prosthesis	Type of luting cement				
	Zinc phosphate	Zinc Polycarboxylate	Glass Ionomer	RMGIC	Resin cement
All metal, PFM crown	✓	✓	✓	✓	✓
Pressed ceramic crown, ceramic inlay, veneer, RBB	✗	✗	✗	✗	✓
Patient with history of post treatment sensitivity	-	✓	-	-	✗
Fixed prosthesis with poor retention	✗	✗	✗	✗	✓
Cast post & core	✓	✗	✓	✓	✓

**GENERALIZED PROPERTIES**

MATERIAL	FILM THICKNESS (MM)	SETTING TIME (MIN)	SOLUBILITY (WT%)	STRENGTH (MPa)		MODULUS OF ELASTICITY (GPa)
				COMPRESSIVE	TENSILE	
Zinc phosphate	25–35	5–14	0.2 max	80–100	5–7	13
Zinc oxide–eugenol						
Unmodified	25–35	2–10	1.5	2–25	1–2	—
Polymer reinforced	35–45	7–9	1	35–55	5–8	2–3
EBA-alumina	40–60	7–13	1	55–70	3–6	3–6
Zinc polycarboxylate	20–25	6–9	0.06	55–85	8–12	5–6
Glass ionomer	25–35	6–9	1	90–140	6–7	7–8
Polymer based	20–60	3–7	0.05	70–200	25–40	4–6

**CONCLUSION**

- Modern day dentistry can no longer provide effective function with conventional water based luting agents which have become diversified due to the invention of adhesion.
- Each cement has different physical, chemical and biological feature.
- To achieve clinical success, it is expected to be aware of all the luting agents available in the field of dentistry.

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**Please Give Your Feedback on this Answer**

**Q. 18: Role of adhesives in maxillofacial prosthodontics (6M)**

**CONTENTS/SYNOPSIS**

Introduction

Retention

Types of retention of maxillofacial prosthesis

Adhesives

- Definition
- Ideal properties of adhesives
- Selection criteria
- Classification of adhesives
  - Medical adhesives based on their use
  - Based on adhesive systems
- Types of adhesives
  - Pressure sensitive tape
  - Silicone adhesives
  - Acrylic resins
- Limitations of adhesives
- Advantages and disadvantages

Conclusion

References

## INTRODUCTION

- Maxillofacial defects can be either congenital or acquired which can be treated with a combination of surgery and prosthetics.
- The aim of prosthodontic rehabilitation is to provide
  - Aesthetic appearance
  - Maintain the difference between the soft and hard tissue continuity
  - Compensate the loss of tissue
  - Psychological positivity
- Prosthodontic rehabilitation of these defects deals with replacement of any part that is either congenitally missing or has been lost due to trauma, infection, surgical resection.
- Factors affecting the success of rehabilitation are aesthetics and retention of the prosthesis.

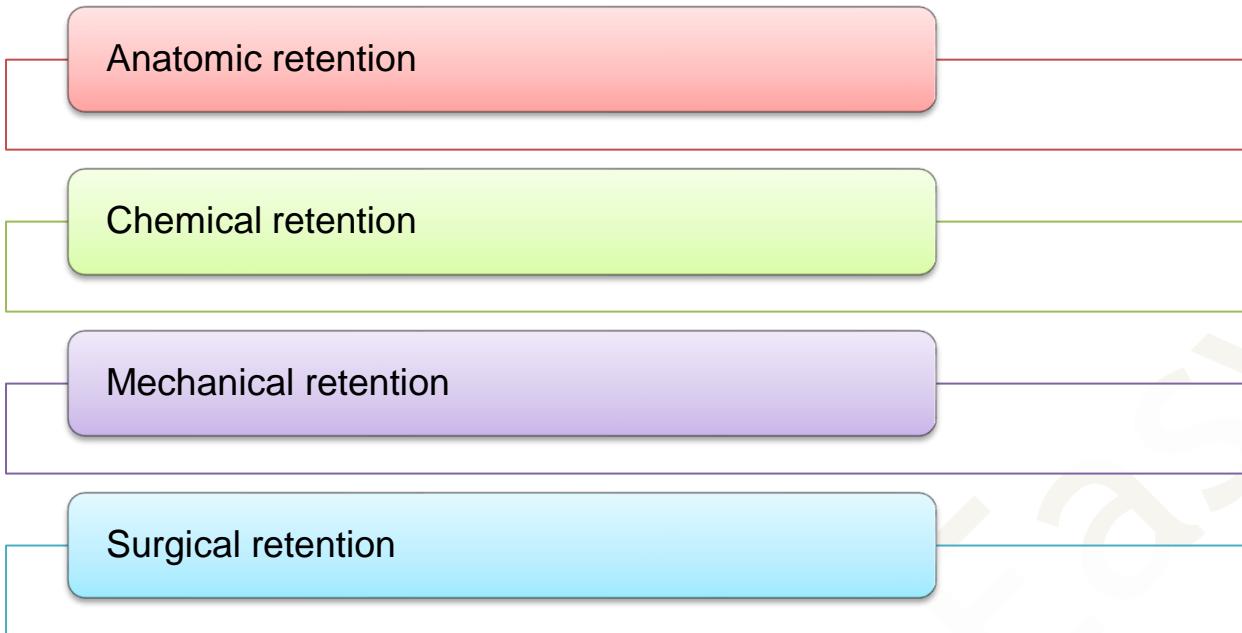
## RETENTION

### Definition

According to GPT 9 (The Glossary of Prosthodontic Terms), retention is defined as that quality inherent in the dental prosthesis acting to resist the forces of dislodgement along the path of placement

### Types of retention in Maxillofacial prosthesis

- Based on the health of adjacent anatomical tissue, size and shape of the defect, age of the patient, systemic condition of the patient the type of retention is selected.



## ADHESIVES

- Chemical retention is achieved by adhesives.
- Adhesives are the most popular form of retention in the field of maxillofacial prostheses.

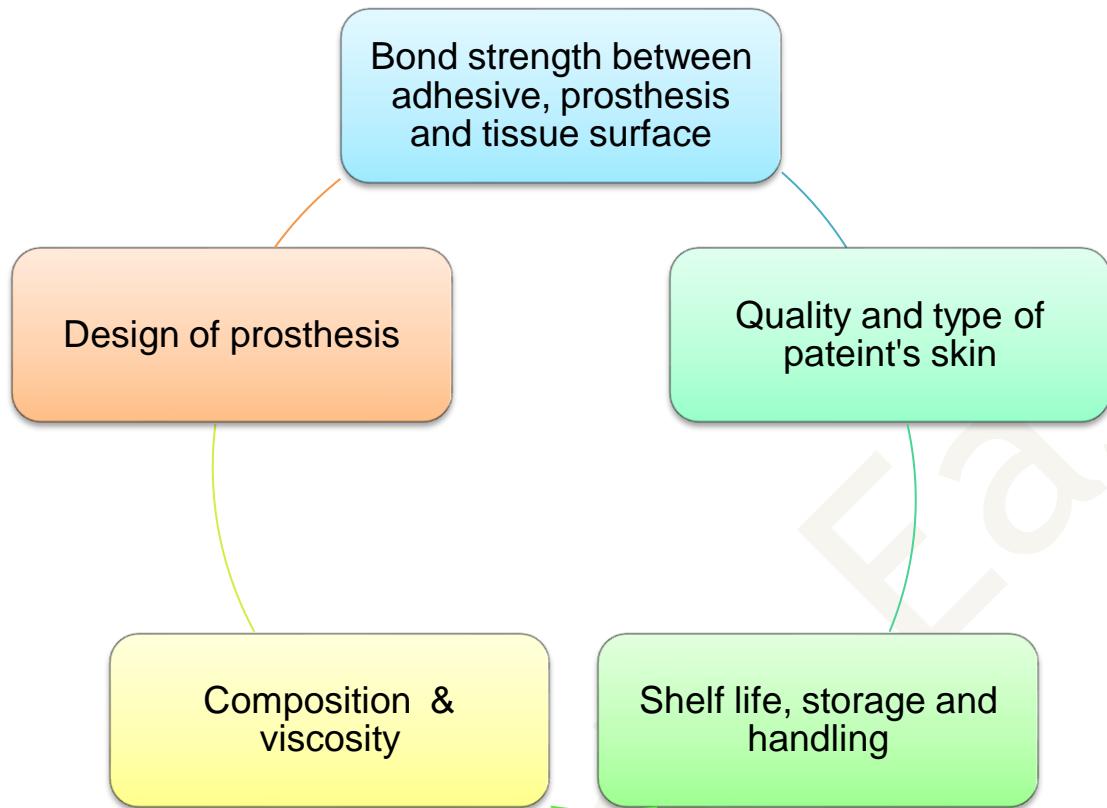
### Definition

According to GPT 9, "maxillofacial prosthetic adhesive is defined as a material used to adhere external prosthesis to the skin and associated structures around the periphery of an external anatomic defect."

### Ideal properties of an adhesive should be

1. Biocompatible, nontoxic and non-irritant
2. Odorless
3. Resistant to moisture
4. Have porosity to allow discharge of secretions
5. Ease on application
6. Should be in place for a minimum of 12 hours
7. Should not harm skin
8. Dry quickly

## Selection Criteria



## Classification of Adhesives

### 1. Medical adhesives based on their use

- Double side tap
- Sprayers
- Glue
- Pastes
- Liquid systems

### 2. Based on adhesive systems

- Rubber based adhesives (natural & latex)
- Silicone adhesives
- Acrylic resins (cyanoacrylate)
- Pressure sensitive tapes

## 1. Pressure Sensitive Tape

- Available as double coated polyethylene and 3M surgical tape in the form of backing strips.
- Comprises of clothe, film, foil, paper with a pressure sensitive adhesive.
- They are applied onto the tissues with finger pressure

Indications	Advantages	Disadvantages
1. Used when the material has poor flexibility. 2. Tissue beds are non mobile	1. Ease of application 2. Ability to clean after removal	1. Weaker bond 2. Recommended to use with liquid adhesive to increase the bond strength

## 2. Silicone Adhesives

- These are a form of RTV silicones dissolved in solvent
- After application, the solvent evaporates leaving a sticky surface to bond with prosthesis material
- Example: Secure medical adhesive

Advantages	Disadvantage
1. Good resistance to moisture 2. Low water sorption	1. Low adhesive strength

## 3. Acrylic Resins

- Available as resins dispersed in water solvent which on application evaporates, leaving a rubber like material.
- Can be easily removed from surface of prosthetic material
- Example: Epithane 3, Pros Aide

## Limitations of Adhesive

1. Patients with poor dexterity cannot apply adhesives and place the prosthesis into proper position
2. Margins adjacent to mobile tissue needs constant reattachment during facial movements
3. Curling of thin prosthetic margins may occur due to base adhesives
4. Some patients may have allergic responses to adhesives
5. Poor hygiene maintainence may interfere with adhesive quality
6. Routine cleaning and removal of adhesives may cause deterioration of external pigments

Advantages	Disadvantages
1. Cost effective 2. Easy to manipulate 3. Ease of application 4. Advised for patients who are not willing for implant supported prosthesis	1. Few adhesives require solvents to clean 2. Retention cannot be quantified 3. Its degradation leads to irritation, compromising the bond on movements, perspiration.

## CONCLUSION

- Adhesives used for the facial prosthesis are easily accepted by patients because of its cost effectiveness and ease of manipulation with limited side effects.
- Proper instructions to the patients about its use and hygiene maintainence, decreases the risk of skin disorders and allows the tissue to rest.

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**Please Give Your Feedback on this Answer**

**Q. 17: Setting expansion of gypsum products (20M)**

**CONTENTS/SYNOPSIS**

Introduction

Types of gypsum products

Setting of gypsum products

Setting reaction

- Theories of setting reaction
  - Colloidal Theory
  - Hydration Theory
  - Dissolution Precipitation Theory
- Factors affecting the setting reaction

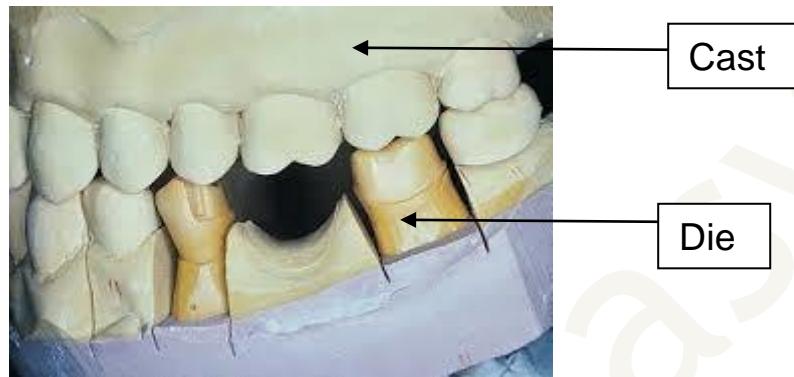
Setting expansion

- Normal setting expansion
  - Factors affecting
- Hygroscopic setting expansion
  - Stages of hygroscopic expansion
    - Initial mix
    - Initial crystal growth
    - Solid contact phase
    - Expansion
    - Termination
- Control of setting expansion
  - Use of additives
  - Water powder ratio

References

## INTRODUCTION

- Gypsum is a naturally occurring, white powdery mineral with the chemical name Calcium Sulphate Dihydrate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ )
- Their main use in dentistry are to make casts or models, dies and investments



## TYPES OF GYPSUM PRODUCTS (ADA Sp. No 25)

Type	Name	Use
Type 1	Dental Impression plaster (Non-elastic impression material)	Primary Impression in CD patients (rarely used now)
Type 2	Dental Plaster, Model	To fill a flask in denture construction
Type 3	Dental Stone(Class I stone or Hydrocal)	For casts used to process dentures
Type 4	Die stone with High strength and Low expansion (Class II stone, Densite)	Die preparation
Type 5	Dental Stone, Die, High Strength, High Expansion	Production of dies for inlays

## SETTING OF GYPSUM PRODUCTS

### Setting Reactions



**Induction period** is the initial reaction with little or no rise in temperature



Thickening of mix into semi fluid consistency



Hardening of the gypsum mix into needle like crystals called **Spherulites**

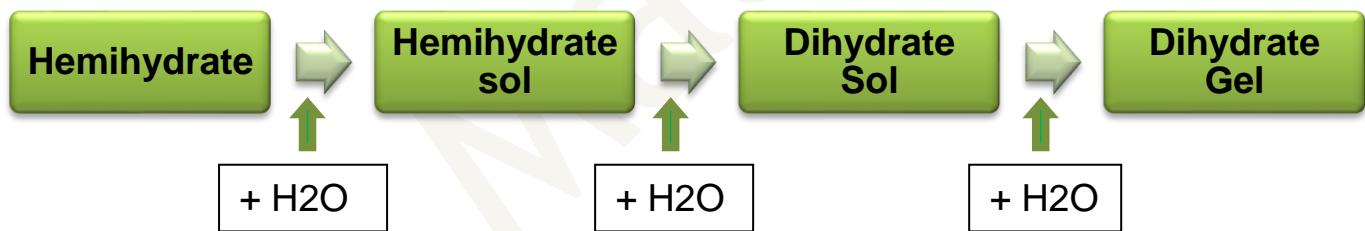


Network of gypsum crystals forms a solid structure

## Theories of Setting Reaction

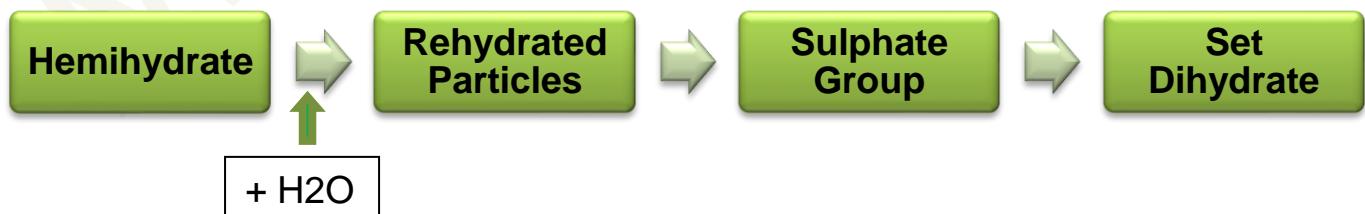
### 1. Colloidal Theory

- Plaster on mixing with water achieves a colloidal state due to sol gel action.



### 2. Hydration Theory

- Rehydrated plaster particles join through hydrogen bonding to the sulphate groups to form the set material.



### 3. Dissolution Precipitation Theory

- Commonly accepted theory.
- Based on dissolution of plaster and instant recrystallization of gypsum, followed by interlocking of the crystals to form the set solid.

### FACTORS AFFECTING

#### Effect of Temperature on setting reaction

- Change in temperature affects the change in solubility of hemihydrate and dihydrate
 

$\downarrow$  Solubility ratio  $\longrightarrow$   $\downarrow$  Setting reaction &  $\uparrow$  Setting time
- Change in ion mobility



### SETTING EXPANSION

- On setting all gypsum products expand externally
- Occurs due to outward growth of growth of crystals from nuclei.
- Ranges between 0.06 - 0.5 %

Type	Setting Time (min)	Setting Expansion Range (%)
1. Impression plaster	2.5–5.0	0–0.15
2. Model plaster	$\pm 20\%$ <sup>a</sup>	0–0.30
3. Dental stone	$\pm 20\%$	0–0.20
4. High-strength/ low-expansion dental stone	$\pm 20\%$	0–0.15
5. High-strength/ high-expansion dental stone	$\pm 20\%$	0.16–0.30

- Theoretically, setting contraction can be measured, but the continuous growth of the gypsum crystals may push against each other and cause an outward thrust which causes an external expansion leading to internal porosity after set.

- A minimum setting expansion is required to achieve accurate dimensional accuracy.
- It is of two types

## 1. Normal Setting Expansion

- Refers to setting expansion when mixed with water and allowed to "set" in air (expansion when exposed to dry environment)

### Factors Effecting Setting Expansion

#### Mechanical mixing

- Decreases setting expansion (Power mixing appears to cause a greater initial volumetric contraction than is observed for hand mixing)

#### W/P ratio an increase

- Reducing the setting expansion

#### Addition of sodium chloride (NaCl) in a small concentration

- Increases the setting expansion of the mass and shortens the setting time

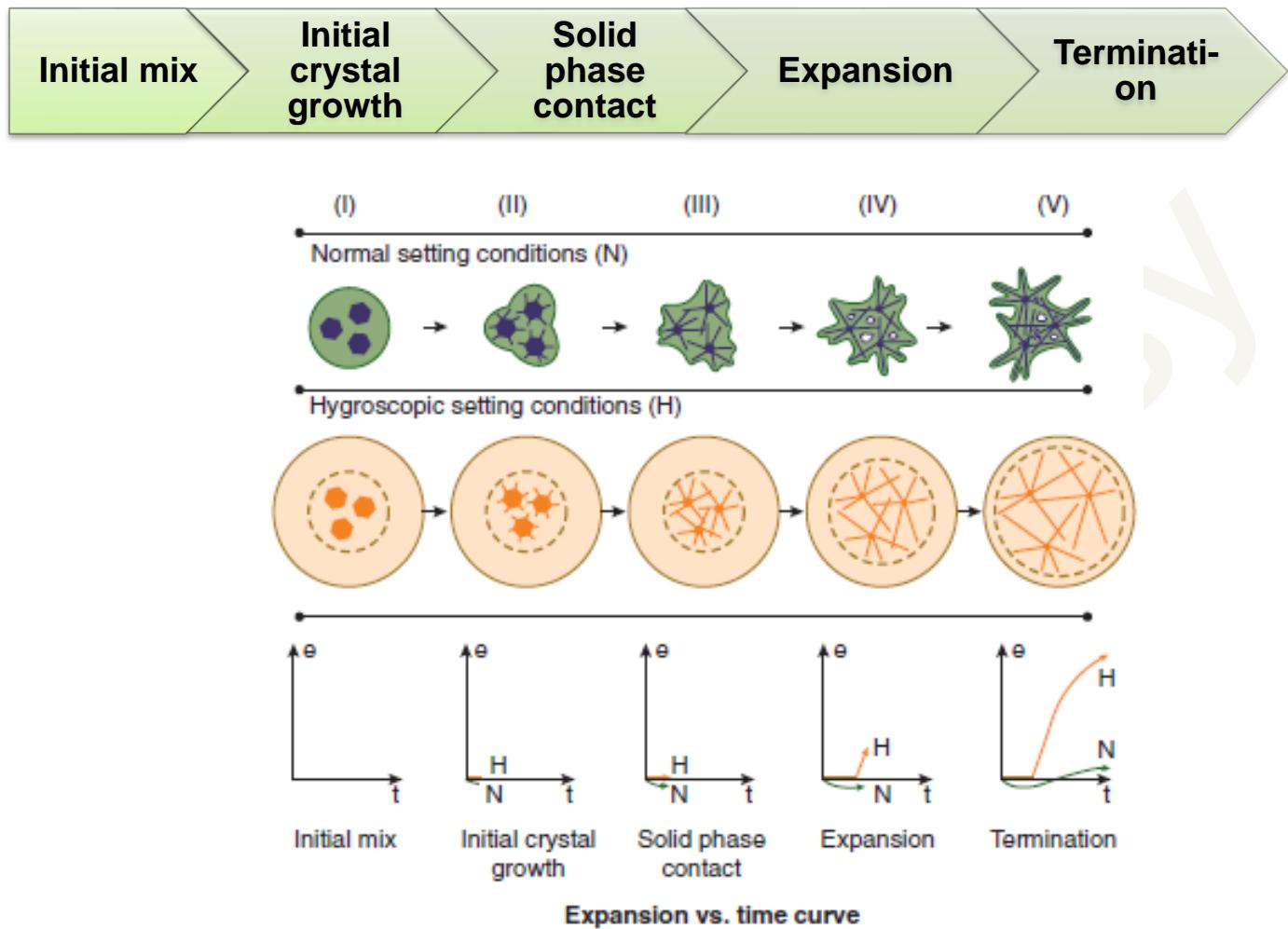
#### Addition of 1% potassium sulfate

- Decreases the setting time but has no effect on the setting expansion

## 2. Hygroscopic Setting Expansion

- When additional water is brought into contact with the setting material, an increased expansion is observed called as "hygroscopic expansion"
- The setting expansion of dental gypsum products is physically contained in its liquid phase by forces of surface tension.
- The full expansion potential is understood only when enough water is brought into contact (full hygroscopic condition), allowing an outward crystal growth into added volume with non-build-up of forces of surface tension

## Stages of Hygroscopic Expansion



## Control of Setting Expansion

### 1. Use of additives

- To achieve a minimal setting expansion, accelerators and retarders are added to the gypsum products which controls setting expansion and setting time.

Accelerators

- Potassium sulphate
- Borax

Retarders

- Potassium sodium tartarate
- Sodium citrate

## 2. Water powder ratio

- Reduction in water leads to effective interaction of crystal growth, thus increasing setting expansion

Setting expansion  $\propto$  1/ Water powder ratio

- Because of their decreased water requirement, dental stone and die stone have higher setting expansion in normal mix when compared to plaster

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*Please Give Your Feedback on this Answer*

**Write in detail about anaphylactic shock and its management (20M).**

## CONTENTS/SYNOPSIS

- Introduction
- Peak action time
- Mediated by
- Etiology
- Pathogenesis
  - Components of type I reactions
  - First contact
  - Second contact
  - Mediators of Type I hypersensitivity
- Types of anaphylaxis
  - Localized hypersensitivity
    - Rhinitis
    - Asthma
  - Systemic anaphylaxis
- Clinical features
- Diagnostic tests
- Treatment
- Management of anaphylaxis in dental practice
- References

## INTRODUCTION

- It is an acute multisystem severe type 1 hypersensitivity reaction
- It is an exaggerated or inappropriate state of rapidly developing immune response in a previously sensitized person
- It is also known as atopic
- It is also known as immediate hypersensitivity reaction

### I. Peak action time

- Reaction appears within 15-30 minutes
- Rapid action time makes it a life threatening medical emergency.

### II. Mediated by

- Humoral antibodies IgE type or regain antibodies
- Type I reaction includes participation by B lymphocytes and plasma cells, mast cells and basophils, neutrophils and eosinophils

### III. Etiology:

- Genetic basis
- Environmental pollutants: Exhibits increased mucosal permeability & hence allows the entry of allergen into the body
- Raised IgE level
- Concomitant factors like viral infection of respiratory tract

### IV. Pathogenesis

- Types of anaphylaxis
  - True anaphylaxis or IgE mediated
  - Pseudo anaphylaxis or Anaphylactic reaction
- A type I hypersensitivity reaction is induced by a certain types of antigens referred to as allergens
- An allergen induces humoral antibody like a normal human response by the same mechanisms of soluble antigens, leading to antibody secreting plasma cells and memory cells

IgE molecules bind to the surface receptors of mast cells and basophils

Shocking dose

Antigen combines with cell bound IgE

Cross linking between adjacent antibody molecules

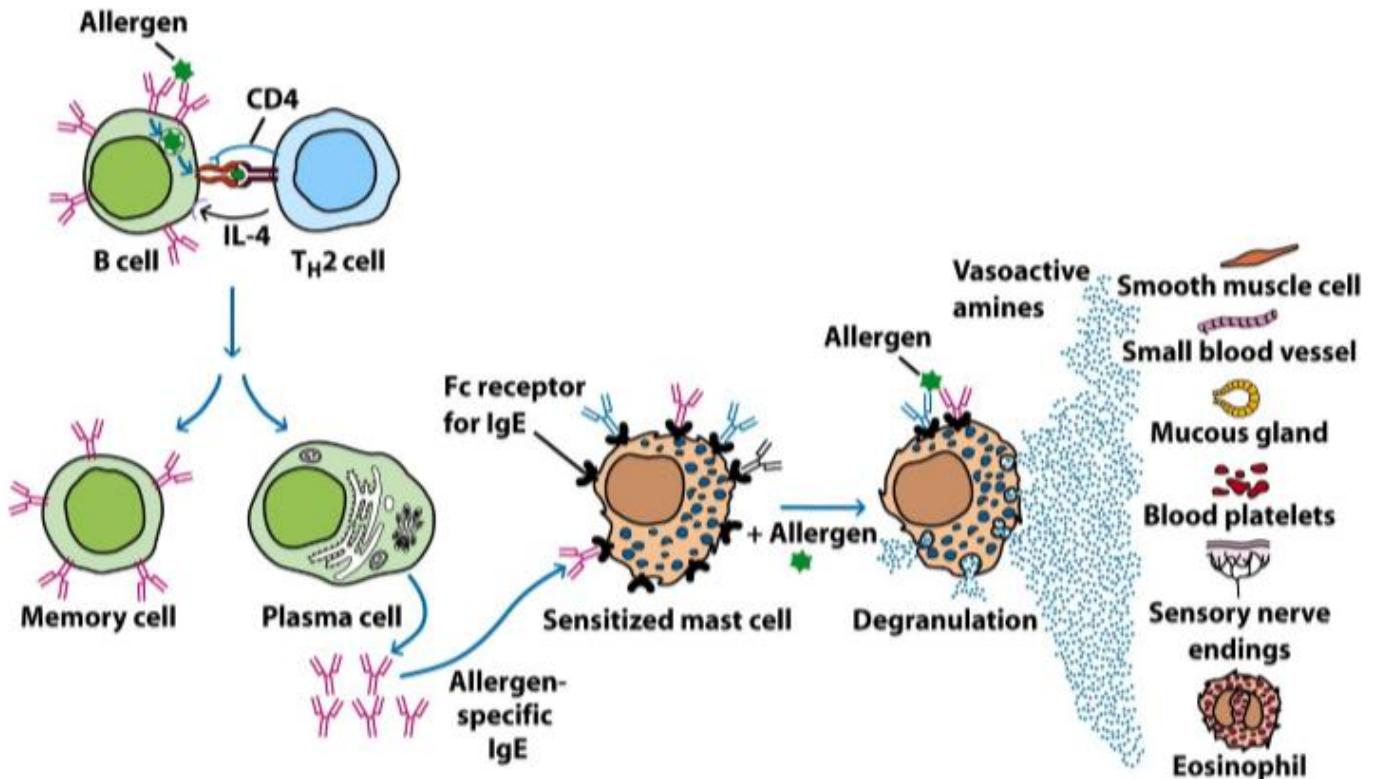
Increased permeability of cells to calcium ions

Degranulation

Release of inflammatory mediators

### Components of type I reactions

- Allergens
- IgE
- Mast cells and basophils



### 1. First contact

- During the first contact of the host with the antigen, sensitisation takes place.
- In response to initial contact with antigen, circulating B lymphocytes get activated and
- differentiate to form IgE-secreting plasma cells.
- IgE antibodies so formed bind to the Fc receptors present in plenty on the surface of mast cells and basophils, which are the main effector cells of type I reaction.
- Thus, these cells are now fully sensitised for the next event.

### 2. Second contact

- During the second contact with the same antigen, IgE antibodies on the surface of mast cells-basophils are so firmly bound to Fc receptors that it sets in cell damage, membrane lysis, influx of sodium and water and degranulation of mast cells-basophils.
- The released granules contain important chemicals and enzymes with pro inflammatory properties— histamine, serotonin, vasoactive intestinal peptide (VIP), chemotactic factors
- of anaphylaxis for neutrophils and eosinophils, leukotrienes B4 and D4, prostaglandins thromboxane A2, prostaglandin D2 and E2) and platelet activating factor.

- The effects of these agents are:
  - Increased vascular permeability;
  - Smooth muscle contraction;
  - Early vasoconstriction followed by vasodilatation;
  - Shock;
  - Increased gastric secretion;
  - Increased nasal and lacrimal secretions; and
  - Increased migration of eosinophils and neutrophils at the site of local injury as well as their rise in blood (eosinophilia and neutrophilia).

### **Mediators of Type I**

- Histamine
- Cytokines TNF- $\alpha$ , IL-1, IL-6
- Chemoattractants for Neutrophils and Eosinophils
- Enzymes tryptase, chymase, cathepsin
- Changes in connective tissue matrix, tissue breakdown
- Leukotrienes
- Prostaglandins

## **V. Types of anaphylaxis**

<b>1. Localized hypersensitivity</b>	<b>2. Systemic anaphylaxis</b>
<ul style="list-style-type: none"> <li>• Reaction is limited to a specific target tissue or organ, involving epithelial surfaces at the site of allergen entry</li> <li>• The tendency to manifest localized anaphylactic reactions is inherited and is called <u>atopy</u></li> </ul>	<ul style="list-style-type: none"> <li>• It is a shock like and often fatal</li> <li>• Causes: insect bites, stings, food, medications</li> <li>• Onset occurs within minutes of a type I hypersensitive reaction</li> <li>• Drug of choice: Epinephrine</li> </ul>

### **Clinical features of Localized hypersensitivity**

#### **1. Allergic rhinitis**

- Most common atopic disorder
- Also known as hay fever

<b>i. Causes</b>	<ul style="list-style-type: none"> <li>• Airborne allergens with sensitized mast cells in the conjunctivae and nasal mucosa to induce the release of pharmacologically active mediators from mast cells</li> </ul>
<b>ii. Symptoms</b>	<ul style="list-style-type: none"> <li>• Watery exudate from conjunctivae, nasal mucosa, upper</li> </ul>

respiratory tract, sneezing &amp; coughing

**2. Asthma**

- It is a respiratory condition with attacks of spasms in the bronchi of the lungs, causing difficulty in breathing
- Usually connected to allergic reactions

<i>i. Causes</i>	<ul style="list-style-type: none"> <li>• Airborne or food borne allergens like pollens, insect products, viral antigens, asthmatic attack triggers</li> </ul>
<i>ii. Symptoms</i>	<ul style="list-style-type: none"> <li>• Cough at night</li> <li>• Wheezing</li> <li>• Shortness of breath</li> <li>• Tightness of chest, pain and pressure</li> </ul>

**Clinical features of anaphylaxis**

<b>1. Skin and mucosal</b>	<ul style="list-style-type: none"> <li>• Flushing</li> <li>• Angiodema of the eyelids, lips, uvula, glottis, tongue</li> <li>• Tearing or itching of eyes</li> <li>• Pruritis</li> <li>• Urticaria</li> </ul>
<b>2. Respiratory</b>	<ul style="list-style-type: none"> <li>• Upper airway angioedema</li> <li>• Persistent cough</li> <li>• Stridor</li> <li>• Wheezing</li> <li>• Sensation of throat</li> <li>• Closure of choking</li> <li>• Shortness of breath</li> <li>• Nasal discharge</li> <li>• Congestion</li> </ul>
<b>3. Gastrointestinal</b>	<ul style="list-style-type: none"> <li>• Nausea</li> <li>• Diarrhoea</li> <li>• Abdominal pain with cramps</li> <li>• Vomiting</li> </ul>
<b>4. Cardiovascular</b>	<ul style="list-style-type: none"> <li>• Hypotension</li> </ul>

	<ul style="list-style-type: none"> <li>• Dizziness</li> <li>• Arrhythmia</li> <li>• Syncope</li> <li>• Tachycardia</li> <li>• Bradycardia</li> <li>• Pale and floppy (young children)</li> </ul>
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## VI. Diagnostic tests for immediate hypersensitivity reaction

- Skin (prick and intradermal) tests
- Measurement of total IgE and specific IgE antibodies against the suspected allergens
  - Total IgE and specific IgE antibodies are measured by a modification of enzyme immunoassay (ELISA)
  - Increased IgE levels are indicative of an atopic condition, although IgE may be elevated in some non-atopic diseases (e.g., myelomas, helminthic infection, etc.)

## VII. Treatment

### Drugs

#### i. Primary treatment

- IV fluids (25-50ml/kg of crystalloids)
- Epinephrine IM (1:1000)
- Epinephrine IV (1:10000) - for severe bronchospasm or hypotension

#### ii. Secondary treatment

- Bronchodilators ( $\beta_2$  agonist): Albuterol (90 $\mu$ mg)
- H<sub>1</sub> Blockers (antihistamine): Diphenhydramine (IV 0.5mg/kg)
- Optional H<sub>2</sub> Blocker: Famotidine (20mg IV)
- Steroids: Hydrocortisone (1 - 2.5 mg/kg)
- Methylprednisolone (1mg/kg)

### Immunotherapy

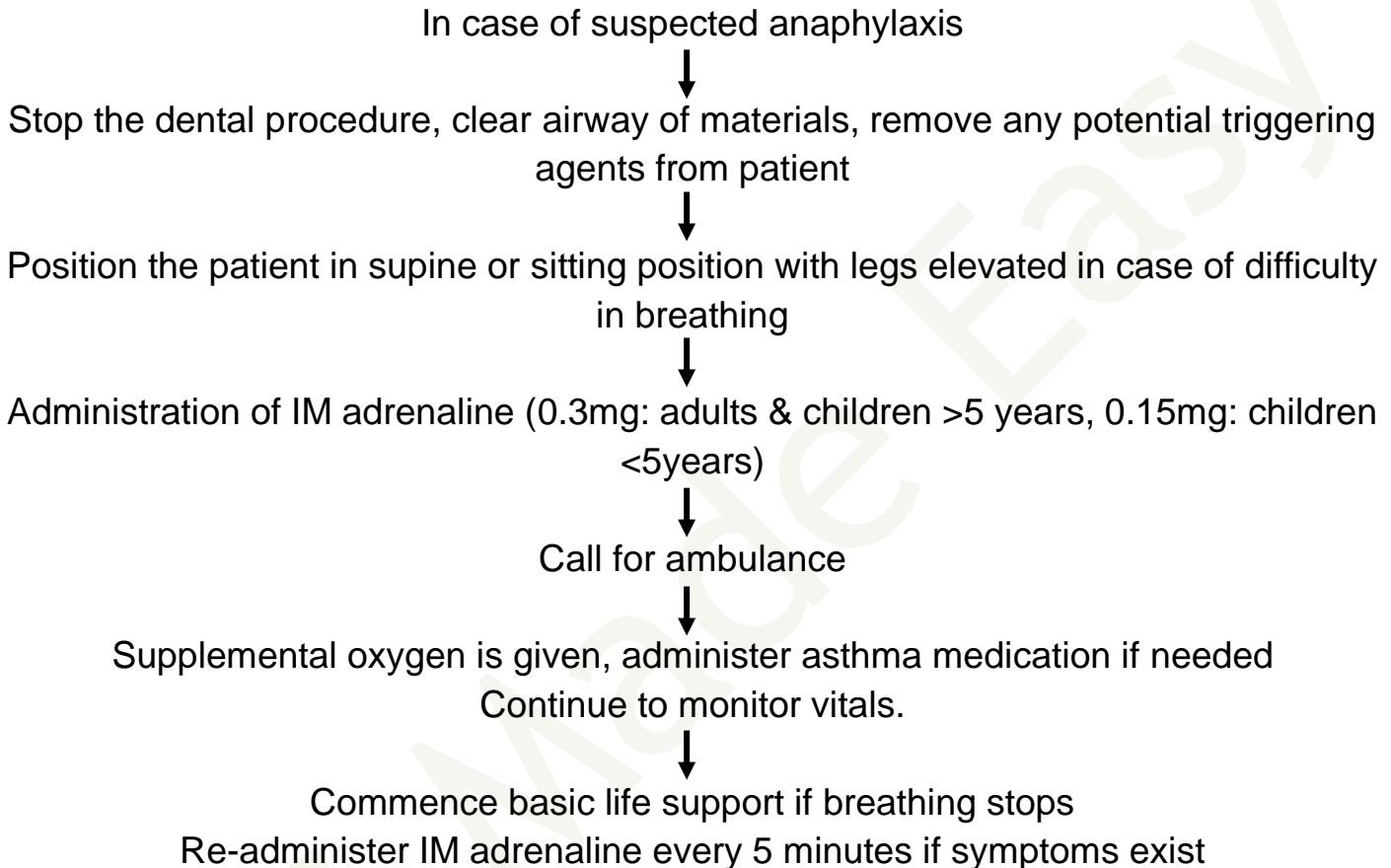
- Desensitization (hypo sensitization) also known as allergy shots
- Repeated injections of allergen to reduce the IgE on Mast cells and produce IgG

## VIII. Management of anaphylaxis in dental practice

- According to Australian resuscitation protocols

Evaluation of airway, breathing, circulation and consciousness

Review of cutaneous and gastrointestinal system for signs and symptoms of anaphylaxis



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4. Waibel KH. Anaphylaxis. *Pediatr Rev*. 2008;29(8):255-263. doi:10.1542/pir.29-8-255
5. Gruchalla R, Pirmohamed M. Antibiotic Allergy NEJM Feb 9, 2006
6. Ralston SH, Penman ID, Strachan M and Hobson R. *Davidson's Principles and Practice of Medicine*, 23rd Edition. Churchill Livingstone: Elsevier health science, 2018

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Please Give Your Feedback on this Answer

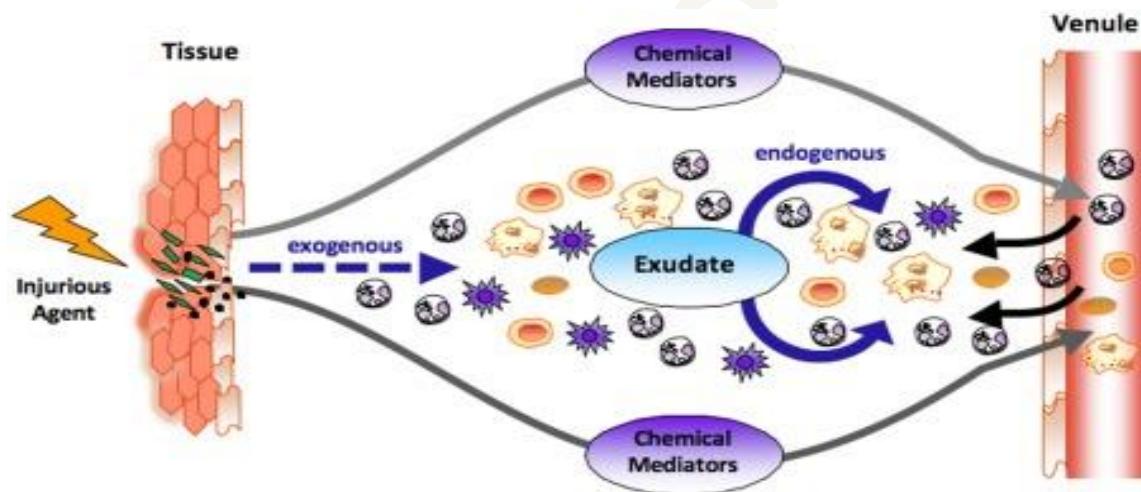
**Chemical mediators of inflammation (6M)****CONTENTS/SYNOPSIS**

- Chemical mediators of inflammation
- Classification of chemical mediators
  - Cell-derived mediators
  - Plasma-derived mediators (plasma proteases)
- Types of chemical mediators
  - Vasoactive Amines
    - Histamine
    - Serotonin
  - Plasma Proteases
    - The complement system
    - Kinin system
    - Clotting system
    - Fibrinolytic system
  - Arachidonic Acid Metabolites
  - Platelet activating factor (PAF)
- References

## CHEMICAL MEDIATORS OF INFLAMMATION

### General principles

- Mediators are the substances that initiate and regulate inflammatory reactions
- Derived from either plasma or cells
- Production of active mediators is stimulated by microbial products or by host proteins
- Perform their biologic activity by initially binding to specific receptors on target cells
- One mediator can stimulate the release of other mediators by target cells themselves
- Mediators can act on one or few target cell types
- Once activated and released from the cell, most of these mediators are short-lived
- Most mediators have the potential to cause harmful effects



## CLASSIFICATION OF CHEMICAL MEDIATORS

### I. Cell-derived mediators

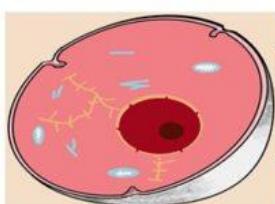
<b>1. Vasoactive amines</b>	<ul style="list-style-type: none"> <li>Histamine, 5-hydroxytryptamine, neuropeptides</li> </ul>
<b>2. Arachidonic acid metabolites (Eicosanoids)</b>	<p>Metabolites via cyclo-oxygenase pathway</p> <ul style="list-style-type: none"> <li>Prostaglandins, thromboxane A<sub>2</sub>, prostacyclins, resolvins</li> </ul> <p>Metabolites via lipo-oxygenase pathway</p> <ul style="list-style-type: none"> <li>5-HETE, leukotrienes, lipoxins</li> </ul>
<b>3. Lysosomal components</b>	<ul style="list-style-type: none"> <li>from PMNs, macrophages</li> </ul>

<b>4. Platelet activating factor</b>	
<b>5. Cytokines</b>	<ul style="list-style-type: none"> <li>IL-1, TNF-<math>\alpha</math>, TNF-<math>\beta</math>, IFN-<math>\gamma</math>, chemokines</li> </ul>
<b>6. Free radicals</b>	<ul style="list-style-type: none"> <li>Oxygen metabolites, nitric oxide</li> </ul>

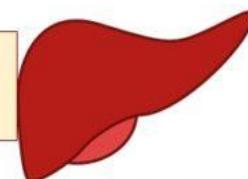
## II. Plasma-derived mediators (plasma proteases)

- Products of:
  - The kinin system
  - The clotting system
  - The fibrinolytic system
  - The complement system

### TYPES OF CHEMICAL MEDIATORS



#### CHEMICAL MEDIATORS OF INFLAMMATION



##### Cell - Derived

###### Preformed

- Histamine
- Serotonin

###### Synthesised de novo

- Arachidonic acid metabolites
- Platelet activating factor
- NO
- Reactive oxygen species
- Cytokines
- Chemokines

##### Plasma - Derived

###### Compliment activation

- C3a
- C3b
- C5a

###### Factor XII activation

- Coagulation system
- Kinin system

## I. Vasoactive Amines

### 1. Histamine

- Released from mast cells, basophils and platelets
- Stimuli: Physical injury such as trauma, cold, or heat
- Immune reactions involving binding of antibodies to mast cells
- Fragments of complement called anaphylatoxins (C3a and C5a)

- Histamine-releasing proteins derived from leukocytes, and neuropeptides
- (e.g. substance P)
- Cytokines like IL-1, IL-8

### *Actions*

- In humans, histamine causes dilation of the arterioles and increases the permeability of venules
- It is the principal mediator of the immediate transient phase of increased vascular permeability that causes venular gaps
- Itching & pain mediator

## **2. Serotonin**

- Released by platelets and enterochromaffin cells
- Released when platelets aggregate after contact with collagen, thrombin, adenosine diphosphate (ADP) and antigen-antibody complexes
- Increases the vascular permeability

## **II. Plasma Proteases**

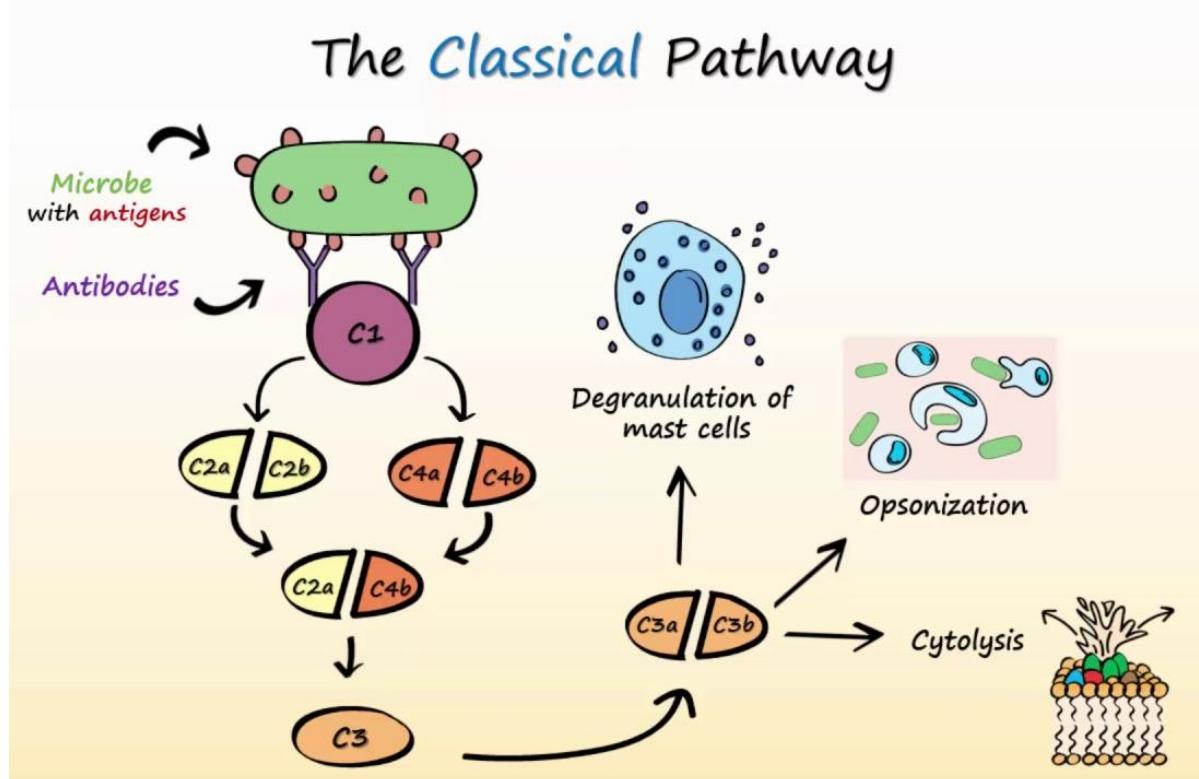
- Plasma proteins that belong to four interrelated systems:
  - The complement system
  - Kinin system
  - Clotting system
  - Fibrinolytic system

### **1. Complement system**

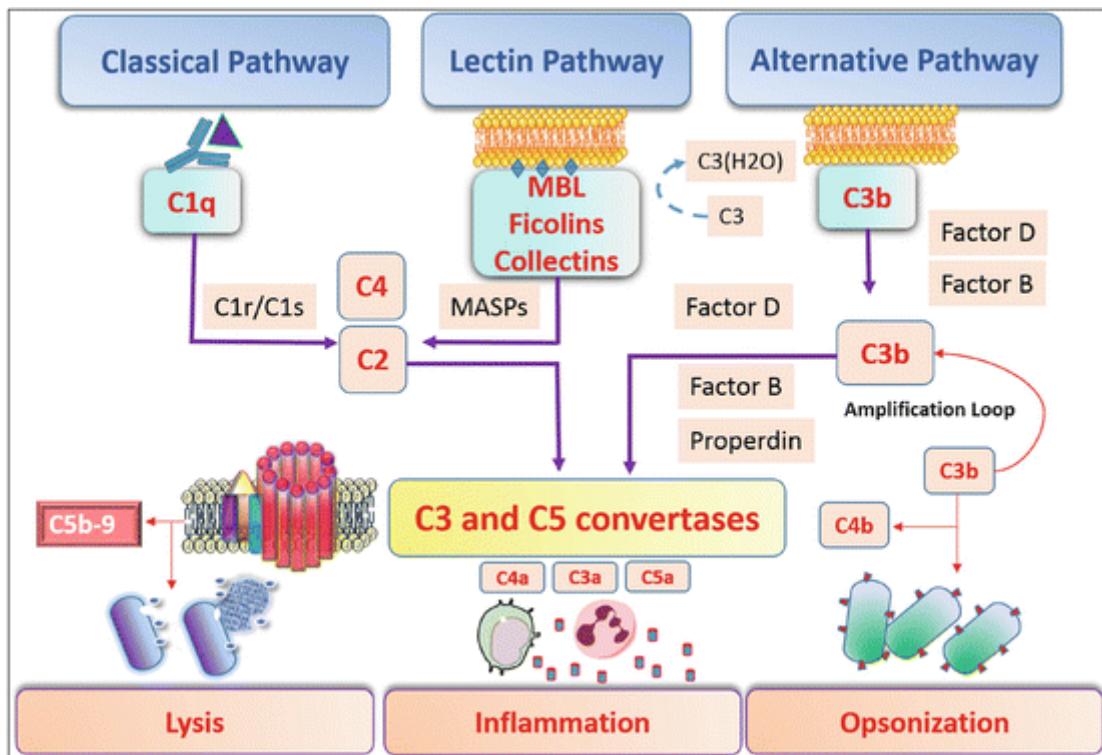
- It consists of 20 component proteins and their cleavage products
- Found in greatest concentration in plasma
- This system functions in both innate and adaptive immunity for defense against microbial agents
- C3 and C5 are the most important inflammatory mediator
- There are 3 pathways :

#### *i. The classical pathway*

- It is an antibody dependent pathway triggered by fixation of C1 to antibody (IgM or IgG) combined with antigen and proteolysis of C2 and C4
- Subsequent formation of a C4b2b complex that functions as a C3 convertase.



<p><i>ii. The alternative pathway</i></p>	<ul style="list-style-type: none"> <li>Antibody independent pathway stimulated by antigen directly</li> <li>Triggered by microbial surface molecules (e.g., endotoxin, or LPS), complex polysaccharides, and cobra venom</li> <li>Involves a distinct set of plasma components (properdin, and factors B and D)</li> <li>In this pathway, the spontaneous cleavage of C3 that take place usually is enhanced and stabilized by a complex of C3b and a breakdown product of Factor B called Bb</li> <li>The C3bBb complex is a C3 convertase</li> </ul>
<p><i>iii. The lectin pathway</i></p>	<ul style="list-style-type: none"> <li>Antibody independent similar to classical pathway</li> <li>In this pathway, plasma mannose-binding lectin binds to carbohydrates on microbes</li> <li>This directly activates C1</li> <li>This mannose-binding lectin, a plasma collectin, attaches to carbohydrate-containing proteins on bacteria and viruses and directly stimulates C1</li> </ul>



### Actions

- Vascular phenomena
- Anaphylatoxins (C3a, C5a): increase vascular permeability & vasodilation
- C5a also activates the lipoxygenase pathway of arachidonic acid (AA) metabolism
- Leukocyte adhesion, chemotaxis and activation
- C5a is a powerful chemotactic agent for neutrophils, monocytes, eosinophils and basophils
- Phagocytosis: C3b-opsonin

### 2. Kinin system

- These are hormones activated by noxious stimuli which participates in tissue defense and repair
- The kinins are peptides of 9 - 11 amino acids produced from plasma proteins called kininogens, by specific proteases called kallikreins
- Once, the Kinin system activated, it results in the release of the vasoactive nonapeptide bradykinin

### Actions

- Bradykinin
- Increases vascular permeability
- Smooth muscle contraction

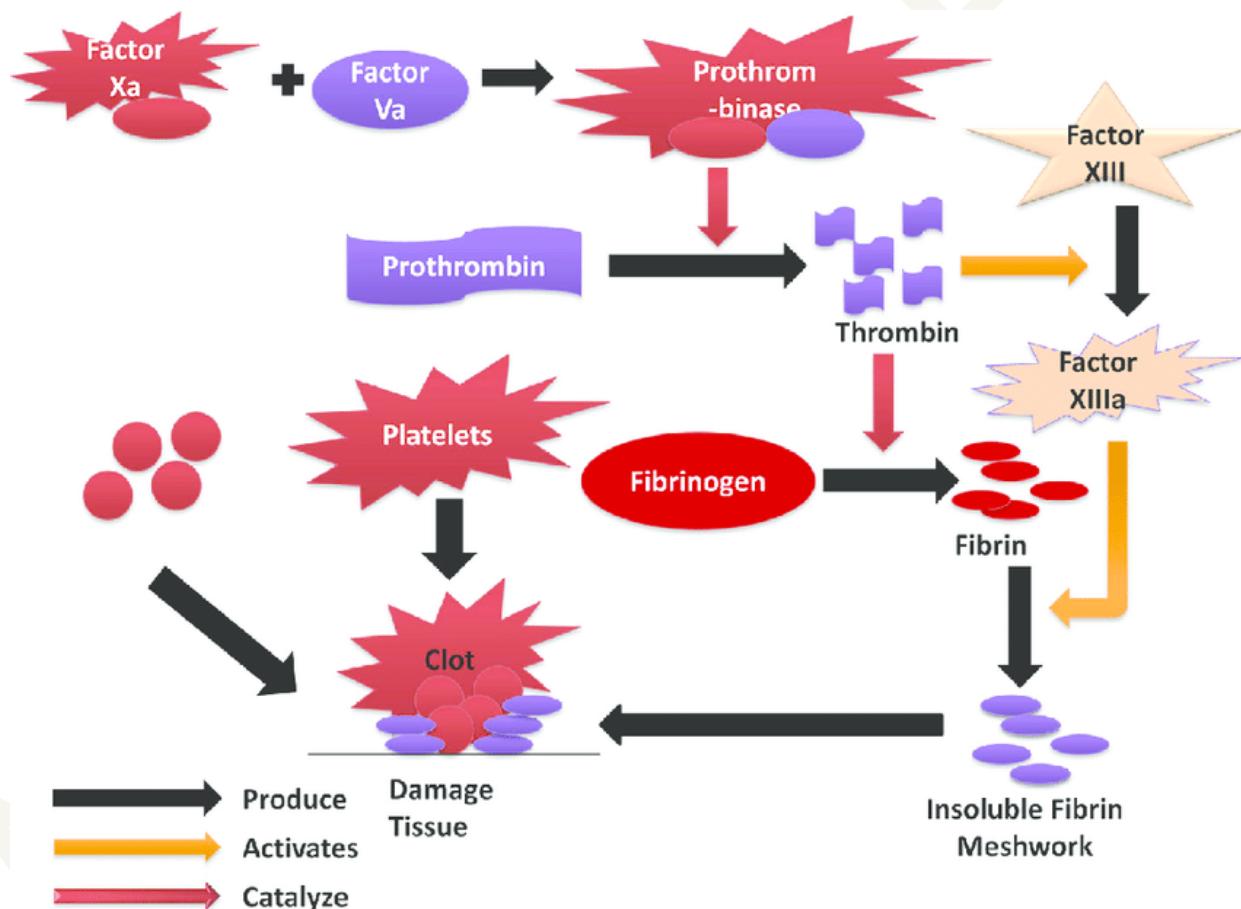
- Pain
- Vasodilation

### 3. Clotting system

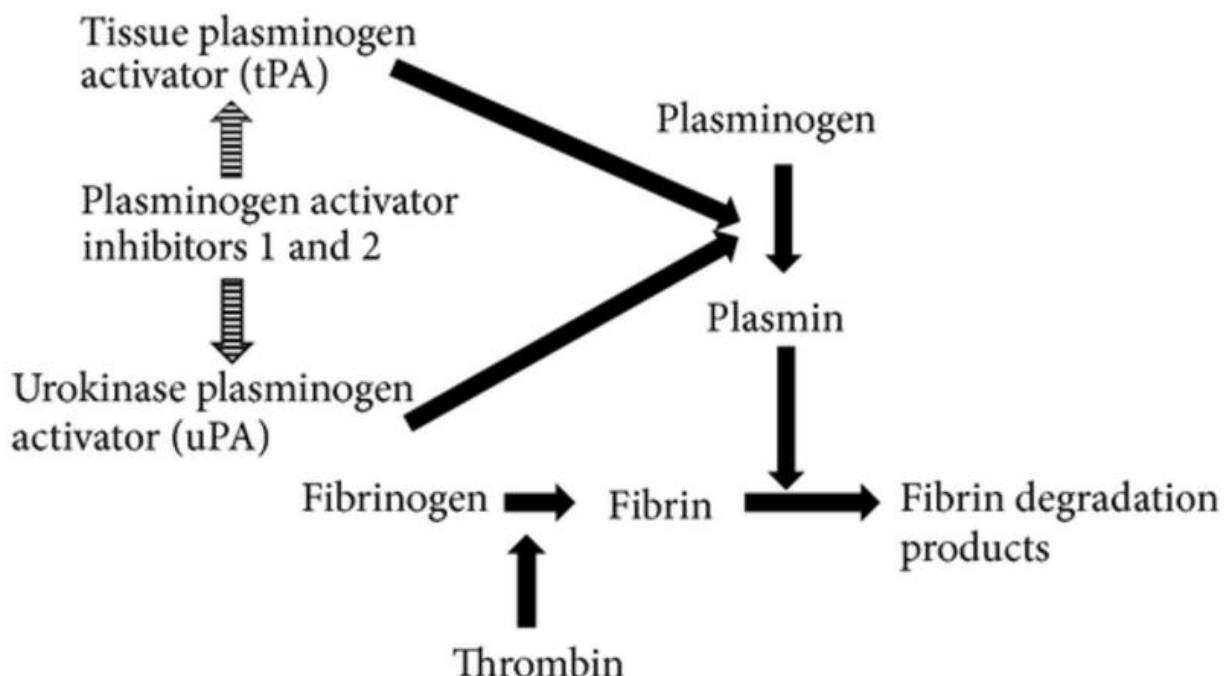
- The clotting system and inflammation are closely connected processes
- Factor XII begins the cascade of the clotting system which results in
- formation of fibrinogen that is acted upon by thrombin to form fibrin and fibrinopeptides

#### Actions

- Increased vascular permeability
- Chemotaxis for leukocyte
- Anticoagulant activity



#### 4. Fibrinolytic system



#### Actions

- Stimulates the kinin system to generate bradykinin
- Splits off complement C3 to form C3a
- Fibrin products : Increases vascular permeability

### III. Arachidonic Acid Metabolites

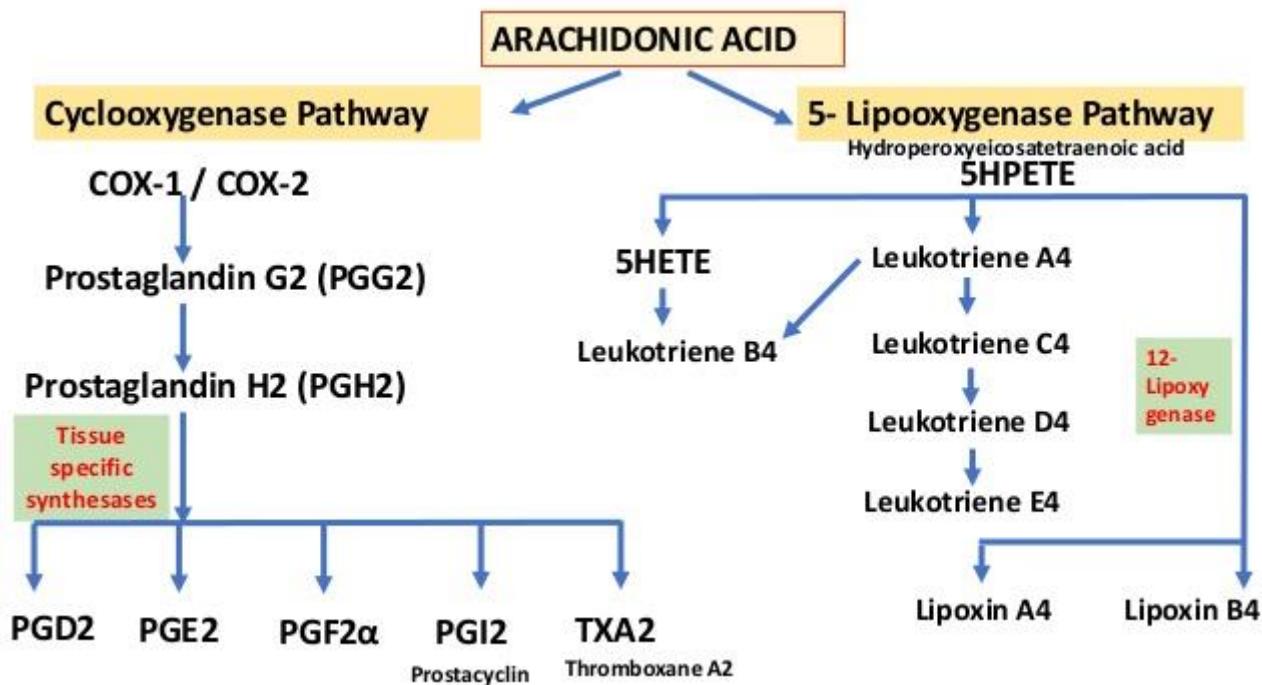
- Arachidonic acid (AA) is derived from dietary sources
- Also derived by conversion from the essential fatty acid linoleic acid
- Activation is initiated due to tissue injury (injury to mast cells, neutrophils, platelets, endothelial cells, macrophages)
- It does not occur free in the cell but is normally esterified in membrane phospholipids and liberates through the action of cellular phospholipases
- Soon after its release, it is converted into bioactive mediator called Eicosanoids which forms prostaglandins, thromboxane, leukotrienes and lipoxins

#### Prostaglandins

Produced by mast cells, macrophages, endothelial cells

#### Leukotrienes & Lipoxins

Produced by Leukocytes and mast cells

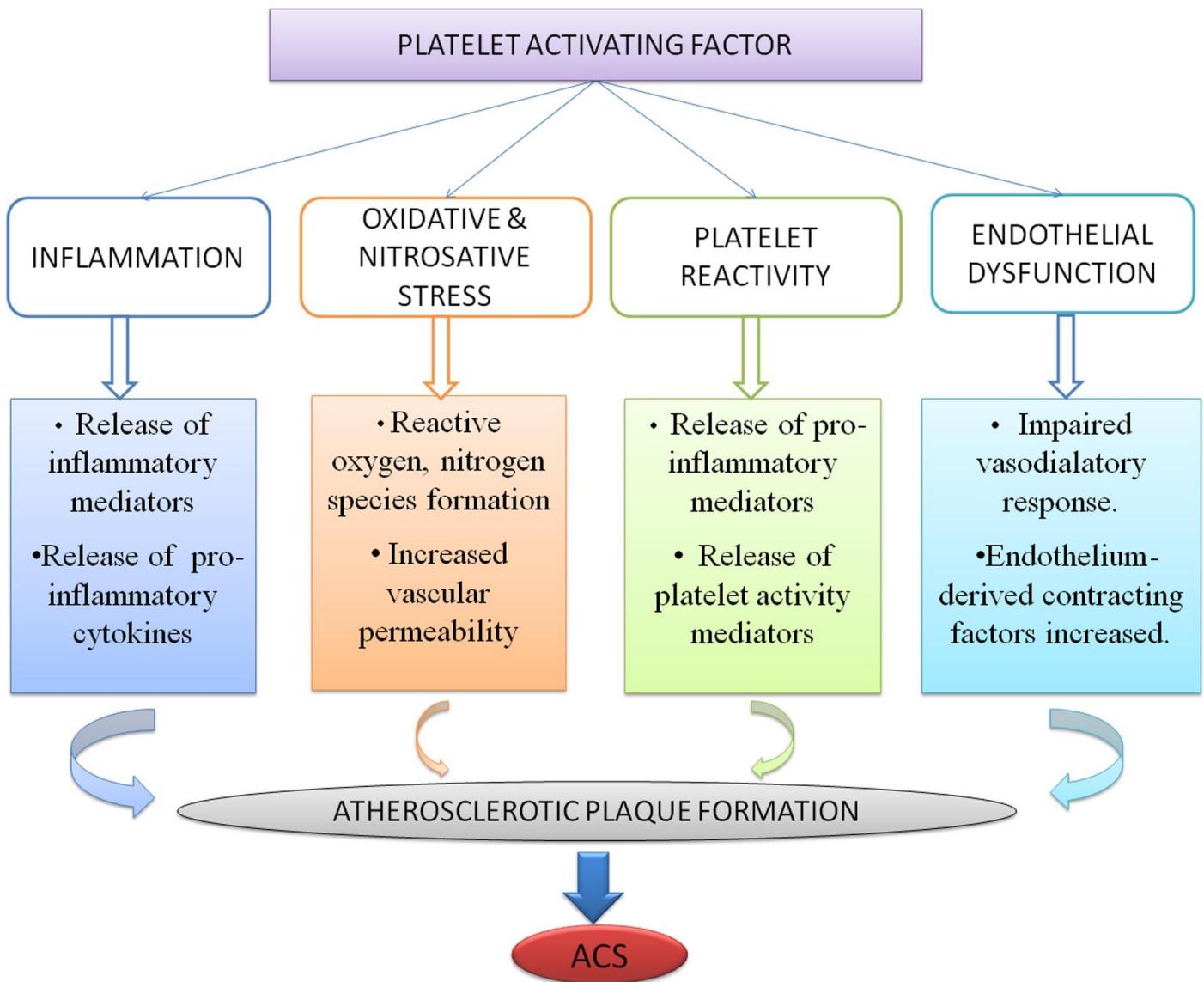


### Actions

- The metabolites of arachidonic acid can mediate almost every step of inflammation:
  - Vasodilation
  - Vasoconstriction
  - Bronchodilation
  - Bronchoconstriction
  - Platelet aggregation and inhibition
  - Chemo attraction
  - Inhibition of chemotaxis
- Hence inhibition of production of these mediators may suppress inflammation

### IV. Platelet activating factor (PAF)

- PAF is another bioactive phospholipid derived mediator
- Variety of cell types like platelets, basophils (and mast cells), neutrophils, monocytes, macrophages and endothelial cells involved in PAF
- PAF mediates its effects through a single G-protein coupled receptor and its effects are maintained by a family of inactivating PAF acetylhydrolases



### Actions

- In addition to platelet stimulation, PAF causes
  - Vasoconstriction and bronchoconstriction
  - At extremely low concentrations induces vasodilation and increased venular permeability
  - Increased leukocyte adhesion to endothelium (by enhancing integrin-mediated leukocyte binding), chemotaxis, degranulation and the oxidative burst
- Boosts the synthesis of other mediators particularly eicosanoids by leukocytes and other cells

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*Please Give Your Feedback on this Answer*

**Describe the regulations of blood glucose level. Add a note on diabetes mellitus and its prosthodontic significance (7M)**

**Management of patients with diabetes mellitus (6M)**

**Endocrine disorders affecting prosthodontic treatment (7M)**

**Discuss the effect of diabetes on success of prosthodontic treatment (7M)**

## CONTENTS/SYNOPSIS

- Introduction
- Epidemiology
- Classification
  - According to American diabetes association (ADA),
  - According to World health organisation (WHO)
- Aetiology
- Pathophysiology
  - Pathophysiology of Type I diabetes mellitus
  - Pathophysiology of Type II diabetes mellitus
- Clinical features
  - Oral manifestations of diabetes
- Diagnosis
  - Urine analysis
  - Blood chemistry
  - Immunological assays
  - Oral Glucose Tolerance Test (OGTT)
- Complications of diabetes
  - Short term complications
  - Long term complications
- Prosthodontic management of patient with diabetes
  - Diabetes and prosthodontics
  - Diabetes and implants
- Conclusion
- References

## INTRODUCTION

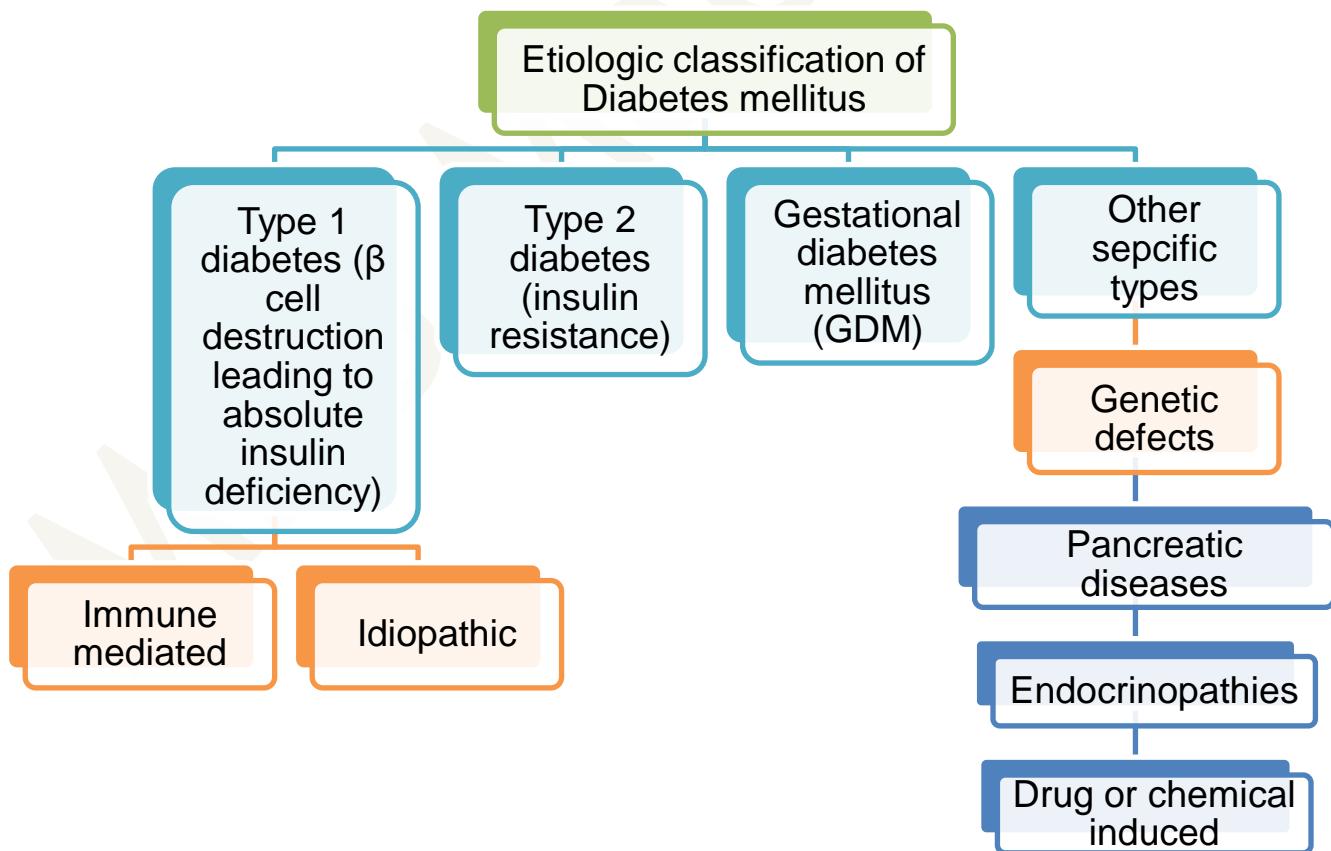
- Diabetes mellitus is a complex metabolic disease with abnormalities of glucose, protein, fat metabolism along with electrolyte and mineral disturbances leading to an impaired insulin production (profound or absolute deficiency), insulin resistance or both.
- The major clinical feature of diabetes is hyperglycemia or high blood sugar which on long standing can damage nerves, kidneys and eyes.

## EPIDEMIOLOGY

- According to the government survey and ICMR, the prevalence of diabetes mellitus in adult population is in the range of 10.9 - 14.2 % in urban areas with more than 62 million patients.
- Both the genders have almost equal prevalence.

## CLASSIFICATION

### I. According to American diabetes association (ADA), the etiologic classification of diabetes is



## II. According to World health organisation (WHO), the classification of diabetes 2019

Type 1 diabetes
Type 2 diabetes
Hybrid forms of diabetes
Slowly evolving immune-mediated diabetes of adults
Ketosis prone type 2 diabetes
Other specific types (see Tables)
Monogenic diabetes
- Monogenic defects of $\beta$ -cell function
- Monogenic defects in insulin action
Diseases of the exocrine pancreas
Endocrine disorders
Drug- or chemical-induced
Infections
Uncommon specific forms of immune-mediated diabetes
Other genetic syndromes sometimes associated with diabetes
Unclassified diabetes
This category should be used temporarily when there is not a clear diagnostic category especially close to the time of diagnosis of diabetes
Hyperglycemia first detected during pregnancy
Diabetes mellitus in pregnancy
Gestational diabetes mellitus

## ETIOLOGY

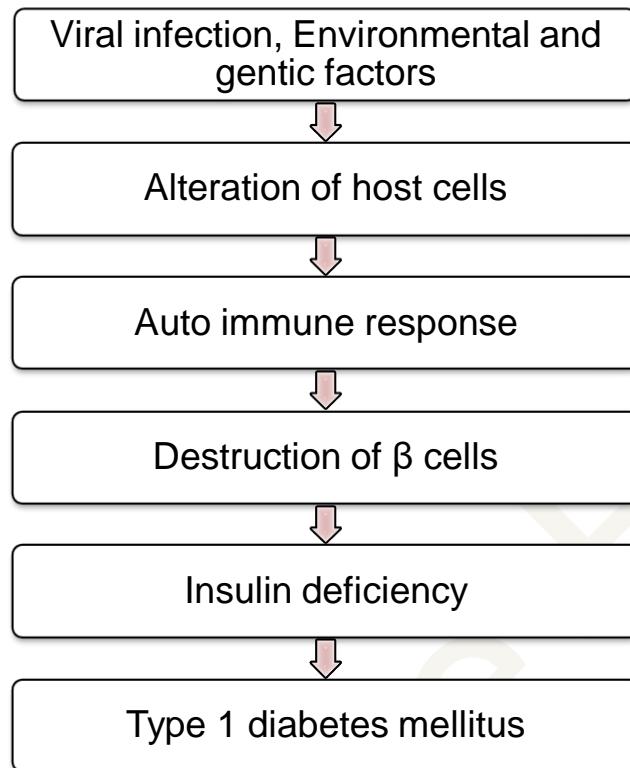
Type 1 Diabetes	Type II Diabetes
<ul style="list-style-type: none"> <li>Genetic factors</li> <li>Environmental factors <ul style="list-style-type: none"> <li>Viruses</li> <li>Diet</li> <li>Stress</li> <li>Immunological factors</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Genetics</li> <li>Pregnancy</li> </ul>

## PATHOPHYSIOLOGY

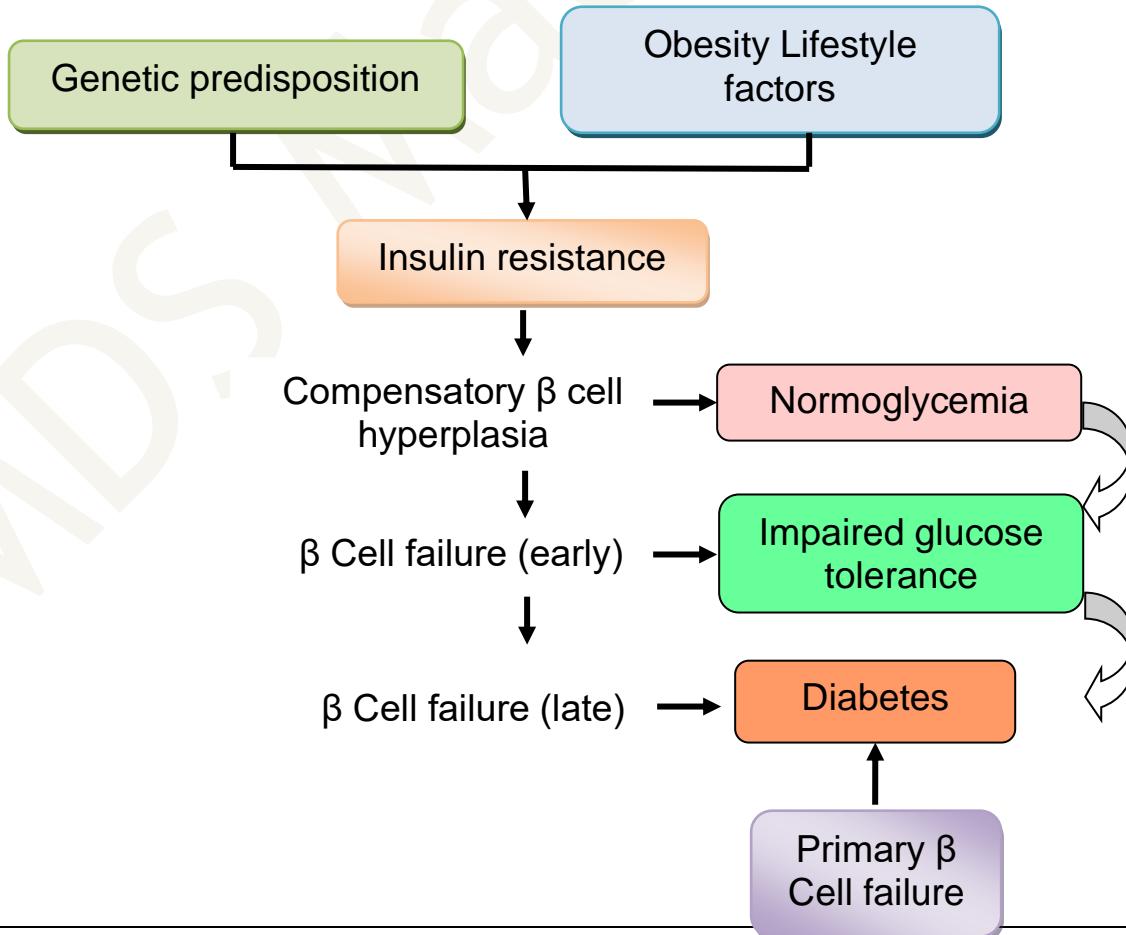
### Etiology:

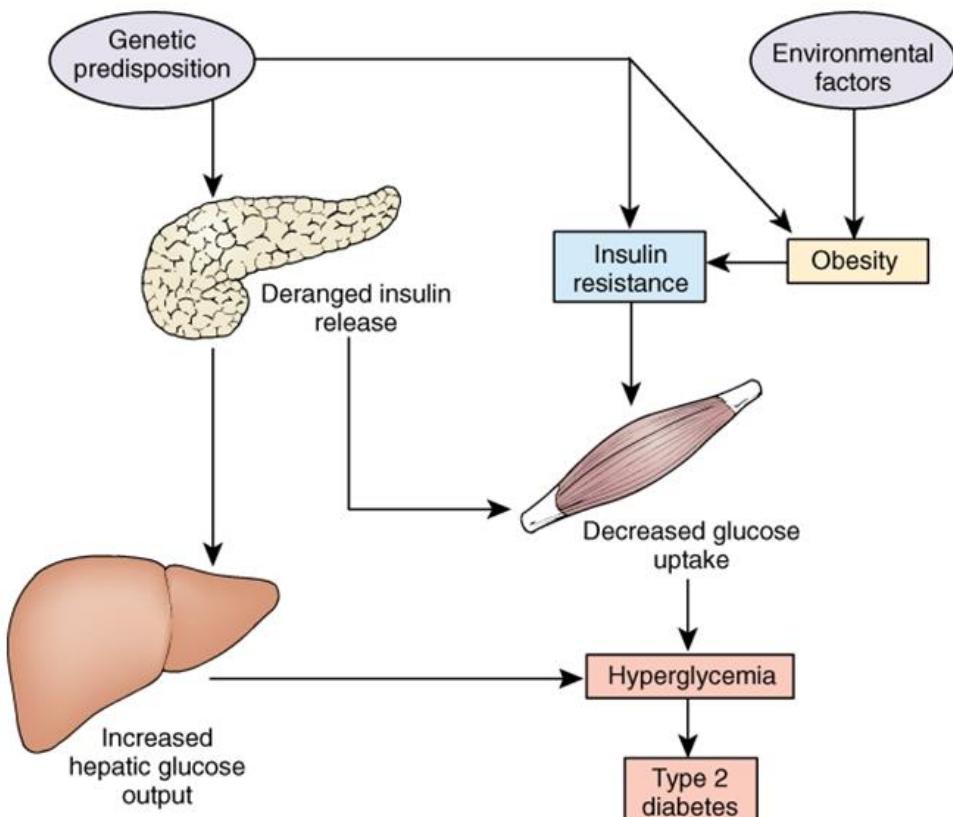
- Impaired insulin secretion
- Impaired insulin function

## 1. Pathophysiology of Type 1 Diabetes Mellitus



## 2. Pathophysiology of Type 2 Diabetes Mellitus





## CLINICAL FEATURES

Polyuria  
(excessive urination)

Polyphagia  
(excessive hunger)

Polydypsia  
(excessive thirst)

- Loss of weight
- Blurred vision
- Extreme fatigue of body with poor muscle strength
- Improper healing of ulcers or sores
- Libido in men
- Urinary tract infections in women
- Generally women with gestational diabetes will not have any symptoms until it has been detected in routine oral glucose tolerance test.

## Oral manifestation of diabetes

- Prone to caries
- Paresthesia leading to burning mouth and altered taste sensation
- Enlargement of salivary glands especially parotid
- Xerostomia
- Gingival (gingivitis, gingival enlargement) and periodontal (Alveolar bone loss, loss of attachment, Mobility of tooth, periodontitis, periodontal abscess) problems
- Improper wound healing
- More prone for infections due to alterations in host defence mechanism
- Increased residual ridge resorption
- Oral candidiasis
- Traumatic ulcers

## DIAGNOSIS

- Generally diagnosis of diabetes is based on the classic symptoms that are seen in patients.
- In the absence of these symptoms, glucose intolerance can be detected using fasting blood glucose.
- Type 1 diabetes generally presents with elevated plasma glucose levels along with the symptoms, whereas type 2 diabetes remains undiagnosed until complications occur. Hence laboratory screening is important.

## Laboratory tests

<b>1. Urine analysis</b>	<ul style="list-style-type: none"><li>• Glucose</li><li>• Microalbuminuria</li><li>• Ketone</li></ul>
<b>2. Blood chemistry</b>	<ul style="list-style-type: none"><li>• Blood glucose estimation</li><li>• Glucose tolerance test</li><li>• Glycated haemoglobin measurement</li><li>• Lipid profile</li><li>• Serum insulin</li></ul>
<b>3. Immunological assays</b>	

- The diagnostic criteria for diabetes mellitus and normal patient recommended by world health organization in 1980

Oral Glucose Tolerance Test (OGTT)		
	Plasma glucose (mmol/l) Venous (capillary)	Blood glucose (mmol/l) Venous (capillary)
<i>i. Diabetes</i>		
• Fasting	> 7.8 (> 7.8)	> 6.7 (> 6.7)
• 2 hrs after glucose load	> 11.1 (>12.2)	> 10.0 (>11.1)
<i>ii. Impaired glucose tolerance</i>		
• Fasting	7.8 (7.8)	< 6.7 (< 6.7)
• 2 hrs after glucose load	7.8 - 11.0 (8.9 - 12.1)	6.7 - 9.9 ( 7.8 - 11.0)

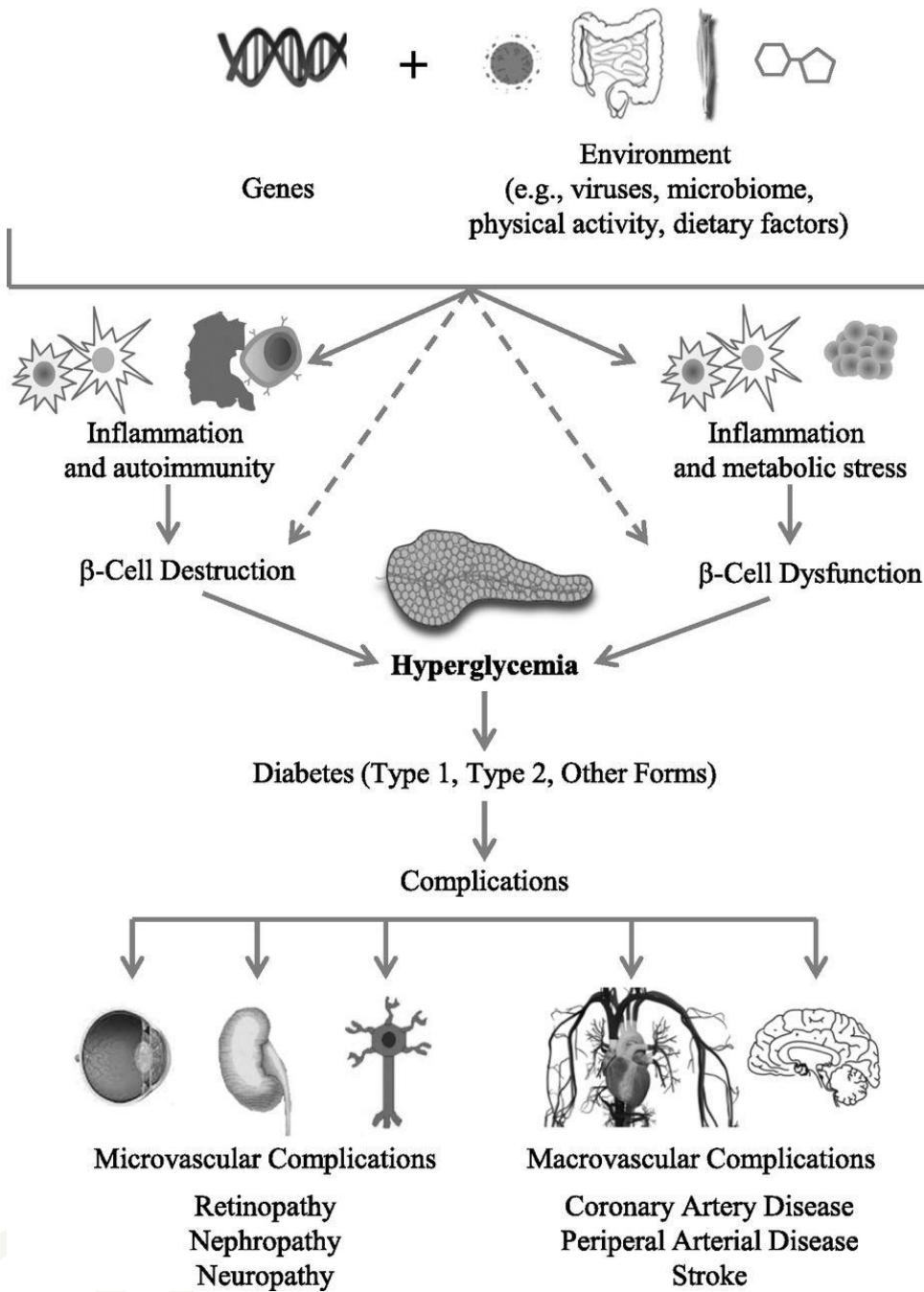
- Intermediate readings of OGTT are classified as Impaired glucose tolerance (IGT) and is an indication that the patient needs further evaluation and to keep them under review



	HbA1c (percent)	Fasting Plasma Glucose (mg/dL)	Oral Glucose Tolerance Test (mg/dL)
Diabetes	≥ 6.5	≥ 126	≥ 200
Prediabetes	5.7 – 6.4	100 - 125	140 – 199
Normal	~ 5.7	≤ 99	≤ 139

## COMPLICATIONS OF DIABETES

I. Long term complications	II. Short term complications
<ul style="list-style-type: none"> <li>Hypoglycemia</li> <li>Diabetic ketoacidosis</li> </ul>	<ul style="list-style-type: none"> <li>Diabetic neuropathy</li> <li>Diabetic retinopathy</li> <li>Diabetic nephropathy</li> <li>Cardiovascular disease</li> </ul>



## PROSTHODONTIC MANAGEMENT OF PATIENTS WITH DIABETES

- A detailed medical history has to be taken to assess the current status whether patient is diagnosed and in control. Dentist should know the details of medications, type and dosage of insulin of patient.
- Patients with controlled Type 1 or 2 diabetes may undergo all dental procedures without any need for precautions, whereas in poorly controlled patients prophylactic antibiotics should be given
- The most important hazard of a diabetic patient during dental procedure is **hypoglycemia**

## Signs & Symptoms of Hypoglycemia

Sweats, tachycardia, anxiety, dizziness, tremors, tingling and numbness

Confusion, seizures, loss of consciousness, coma

Reasons for hypoglycemia	Management of hypoglycemia
<b>1. Disrupted pattern of food intake</b>	<ul style="list-style-type: none"> <li>Constant check of blood glucose levels using a glucometer</li> <li>Emergency refreshment of 15gm of oral carbohydrate.</li> <li>If unable to eat food, intravenous line of 25 - 50ml of 50% dextrose or 1 mg glucagon can be given</li> </ul>
<b>2. Stress induced hypoglycemia</b>	<ul style="list-style-type: none"> <li>Stress produces epinephrine and cortisols.</li> <li>Hence early morning appointments are preferred (before or after periods of insulin activity)</li> <li>Conscious sedation can be considered for anxious patients</li> </ul>

### Diabetes and prosthodontics

- Mucostatic impression technique should be used to reduce the rate of resorption by increasing compatibility of denture base and supporting structure.
- Occlusal corrections should be checked and removed at all interfaces
- Occlusal table should be small to minimize load on to the abutment and ridge
- Oral hygiene instructions should be given with frequent prophylaxis to reduce the risk of periodontal disease
- Frequent denture evaluation should be made

### Diabetes and implants

- Implants are not a contraindication in patients with diabetes whose blood glucose is less than 100 mg/dl, whereas there are still evidences that increase the risk of implant failure in poorly controlled diabetes.
- Local anesthesia and antibiotics can be given to control the risk of infection
- Stress reduction protocol should be maintained

Risk	Impressions	Implant procedure
Mild $\leq$ 150 mg/dl	+	Sedation, premedication, diet and insulin adjustment
Moderate $\leq$ 200 mg/dl	+	Sedation, premedication, diet and insulin adjustment, hospitalization
Severe $>$ 250 mg/dl	+	Postpone of elective procedure

### CONCLUSION

- Diabetes is a commonly seen metabolic disorder which can be controlled with proper diet, medication and prophylaxis.
- The successful management of patient begins with right medical history till the treatment plan

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**Please Give Your Feedback on this Answer**

**Oral cavity epitomizes the systemic conditions of an individual - Justify (20M)**

**CONTENTS/SYNOPSIS**

- Introduction
- Cardiovascular diseases
  - Oral manifestations of cardiovascular diseases
    - Periodontal disease
    - Lichenoid stomatitis
    - Dry mouth
    - Gingival hyperplasia
    - Haemorrhagic complication
- Renal disorders
  - Intra oral findings
    - Uremic stomatitis
    - Soft tissue changes
    - Hard tissue changes
- Diseases of respiratory tract
  - Oral health considerations of allergic rhinitis
  - Oral manifestations of asthma
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- Oral manifestation of TB
- Oral manifestations in Diabetics
- Oral manifestations in Hyperparathyroidism
- Salivary Dysfunction & Xerostomia
- Burning mouth syndrome
- GIT diseases
  - Gastroesophageal reflux disease
    - Oral manifestations & dental considerations
  - Ulcerative colitis
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- Disorders of red blood cells and haemoglobin
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    - Iron deficiency anaemia
    - Pernicious anaemia

- Folic acid and vitamin B12 deficiency anaemia
- Thalassemia (Mediterranean or cooley anaemia)
- Sickle cell anaemia
- Aplastic anaemia
- **Disorders of white blood cells**
  - Agranulocytosis
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    - Acute leukaemia
    - Chronic leukaemia
- **Bleeding disorders**
  - Purpura
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    - Non-thrombocytopenic purpura
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- **Oral lesions associated with HIV**
  - Human papilloma virus infection
  - Hairy leukoplakia
  - Kaposi's sarcoma
  - Non-hodgkin's lymphoma
- **References**

## INTRODUCTION

- The oral cavity is a mirror that reflects many of the human body's internal secrets
- Some of these manifestations are disease specific and may be accompanied by many systemic diseases
- It is very important to recognize them and provide correct diagnosis.

## CARDIOVASCULAR DISEASES

- Angina Pectoris
- Congestive Heart Failure (CHF)
- Cyanotic and non-cyanotic valvular heart diseases
- Artherosclerosis
- The classical risk factors:
  - Hypertension
  - Hyper-cholesterolemia
  - Cigarette smoking
- Two biological mechanisms that explain the relationship between cardiovascular disease and periodontal disease
  - Bacteria from periodontal disease may enter the circulation and contribute directly to the atheromatous or thrombotic processes
  - Systemic factors alter the immune inflammatory process involved in both periodontal and cardiovascular diseases

### Oral manifestations of Cardiovascular diseases

<b>1. Periodontal disease</b>	<ul style="list-style-type: none"> <li>• Cardiovascular patients with active periodontal disease are 1.5-2.7 more likely to experience a fatal cardiovascular event. Increased inflammation &amp; Increased bacteraemia risk</li> </ul>
<b>2. Lichenoid stomatitis</b>	<ul style="list-style-type: none"> <li>• Various cardiovascular drugs may induce lichenoid lesions, oral discomfort           <ul style="list-style-type: none"> <li>➤ Diuretics</li> <li>➤ B1-adrenergic blockers</li> <li>➤ ACE- inhibitors (angiotensin-converting-enzyme inhibitors)</li> </ul> </li> </ul>
<b>3. Dry mouth</b>	<ul style="list-style-type: none"> <li>• Numerous cardiovascular drugs may reduce salivary function:           <ul style="list-style-type: none"> <li>➤ Diuretics</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>➤ B1-adrenergic blockers</li> <li>➤ Centrally acting sympathetic agonists</li> <li>➤ Synergistic affect with other medications</li> </ul>
<b>4. Gingival hyperplasia</b>	<ul style="list-style-type: none"> <li>• Calcium-channel blockers are commonly prescribed <ul style="list-style-type: none"> <li>➤ Gingival enlargement usually apparent within 1-2 months of therapy</li> <li>➤ Tissue usually firm and painless</li> <li>➤ Overlying inflammation may occur</li> </ul> </li> </ul>
<b>5. Haemorrhagic complication</b>	<ul style="list-style-type: none"> <li>• Antithrombotic/anti-coagulant agents increase the risk of petechiae (&lt;2mm), purpura (&gt;2mm - &lt;1cm), ecchymosis (&gt;1cm), haemorrhage</li> </ul>

## RENAL DISORDERS

### Intra oral findings

- Oral ulcers: Blood urea nitrogen increases  $> 150\text{mg/dl}$ , it gets secreted through saliva as uremic crystals and burns mucosa into red
- Uremic stomatitis: Burning sensation

<b>1. Uremic stomatitis</b>	<ul style="list-style-type: none"> <li>• Urea secreted in saliva</li> <li>• Urease enzyme produced by oral microflora</li> <li>• Liberates free ammonia</li> <li>• Damages oral mucosa</li> </ul>
<b>2. Soft tissue changes</b>	<ul style="list-style-type: none"> <li>• Ulcers secondary to anaemia, viral infections (immune-suppressed)</li> <li>• Gingival hyperplasia: cyclosporine &amp; nifedepine</li> <li>• Salivary glands: enlarged, xerostomia</li> <li>• Gingival bleeding, petechiae, ecchymosis due to platelet changes</li> <li>• Candidal infection: immune-suppression</li> <li>• Halitosis: uremic odour, ammonical smell</li> <li>• Dysesthesia of lower lip</li> </ul>
<b>3. Hard tissue changes</b>	<ul style="list-style-type: none"> <li>• Staining in teeth: due to iron supplements</li> <li>• Reduced caries due to urea in saliva</li> <li>• Delayed tooth eruption</li> <li>• Enamel hypoplasia</li> <li>• Tooth Mobility</li> </ul>

## DISEASES OF RESPIRATORY TRACT

- Upper airway infections
  - Allergic rhinitis and conjunctivitis
  - Sinusitis
  - Pharyngitis & Tonsillitis
- Lower airway infections
  - Asthma
  - Cystic fibrosis
  - Acute bronchitis
  - Tuberculosis

### I. Oral health considerations of allergic rhinitis

- Oral dryness
- Oral candidiasis (corticosteroids)

- Sinus infections usually present with pain involving more than one tooth.
- Chronic sinus infections are often accompanied by mouth breathing-gingivitis.
- Prolonged use of antibiotics: the potential development of bacterial resistance

### II. Oral manifestations of asthma

- Candidiasis
- Decreased salivary flow
- Increased calculus
- Increased gingivitis
- Increased periodontal disease
- Increased incidence of caries

#### Consideration for dental care

- Fluoride supplements: particularly those taking  $\beta$ 2-agonists
- Patient should be instructed to rinse his or her mouth with water after using inhalers
- Oral hygiene should be reinforced to reduce gingivitis and periodontitis

## ORAL MANIFESTATION OF TUBERCULOSIS

- Rare
- Mainly seen in middle aged & older people
- Males are affected more commonly
- Most commonly seen in tongue
- Oral lesion: Ulcer, nodule, vesicle, granuloma, fissure
- Ulceration: ragged border, minimal induration, granular base
- Sentinel tubercle; nodules seen around ulcer

## ORAL MANIFESTATIONS IN DIABETICS

- More severe periodontal disease
- Patients with multiple abscesses should be referred for blood sugar estimation
- Sialosis: swelling of salivary glands due to autonomic neuropathy
- Xerostomia may result from hyperglycaemia and subsequent polyuria that depletes the extracellular fluids
- Oral candidiasis & angular chelitis
- Oral mucosal lichenoid reactions: hypoglycaemics
- Burning tongue: associated with candidiasis or peripheral neuropathies

## ORAL MANIFESTATIONS IN HYPERPARATHYROIDISM

- Tooth appear more radiopaque in background of osteoporotic bone
- Loss of trabeculations of bone
- Ground glass appearance
- Total/ partial loss of lamina dura
- Loss of cortical outlines of inferior alveolar sinus, cortex of mandible
- Pulpal calcifications
- Multilocular radiolucency: osteitis fibrosa cystica/ brown's tumour
- Arterial & oral calcifications

## SALIVARY DYSFUNCTION & XEROSTOMIA

- Salivary hypofunction/ dry mouth (xerostomia) occurs when the salivary glands are not functioning properly resulting in decreased saliva
- Saliva not only aids in digestion, but is a necessary factor in oral health because it helps to keep the mouth moist and prevent tooth decay
- Diabetic neuropathy can also affect the salivary glands
- Polyuria
- Topical treatments:
  - Fluoride containing mouth rinses
  - Salivary substitutes

## BURNING MOUTH SYNDROME (BMS)

- Burning mouth syndrome is a condition with no determined cause and is characterized by a chronic burning pain in your mouth
- This burning sensation can be severe, feeling much the same as scalding and can affect the overall areas of your mouth such as your tongue, gums, lips, inside of your cheeks, and the roof of your mouth
- Although BMS has no known cause and finding treatment may be difficult, most people can bring it under control by working with an oral health specialist

## GIT DISEASES

- Gastroesophageal reflux disease
- Ulcerative colitis (Inflammatory Bowel Disease)
- Crohn's disease (Inflammatory Bowel Disease)
- Peutz-jegher's syndrome

### I. Gastroesophageal reflux disease

- Most common disease of upper GI tract
- Gastric contents passively move up from the stomach into the oesophagus
- Symptoms/signs
  - Heart burn (pain/burning sensation extending from epigastrium to the neck): commonly felt after a meal
  - Esophagitis, oesophageal ulceration & stricture
  - Chest pain (mimics anginal pain)
  - Dysphagia

### **Oral Manifestations & Dental Considerations:**

- Erythema and mucosal atrophy
- Dysgeusia, sensitivity & erosion (palatal aspects of upper anteriors and premolars)
- Erosion leads to dentin sensitivity & irreversible pulpal involvement due to gastric content (pH < 1)
- Treatment: Head elevation, small meals, H2 blockers

## **II. Ulcerative colitis**

- Inflammatory process usually extends from rectum proximally in a continuous fashion involving variable lengths of large intestine but confined to mucosa & superficial submucosa
- Destructive oral ulceration due to immune mediated vasculitis
- Polystomatitis Vegetans: micro-abscess on lips, palate, ventral tongue
- May manifests as aphthous ulcers
- Bloody diarrhoea is a cardinal symptom
- Treatment
  - Sulfasalazine
  - 5 amino salicylates
  - Corticosteroids (Topical & Systemic)
  - Immuno-suppressants (Tacrolimus, Cyclosporine, Infliximab)
  - Surgery

## **III. Crohn's disease (regional enteritis, ileitis)**

- Affects entire thickness of intestinal wall, in segments forms strictures and scarring Small intestine - 40%; Large intestine - 30% and both intestines- 30%
- Pain & diarrhoea
- Fistulas which connect different sites in GIT, urinary bladder, vagina, prostate and skin
- Arthritis, uveitis & erythema nodosum of skin are common in both diseases

**Oral Manifestations of Crohn's disease**

- Oral granulomatous lesions as a nodular mass in the mucobuccal fold
- Lesions resembling aphthous ulcers
- Cobblestone appearance on buccal mucosa
- Linear hyperplastic folds with ulcers in the vestibule
- Swollen & indurated lips
- Granular red lesions on gingiva and alveolar mucosa and palatal ulcers (rarely)

- *Treatment:*

- High fibre diet
- Sulfasalazine
- Corticosteroids
- Immuno-suppressants
- Surgery

**IV. Peutz-Jegher's Syndrome**

- Autosomal dominant
- Mucocutaneous pigmentation & intestinal polyposis (hamartomas)
- Black spots (macule): perioral skin, lips, buccal mucosa, tongue
- Treatment: Conservative or local excision

**DISORDERS OF RED BLOOD CELLS AND HAEMOGLOBIN**

- Iron Deficiency Anaemia
- Pernicious Anaemia
- Folic Acid Deficiency Anaemia
- Thalassemia
- Sickle Cell Anaemia
- Aplastic Anaemia

**Anaemia**

- A reduction in the oxygen-carrying capacity of blood
- Most often related to a decrease in the number of circulating red blood cells

- Nutritional anaemia: A deficiency in a substance required for the normal development of red blood cells, commonly vitamins; Suppression of bone marrow stem cells

#### Clinical features

- Pallor of skin and oral mucosa
- Angular cheilitis
- Erythema and atrophy of oral mucosa
- Loss of filiform and fungiform papillae on the dorsum of the tongue

### **1. Iron Deficiency Anaemia**

- An insufficient amount of iron is supplied to bone marrow for red blood cell development
  - May occur as a result of deficient iron intake,
  - Blood loss from heavy menstrual bleeding
  - Chronic gastrointestinal bleeding, poor iron absorption,
  - Increased requirement for iron in situations such as pregnancy or infancy
- Plummer-Vinson syndrome may result from long standing iron deficiency anaemia
  - Includes dysphagia, atrophy of the upper alimentary tract, and a predisposition to developing oral cancer

<i>Clinical Features and Oral Manifestations of Iron Deficiency Anaemia</i>	<i>Treatment</i>
<ul style="list-style-type: none"> <li>• Often asymptomatic, may have nonspecific symptoms such as weakness and fatigue</li> <li>• In severe cases may see angular cheilitis, pallor of oral tissue, and an erythematous, smooth, painful tongue</li> </ul>	<ul style="list-style-type: none"> <li>• Ferrous sulphate 200 mg three times daily (orally)</li> <li>• Ferrous Gluconate (250mg/day)</li> </ul>

### **2. Pernicious Anaemia**

- Probably an autoimmune disorder in most situations
- May be caused by removal of the stomach, gastric cancer, or gastritis

- Caused by a deficiency of intrinsic factor
- Intrinsic factor is secreted by parietal cells in the stomach; it is necessary for absorption of vitamin B12

<i>Clinical Features and Oral Manifestations of Pernicious Anaemia</i>	<i>Treatment</i>
<ul style="list-style-type: none"> <li>• Weakness, pallor, and fatigue on exertion</li> <li>• Nausea, dizziness, diarrhoea, abdominal pain, loss of appetite, and weight loss</li> <li>• Angular cheilitis, mucosal pallor, painful atrophic and erythematous mucosa, mucosal ulceration, loss of papillae on the dorsum of the tongue, and burning and painful tongue</li> </ul>	<ul style="list-style-type: none"> <li>• Intramuscular hydroxycobalamin 1 mg 5 times at 3 days interval and then at about 3 monthly intervals</li> </ul>

### 3. Folic Acid and Vitamin B12 Deficiency Anaemia

<i>i. Etiology</i>	<ul style="list-style-type: none"> <li>• Can occur in association with malnutrition</li> <li>• May be found with alcoholism or pregnancy</li> </ul>
<i>ii. Oral Manifestations</i>	<ul style="list-style-type: none"> <li>• Oral manifestations are indistinguishable from those of pernicious anaemia</li> </ul>
<i>iii. Treatment</i>	<ul style="list-style-type: none"> <li>• Folic Acid 5mg daily by mouth at least for 4 months</li> </ul>

### 4. Thalassemia (Mediterranean or Cooley Anaemia)

- A group of inherited disorders of haemoglobin synthesis
- An autosomal dominant inheritance pattern
  - The heterozygous form may be mildly symptomatic or asymptomatic
  - The homozygous form is associated with severe haemolytic anaemia

<i>i. Clinical Features and Oral manifestations</i>	<ul style="list-style-type: none"> <li>• Yellow skin pallor, fever, malaise, and weakness</li> <li>• The face includes prominent cheekbones, depression of the bridge of the nose, a prominent maxilla, and protrusion or flaring of maxillary anterior teeth</li> <li>• Radiographs may show a “salt and pepper” pattern</li> </ul>
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	<ul style="list-style-type: none"> <li>• Some trabeculae are prominent, and others are blurred</li> <li>• Risk of Infections &amp; liver disease</li> <li>• Heamosiderosis &amp; death</li> </ul>
<i>ii. Treatment</i>	<ul style="list-style-type: none"> <li>• Blood transfusion</li> <li>• Folic Acid supplements</li> <li>• Iron Chelating Agents (Desferrioxamine)</li> <li>• Ascorbic Acid</li> </ul>

## 5. Sickle Cell Anaemia

- An inherited blood disorder
  - When someone is heterozygous, it is called sickle cell trait
  - When someone is homozygous, they are much more severely affected
- Occurs before age 30 and is more common in women than in men
- The red blood cells develop a sickle shape when there is decreased oxygen
- This can be triggered by exercise, exertion, administration of a general anaesthetic, pregnancy, or even sleep

<i>i. Clinical Features and Oral Manifestations</i>	<ul style="list-style-type: none"> <li>• The person has weakness, shortness of breath, fatigue, joint pain, and nausea</li> <li>• Radiographic</li> <li>• There is a loss of trabeculation, and large, irregular marrow spaces appear</li> <li>• A “hair-on-end” pattern may be seen in the skull</li> </ul>
<i>ii. Treatment</i>	<ul style="list-style-type: none"> <li>• <u>Prevention of Triggers</u>: Dehydration, Acidosis, Hypoxia, Trauma, Stress, Infection</li> <li>• <u>Management of Crisis</u>: Analgesics (Morphine, Pethidine), Hydration, Bicarbonate, 100% Oxygen, PRC</li> <li>• <u>Long Term Treatment</u>: Hydroxycarbamide, Chelating agents, Infections &amp; Liver diseases</li> </ul>

## 6. Aplastic Anaemia

- A severe depression of bone marrow activity causes a decrease in all circulating blood cells: pancytopenia

- Primary aplastic anaemia: the cause is unknown
- Secondary aplastic anaemia: a result of a drug or chemical agent

<i>i. Oral Manifestations</i>	<i>ii. Treatment</i>
<ul style="list-style-type: none"> <li>• Infection</li> <li>• Spontaneous bleeding</li> <li>• Petechiae</li> <li>• Purpuric spots</li> </ul>	<ul style="list-style-type: none"> <li>• Removal of cause</li> <li>• Antibiotics</li> <li>• Hematopoietic stem cell transplantation</li> <li>• Corticosteroids</li> <li>• Prognosis is poor, 50% of patients die within 6 months usually from haemorrhage or infection</li> <li>• Iron Overload may result from repeated blood transfusions</li> </ul>

## DISORDERS OF WHITE BLOOD CELLS

### I. Agranulocytosis

- Sudden onset of fever
- Chills
- Jaundice
- Weakness
- Sore throat
- Oral infection

### II. Leukaemia

- Malignant neoplasms of hematopoietic stem cells
- Characterized by an excessive number of abnormal white blood cells in circulating blood
- Unknown cause; some are investigating oncogenic viruses

#### 1. Acute Leukaemia

- Characterized by very immature cells and a rapidly fatal course if not treated

<i>i. Acute lymphoblastic leukaemia</i>	<i>ii. Acute myeloblastic leukaemia</i>
<ul style="list-style-type: none"> <li>• Involves immature lymphocytes</li> <li>• Primarily affects children and young adults</li> </ul>	<ul style="list-style-type: none"> <li>• Involves immature granulocytes</li> <li>• Primarily affects adolescents and young adults</li> </ul>

- |                  |                            |
|------------------|----------------------------|
| • Good prognosis | • Prognosis is not as good |
|------------------|----------------------------|

### *Clinical Features of Acute Leukaemia*

- Weakness
- Fever
- Enlargement of lymph nodes
- Bleeding
- Gingival enlargement
- Oral infection
- Bleeding gums, petechiae and ecchymosis

## **2. Chronic Leukaemia**

- Slow onset
- Primarily affect adults
- Clinical Features and Oral Manifestations of Chronic Leukaemia
  - Easy fatigability, weakness, weight loss, anorexia
  - Pallor of lips and gingiva
  - Gingival enlargement
  - Petechiae and ecchymosis
  - Gingival bleeding

## **BLEEDING DISORDERS**

### **1. Purpura**

- A reddish-blue or purplish discoloration of skin or mucosa from spontaneous extravasations of blood
- May be due to a defect or deficiency in blood platelets
- Blood may ooze from gingival margins.

#### **1. Thrombocytopenic Purpura**

- A bleeding disorder that results from a severe reduction in circulating platelets
  - Idiopathic thrombocytopenic purpura: If the cause is unknown
  - Immune thrombocytopenia: An

#### **2. Non-thrombocytopenic Purpura**

- Bleeding disorders that can result from either a defect in capillary walls or disorders of platelet function
- Vitamin C deficiency and infections or chemicals and allergy may be the cause of alterations in vascular

<p>autoimmune type of process</p> <p>➤ Secondary thrombocytopenic purpura: Often associated with drugs</p>	<p>walls</p> <ul style="list-style-type: none"> <li>Drugs, allergy, and autoimmune disease may cause disorders of platelet function</li> <li>Von Willebrand disease is an autosomal dominant disorder of platelet function.</li> </ul>
<ul style="list-style-type: none"> <li>Clinical and Oral Manifestations of Thrombocytopenic Purpura           <ul style="list-style-type: none"> <li>➤ Spontaneous purpuric or haemorrhagic lesions on the skin</li> <li>➤ Patients bruise easily</li> <li>➤ May have blood in urine</li> <li>➤ Have frequent nose bleeds</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Oral Manifestations of Non-thrombocytopenic Purpura           <ul style="list-style-type: none"> <li>➤ Spontaneous gingival bleeding</li> <li>➤ Petechiae</li> <li>➤ Ecchymoses</li> <li>➤ Haemorrhagic blisters</li> </ul> </li> </ul>

## II. Haemophilia

- A disorder of blood coagulation
- Results in severely prolonged clotting time
- Due to a deficiency in plasma proteins
- Transmitted as X-linked diseases through an unaffected carrier daughter to a son
- Types of Haemophilia: most common types are type A and type B.

- Type A:** Caused by a deficiency of plasma thromboplastinogen or factor VIII
- Type B:** Christmas disease; Less common, the clotting defect is plasma thromboplastin or factor IX

- Oral Manifestations of Haemophilia**

- Spontaneous gingival bleeding
- Petechiae
- Ecchymosis

## ORAL LESIONS ASSOCIATED WITH HIV

- Early recognition, diagnosis, & treatment of HIV associated oral lesions - reduce morbidity
- Oral lesions
  - Early diagnostic indicator of HIV infection
  - Stage of HIV infection
  - Predictor of the progression of HIV disease
- Fungal Infection: Candidiasis, Histoplasmosis, Periodontitis, Cryptococcosis complex
- Bacterial Infection: Linear Gingival Erythema, Necrotizing Ulcerative, Mycobacterium Avium
- Viral Infection: Herpes simplex, Herpes zoster, HPV Infection, CMV Infection, Hairy Leucoplakia
- Neoplastic: Kaposi's Sarcoma, Non-Hodgkin's Lymphoma
- Others: Recurrent Aphthous Ulcers, Salivary Gland Disease

### I. Human papilloma virus infection

- Oral warts (papillomas), skin warts & genital warts – HPV (types 7,13 & 32)
- **Clinical Features:**
  - Arises from Stratified squamous epithelium, painless, exophytic, numerous finger like projections-cauliflower like appearance
  - Tongue, gingiva & palate
- **Biopsy:** Histological diagnosis
- **Treatment:** Surgical removal, Laser (CO<sub>2</sub> laser)

### II. Hairy Leukoplakia

- Epstein Barr virus
- Common, characteristic lesion : HIV infection
- White, asymptomatic, raised, corrugated, irremovable patch on lateral margins of tongue
- The surface is irregular and may have prominent folds or projections, sometimes markedly resembling hairs
- Lateral margins → may spread to dorsum of tongue
- **Diagnosis:** Biopsy
- **Treatment:** Usually asymptomatic-Rx not required, Antiviral (Aciclovir/ valaciclovir)

### III. Kaposi's sarcoma

- Most common malignancy in HIV (+ve)
- Human Herpes Virus-8(KSHV)
- Derived from capillary endothelial cells
- Occur intraorally, either alone or in association with skin & disseminated lesions (lymph nodes, salivary gland)
- Intraorally: hard palate, buccal mucosa, & gingiva
- Bluish, purple or red patches or papules, nodular, ulcerate & bleed
- **Diagnosis:** Biopsy
- **Treatment:** Low dose radiation & chemotherapy (eg. Vinblastine), Surgical excision (eg.CO<sub>2</sub> laser), Immunotherapy (Interferon)

### IV. Non-Hodgkin's Lymphoma

- **Etiology:** Unknown, genetic & environmental factors (viruses, radiation)
- **Clinical features:**
  - Both sexes - any age
  - Lymph nodes involved
  - Oral lesions - part of a disseminated disease, or the only sign
- Oral Lymphoma: diffuse, painless swelling, which may or may not be ulcerated. Soft palate, the posterior part of the tongue, the gingiva, & the tonsillar area
- HPE & Immunohistochemical examination
- **Treatment:** Radiotherapy & Chemotherapy

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**Please Give Your Feedback on this Answer**

**What is osteomyelitis. Mention the management of body of the mandible (10M)**

### CONTENTS/SYNOPSIS

- Introduction to osteomyelitis
- Classification
- Factors predisposing to osteomyelitis
  - Local factors
  - Systemic factors
- Pathogenesis
  - Microbiology involved
- Types of osteomyelitis
  - Suppurative osteomyelitis
    - Acute suppurative osteomyelitis
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  - Focal sclerosing osteomyelitis
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  - Proliferative periostitis
- Pathogenesis
- Clinical features
- Histological features
- Radiographic features
- Management
- References

**INTRODUCTION**

- The word osteomyelitis originated from greek words osteon: bone and muelions: marrow, means infection of medullary portion of bone
- It is an acute and chronic inflammatory process in the medullary spaces or cortical surfaces of bone that extends away from the initial site of involvement

**CLASSIFICATION**

<b>I. Based on duration</b>	<ul style="list-style-type: none"> <li>• Acute</li> <li>• Subacute</li> <li>• Chronic</li> </ul>
<b>II. Based on mechanism</b>	<ul style="list-style-type: none"> <li>• Haematogenous</li> <li>• Exogenous</li> </ul>
<b>III. Based on host response</b>	<ul style="list-style-type: none"> <li>• Pyogenic</li> <li>• Granuloma</li> </ul>

**FACTORS PREDISPOSING TO OSTEOMYELITIS**

<b>I. Local factors</b>	<b>II. Systemic factors</b>
<ul style="list-style-type: none"> <li>• Decreases vascularity/ vitality of bone</li> </ul>	<ul style="list-style-type: none"> <li>• Impairs the host defense</li> </ul>
<ul style="list-style-type: none"> <li>• Trauma</li> <li>• Radiation</li> <li>• Paget's disease</li> <li>• Osteoporosis</li> <li>• Major vessel disease</li> </ul>	<ul style="list-style-type: none"> <li>• Immune deficiency states</li> <li>• Immunosuppression</li> <li>• Diabetes mellitus</li> <li>• Malnutrition</li> <li>• Extremes of age</li> </ul>

**PATHOGENESIS**

Inflammatory process occurs in entire bone including cortex and periosteum

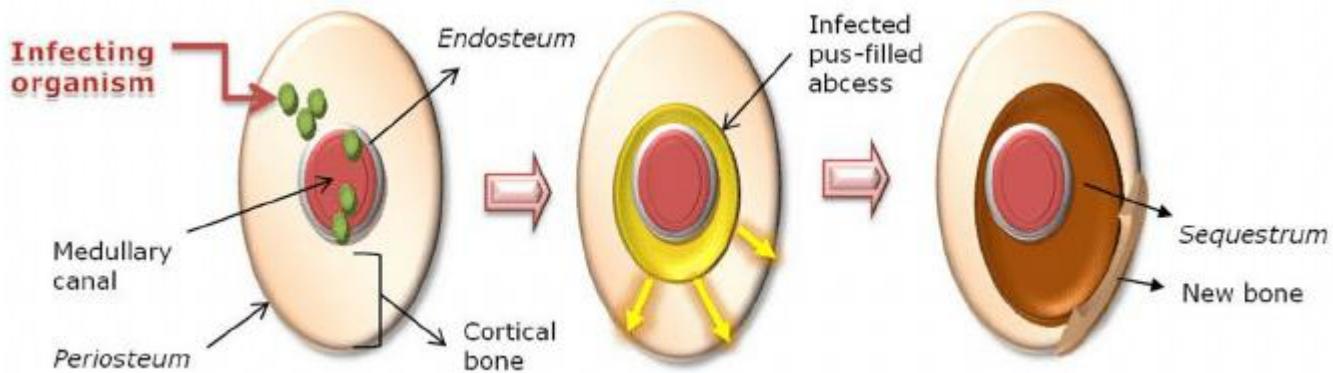


Inflammation in the medullary cavity and haversion system and extends into periosteum of the affected area/bone



Local factors decreases the vascularity and hence vitality of bone is reduced

Host defense system is compromised due to systemic conditions



## Microbiology

- Streptococci, Bacteriodes, Peptostreptococci and other opportunistic infections
- In chronic state: Actinomyces, Eikenella, Arachnia, Coccidioides, Mycobacterium tuberculosis, Klebsiella

## TYPES OF OSTEOMYELITIS

- Suppurative osteomyelitis
- Focal sclerosing osteomyelitis
- Diffuse sclerosing osteomyelitis
- Proliferative periostitis

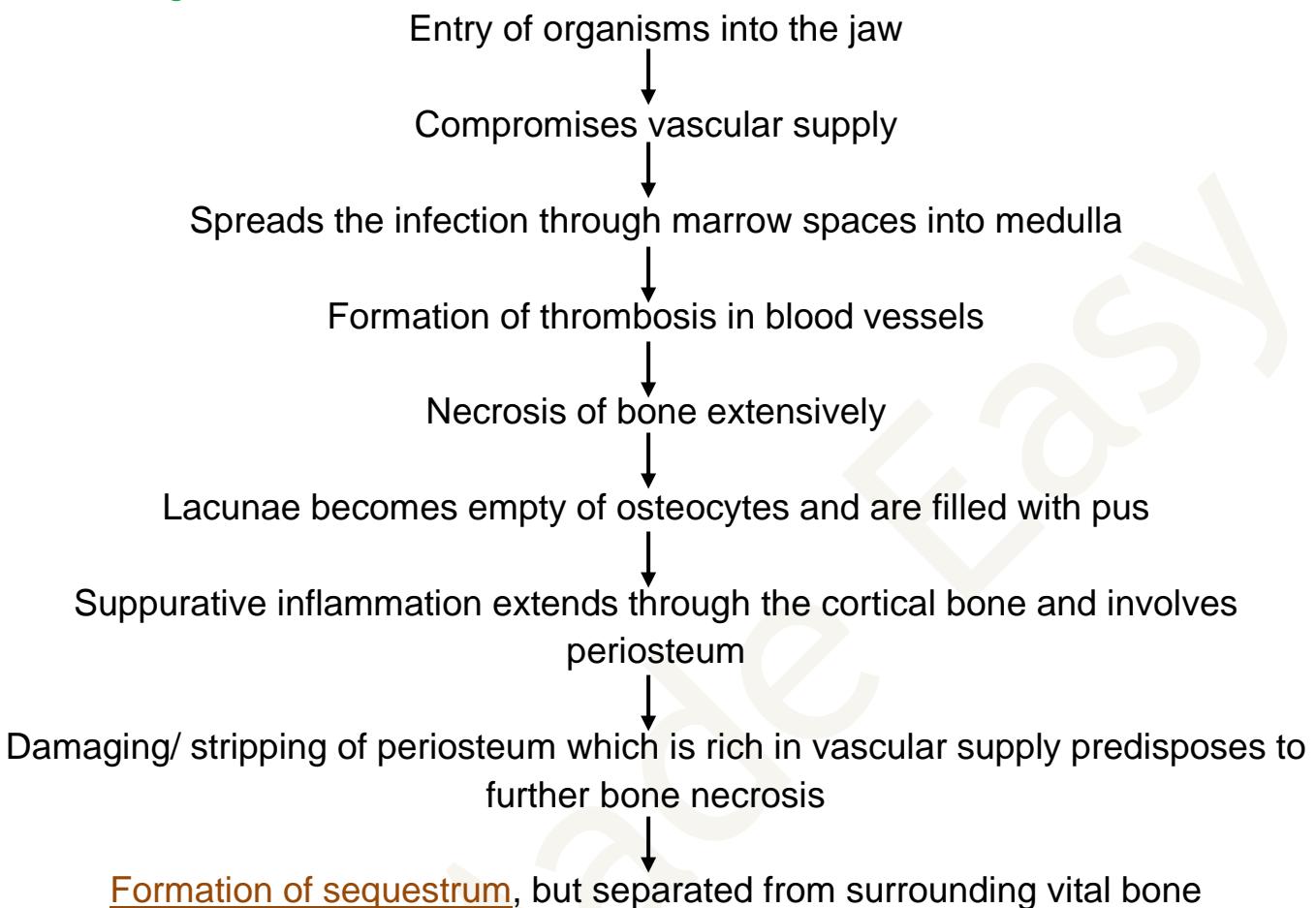
- A sub acute stage also exists in which acute symptoms such as elevated temperature and white blood cell count is nearly normal but production of pus and extension into adjacent bone continues

### I. Suppurative osteomyelitis

- It is a polymicrobial infection predominantly with anaerobes such as bacteroids, porphyromonas, provetella, staphylococci (in case of open fractures)
- Mandible is more prone than maxilla as vascular supply is easily compromised
- Onset of disease: Deep bacterial invasion into medullary and cortical bone
- Based on the duration, it is divided into two types:
  - Acute Suppurative Osteomyelitis
  - Chronic Suppurative Osteomyelitis

## 1. Acute suppurative osteomyelitis

### i. Pathogenesis



### ii. Clinical features

Early	Late	Final
<ul style="list-style-type: none"> <li>Severe throbbing, deep pain</li> <li>Swelling/ edema is seen due to inflammation</li> <li>Gingiva are red, swollen and tender</li> </ul>	<ul style="list-style-type: none"> <li>Distension of periosteum with pus</li> </ul>	<ul style="list-style-type: none"> <li>Subperiosteal bone formation leads to a firm/hard swelling</li> </ul>

### iii. Histological features

- Predominantly consists of necrotic bone (sequestrum)
- Loss of osteocytes from lacunae
- Resorption of peripheral bone
- Colonization of bacteria
- Acute inflammatory infiltrate (PMNs in haversion

	canals and peripheral bone)
iv. <i>Radiological features</i>	<ul style="list-style-type: none"> <li>• No signs of radiological features until 10 days</li> <li>• Demonstrates ill defined radiolucency</li> <li>• After bone resorption: irregular moth eaten radiolucencies appear</li> </ul>



**Moth eaten appearance**

v. *Management*

Basic measures	Adjunctive treatment
<ul style="list-style-type: none"> <li>• Bacterial cultures followed by antibiotic treatment based on culture and sensitivity</li> <li>• Drainage</li> <li>• Analgesics for pain relief</li> <li>• Debridement</li> <li>• Removal of source of infection</li> </ul>	<ul style="list-style-type: none"> <li>• Sequestromy</li> <li>• Decortication</li> <li>• Hyperbaric oxygen</li> <li>• Resection and reconstruction for extensive bone destruction</li> </ul>

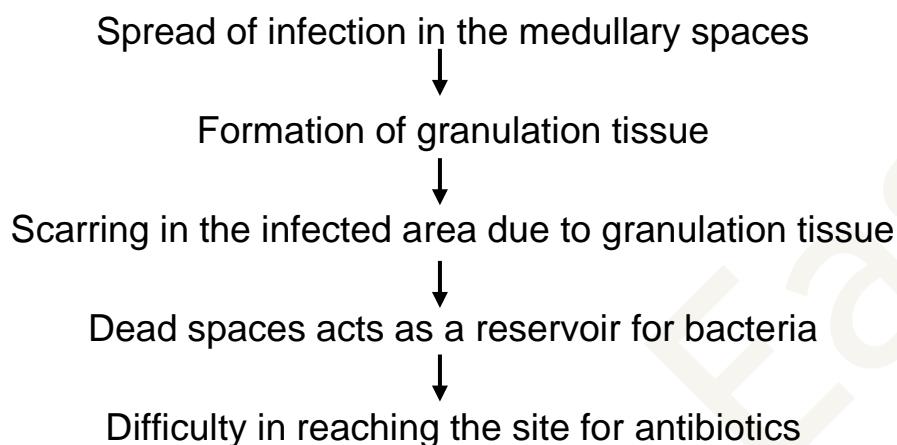
vi. *Complications*

- Extensive bone destruction leads to pathological fracture
- Inadequate treatment leads to osteomyelitis
- Virulent bacteria causes cellulitis
- Immunocompromised patients - Septicemia

## 2. Chronic suppurative osteomyelitis

### i. Pathogenesis

Improper or inadequate treatment for acute osteomyelitis, infected fractures, periodontal diseases, pulpal infections, extraction wounds.



### ii. Clinical features

- Swelling
- Pain
- Sinus formation
- Sequestrum formation
- Purulent discharge
- Loss of tooth
- Pathological fracture

iii. Histological features	<ul style="list-style-type: none"> <li>• Connective tissue in trabecular areas is inflamed</li> <li>• Scattered sequestra</li> <li>• Abscess pockets</li> </ul>
iv. Radiographic features	<ul style="list-style-type: none"> <li>• Radiopaque sequestra</li> <li>• Patchy, ragged and ill defined radiolucency</li> </ul>

### v. Management

- Medical management is difficult
- Based on spread of the disease, surgical intervention is mandatory
- Higher dose of antibiotics are to be given intravenously

**Smaller lesions:** Removal of necrotic bone and decortication followed by curettage

**Extensive osteomyelitis:** Decortication + Transplantation of cancellous bone chips

**Persistent osteomyelitis:** Resection of infected bone followed by immediate reconstruction using an autologous graft. Immobilization of weakened bone

## II. Focal sclerosing osteomyelitis

- Also called as condensing osteitis
- Localized areas of bone sclerosis
- Bone reacts to low grade periapical infections or to strong host defensive response
- Inflammatory association is critical

### 1. Clinical features

- Age: children and young adults
- Location: premolar and molar regions of mandible
- Bony sclerosis is associated with nonvital pulp or pulpitic tooth

<b>2. Histological features</b>	<ul style="list-style-type: none"> <li>• Sclerotic bone is dense</li> <li>• Connective tissue is scanty</li> <li>• Inflammatory cells are evident</li> </ul>
<b>3. Radiographic features</b>	<ul style="list-style-type: none"> <li>• Uniform and localized radiodensity around the teeth is seen</li> <li>• Periodontal ligament space or periapical space are widened</li> <li>• Few cases, adjacent inflammatory lesions are seen</li> </ul>

### 4. Management

- Eliminating the source of inflammation either by removal of teeth or endodontic management of infected tooth
- For persistent lesions with widened periodontal ligament, reevaluation of endodontic therapy is considered
- Bone scarring will be seen after resolution of lesion

### III. Diffuse sclerosing osteomyelitis

- It is an ill defined bony infection
- Etiology is unknown
- Chronic intraosseous bacterial infection leads to formation of chronically inflamed granulation tissue

<b>1. Clinical features</b>	<ul style="list-style-type: none"> <li>• No sex predominance</li> <li>• Adults are commonly affected</li> <li>• <u>No pain or swelling is seen</u></li> </ul>
<b>2. Histological features</b>	<ul style="list-style-type: none"> <li>• Bony sclerosis and remodeling is seen</li> <li>• Marrow spaces are scanty</li> <li>• Necrotic bone is surrounded by granulation tissue, separated from vital bone</li> <li>• Colonization of secondary bacteria is seen</li> </ul>
<b>3. Radiographic features</b>	<ul style="list-style-type: none"> <li>• Increase in radiodensity in areas with lesion</li> </ul>

### 4. Management

- Eliminating the origin of source of inflammation either through extraction or endodontic management of tooth

### IV. Proliferative periostitis

- Also called 'Periostitis ossificans' and 'Garre's osteomyelitis'
- Represents a periosteal reaction to the inflammation
- Affected periosteum forms several rows of reactive vital bone parallel to each other and expands the surface of bone

#### 1. Pathogenesis

Spread of low grade, chronic apical inflammation through cortical bone



Periosteal reaction



Stimulation of proliferative reaction of periosteum

#### 2. Clinical features

- Age: Children and young adults with a mean age of 13 years
- No gender predilection
- Location: Premolar and molar regions of mandible

- Hyperplasia is located most commonly along the lower border of mandible
- They are unifocal and multiple quadrants can be affected

<b>3. Histological features</b>	<ul style="list-style-type: none"> <li>• Highly cellular reactive woven bone arranged in parallel is seen</li> <li>• Perpendicular oriented trabeculae to the surface, sometimes with an interconnecting mesh work</li> <li>• Uninflamed fibrous tissue is evident</li> </ul>
<b>4. Radiographic features</b>	<ul style="list-style-type: none"> <li>• Radiopaque laminations of parallel reactive woven bone</li> <li>• Laminations may vary between 1 - 12</li> <li>• Radiolucent separations between new bone and cortical bone</li> </ul>



### 5. Management

- Removal of origin of infection
- After resolving the infection, layers of bone will consolidated in 6 - 12 months

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**Please Give Your Feedback on this Answer**

## Regulation of blood pressure (7M)

### CONTENTS/SYNOPSIS

- Introduction
- Regulation of the blood pressure
- Nervous regulation
  - Auto-regulation by kidneys
    - Renal Fluid Mechanism
    - Aldosterone system
    - Renin - angiotensin system
- Hormonal regulation
  - Hormones which increase blood pressure
  - Hormones which decrease blood pressure
- Local mechanisms
  - Vasoconstrictors
  - Vasodilators
- References

## INTRODUCTION

- Blood pressure is a measure of the force blood exerts against the blood vessel walls.
- During ventricular systole, the heart pushes blood into the arteries, and the pressure reaches a maximum called the systolic pressure.
- The normal systolic blood pressure ranges between 110 and 130mm Hg.
- During ventricular relaxation, blood pressure in the arteries falls to a minimum value called the diastolic pressure.
- The normal diastolic blood pressure ranges between 60 and 80mm Hg.
- The blood pressure is conventionally written as systolic pressure over diastolic pressure, i.e. 120/80mm Hg.

## REGULATION OF THE BLOOD PRESSURE

- Regulatory mechanisms of the body are:
  - Nervous regulation
  - Auto-regulation by kidneys
  - Hormonal regulation
  - Local mechanisms

### I. Nervous regulation

- The nervous regulation begins to act within seconds to minutes after arterial blood pressure becomes abnormal.
- These are primarily the circulatory reflexes which begin to act within seconds and help to control blood pressure from rising extremely high or falling extremely low.

For e.g. during sudden change in body posture or in case of profuse bleeding

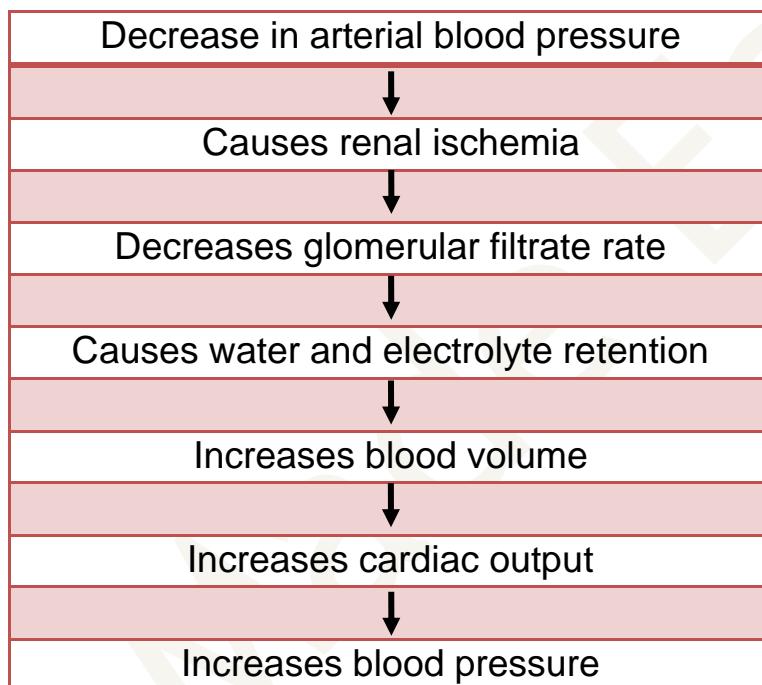
- The nervous mechanism regulating the arterial blood pressure constitutes the Vasomotor system.
- It Includes three components
  - Vasomotor center
  - Vasoconstrictor fibers
  - Vasodilator fibers

### II. Auto regulation by kidneys

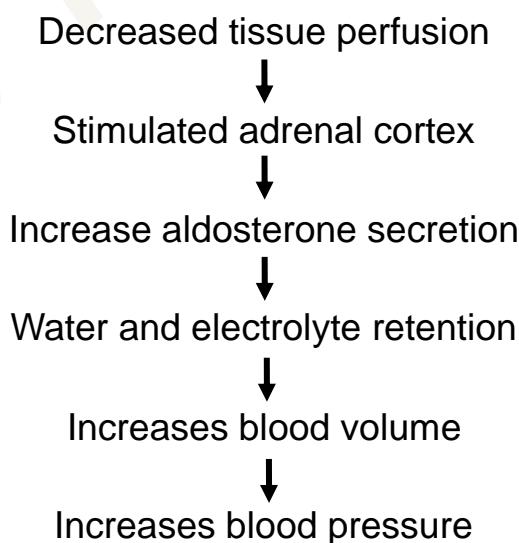
- Generally it takes 3-10 days for these mechanisms to come to complete equilibrium.

- Their functions is to control the arterial blood pressure over a period of days to years.
- It is sub-divided into:
  - Direct mechanism: Renal Fluid Mechanism
  - Indirect mechanism
    - Aldosterone system
    - Renin-angiotensin system

### 1. Renal fluid mechanism

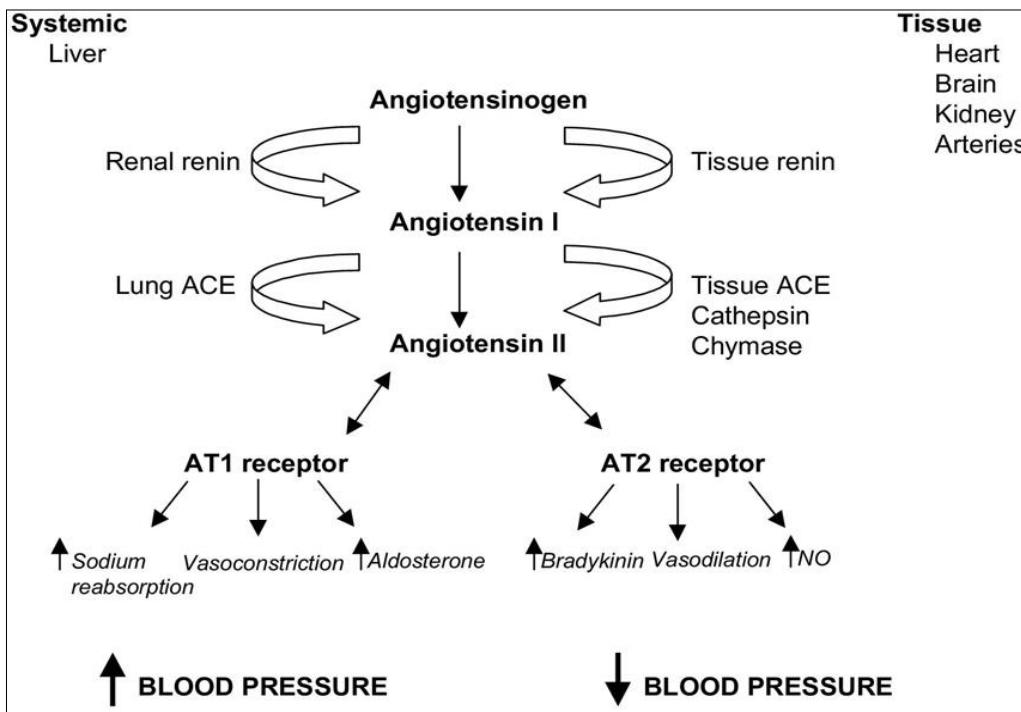


### 2. Aldosterone system



### 3. Renin-angiotensin system

- When blood pressure decreases, rennin secretion from kidney is increased.
- It converts Angiotensinogen into Angiotensin I.



- This is converted into Angiotensin II by Angiotensin converting enzyme.
- Angiotensin II acts in two ways to restore the blood pressures

### III. Hormonal regulation

#### 1. Hormones which increase blood pressure

i. <b>Adrenaline</b>	<ul style="list-style-type: none"> <li>It regulates through heart and blood vessels</li> <li>Increases systolic blood pressure by increasing force of contraction and cardiac output through <math>\alpha</math> receptors</li> <li>Decreases diastolic pressure by decreasing total peripheral resistance through <math>\beta_2</math> receptors</li> </ul>
ii. <b>Noradrenaline</b>	<ul style="list-style-type: none"> <li>It increases Diastolic blood pressure by general vasoconstrictor effects through <math>\alpha</math> receptors.</li> <li>Has strong action on blood vessels than heart.</li> <li>It elevates blood pressure by increasing total peripheral resistance.</li> <li>It causes slight increase in systolic blood pressure by increase in force of contraction</li> </ul>
iii. <b>Thyroxine</b>	<ul style="list-style-type: none"> <li>It increases systolic pressure by increasing</li> </ul>

	<p>cardiac output.</p> <ul style="list-style-type: none"> <li>Decreases diastolic pressure indirectly by action of metabolites.</li> <li>Mean arterial pressure is generally not altered by thyroxin.</li> <li>Only pulse pressure increases.</li> </ul>
iv. <i>Vasopressin</i>	<ul style="list-style-type: none"> <li>Vasoconstriction of arteries in all parts of the body.</li> <li>It increases blood pressure.</li> </ul>
v. <i>Serotonin</i>	<ul style="list-style-type: none"> <li>It is - 5 hydroxy tryptamine</li> <li>It increases blood pressure by producing vasoconstriction.</li> </ul>

## 2. Hormones which decrease blood pressure

i. <i>Vasoactive Intestinal polypeptide</i>	<ul style="list-style-type: none"> <li>Secreted in Stomach, Small intestine and Large intestine.</li> <li>Causes decrease in blood pressure by vasodilatation.</li> </ul>
ii. <i>Bradykinin</i>	<ul style="list-style-type: none"> <li>It is produced in blood in conditions like inflammation.</li> <li>Kallikrein acts on <math>\alpha</math>2 globulin to convert Kallidin to bradykinin.</li> <li>It causes vasodilatation.</li> </ul>
iii. <i>Prostaglandins</i>	<ul style="list-style-type: none"> <li>It is secreted from almost all tissues of the body.</li> <li>It causes vasodilatation.</li> </ul>
iv. <i>Histamine</i>	<ul style="list-style-type: none"> <li>It secreted by nerve endings of hypothalamus, limbic system and parts of cerebral cortex.</li> <li>It is also released from tissues during allergic and inflammatory conditions.</li> <li>Causes vasodilatation.</li> </ul>
v. <i>Acetylcholine</i>	<ul style="list-style-type: none"> <li>Cholinergic neurotransmitter released from the ends of preganglionic parasympathetic nerves, postganglionic parasympathetic nerves, preganglionic sympathetic nerves.</li> <li>It also released from postganglionic sympathetic cholinergic nerves supplying eccrine sweat</li> </ul>

	glands and sympathetic vasodilator nerves in skeletal muscles.
vi. <i>Atrial natriuretic peptide [ANP]</i>	<ul style="list-style-type: none"> <li>ANP is a hormone is a secreted by the musculature of atria of the heart.</li> <li>Causes dilation of blood vessels.</li> </ul>

#### IV. Local mechanisms

- Local substances released in the body regulate blood pressure by vasoconstriction or dilatation.

<b>Vasoconstrictors</b>	<b>Vasodilators</b>
<ul style="list-style-type: none"> <li>Endothelial origin, hence known as Endothelins (ET)</li> <li>They are of three types, ET1, ET2, ET3</li> <li>Released by stretching of blood vessels</li> <li>Acts by activating phospholipases, which in turn activates prostacycline &amp; thromboxane A2</li> <li>These causes vasoconstriction</li> </ul>	<ul style="list-style-type: none"> <li>Metabolic origin           <ul style="list-style-type: none"> <li>Carbon dioxide</li> <li>Lactate</li> <li>Hydrogen ions</li> <li>Adenosine</li> </ul> </li> <li>Endothelial origin           <ul style="list-style-type: none"> <li>Nitric oxide (NO) is an endothelium derived relaxing factor synthesized from Arginine.</li> </ul> </li> </ul>

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*Please Give Your Feedback on this Answer*

## Shock (10M)

### CONTENTS/SYNOPSIS

- Introduction
- Classification
- Pathophysiology of shock
- Types of shocks
  - Hypovolemic shock
  - Cardiogenic shock
  - Septic shock
  - Traumatic shock
  - Neurogenic shock
  - Hypoadrenal shock
- Etiology
- Pathophysiology
- Clinical manifestations
- Investigations
- Management
- References

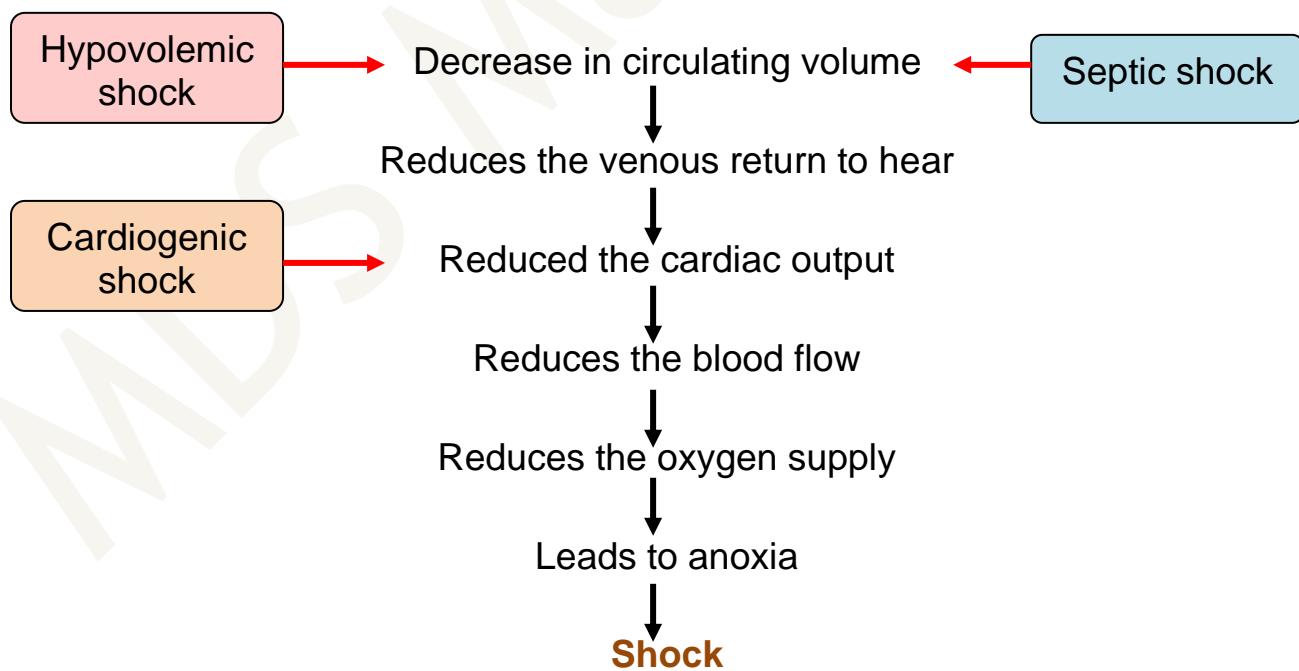
## INTRODUCTION

- Shock is defined as a state of cellular and tissue hypoxia caused due to either
  - Reduced oxygen delivery,
  - Increased consumption of oxygen,
  - Inadequate utilization of oxygen,
  - Combination of these
- It is a physiological state characterized by systemic decrease in tissue perfusion & results in reduction of tissue oxygen delivery
- Initially it is reversible, should be recognized earlier and treated to prevent progression to a irreversible organ damage

## CLASSIFICATION

- Based on the factors, there are three types of shocks
  - Hypovolemic shock
  - Cardiogenic shock
  - Septic shock
  - Traumatic shock
  - Neurogenic shock
  - Hypoadrenal shock

## PATHOPHYSIOLOGY



## TYPES OF SHOCK

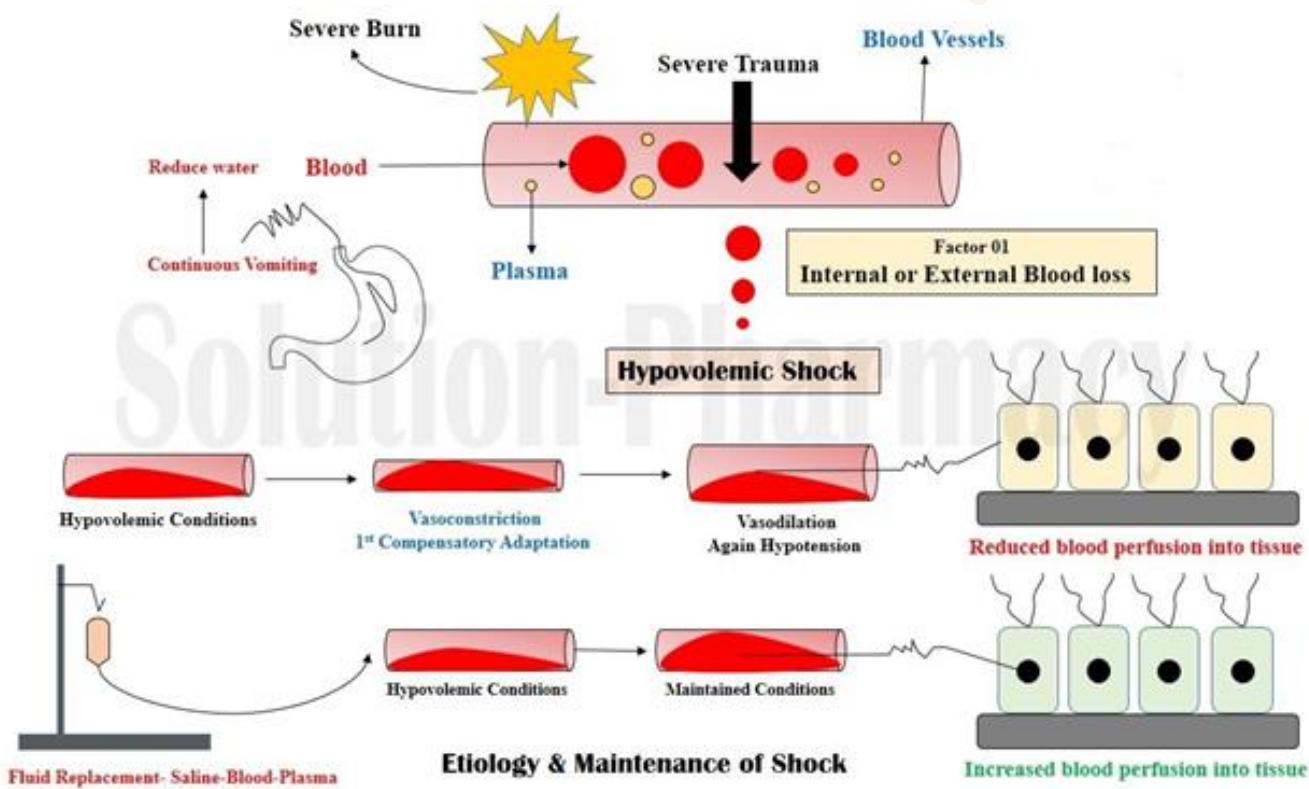
### I. Hypovolemic Shock

- Most common type of shock
- Mainly due to the deficient circulatory blood volume by different etiological factors
- Loss of red cell mass & plasma in hemorrhage or loss of plasma volume alone

External or internal injury leads to hemorrhagic hypovolemic shock

Vomiting, diuresis, diarrhoea, burns leads to non hemorrhagic hypovolemic shock

### 1. Pathophysiology



## 2. Clinical manifestations

- Anxiety
- Lethargy
- Tachypnea
- Tachycardia with weak and thready pulse
- Orthostatic drop leads to hypotension
- Delayed capillary refill
- Skin becomes cool and clammy
- Oliguria
- Thirst

<i>i. Mild (&lt; 20% blood volume)</i>	<i>ii. Moderate (20 - 40% blood volume)</i>	<i>iii. Severe (&gt;40% blood volume)</i>
<ul style="list-style-type: none"> <li>• Extremities will become cool</li> <li>• Increased capillary refill time</li> <li>• Diaphoresis</li> <li>• Collapsed veins</li> <li>• Anxiety</li> </ul>	<ul style="list-style-type: none"> <li>• Similar to mild symptoms and</li> <li>• Tachycardia</li> <li>• Tachypnea</li> <li>• Oliguria</li> <li>• Postural changes</li> </ul>	<ul style="list-style-type: none"> <li>• Similar to mild symptoms and</li> <li>• Hemodynamic instability</li> <li>• Hypotension</li> <li>• Tachycardia</li> <li>• Mental status deterioration</li> <li>• Coma</li> </ul>

## 3. Management

- The main goal is to restore blood volume and improve tissue perfusion and oxygenation
- Control of bleeding or loss of blood volume
- Rapid re-expansion of the circulating intravascular blood volume by fluid therapy and blood transfusions
- Fluid therapy: 20ml/kg should be given between 5 - 15mins
  - Crystalloid solutions (0.9% saline, ringers lactate)
  - Colloid solutions (5% albumin, gelatins)
- Blood transfusion: 1 unit of blood in 20 minutes

## II. Cardiogenic Shock

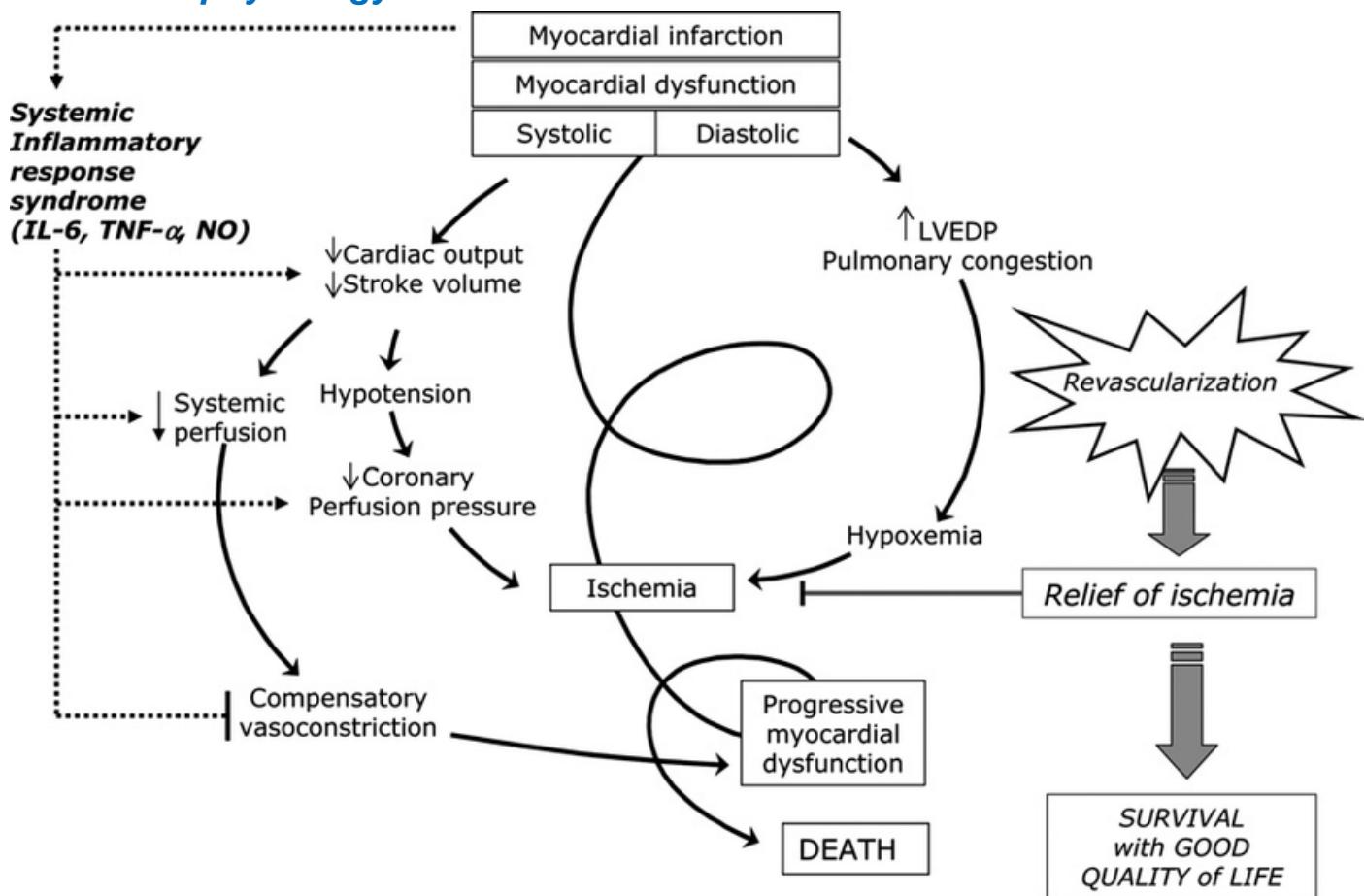
- Defined as persistent hypotension and tissue hypo perfusion due to cardiac dysfunction in the presence of inadequate intravascular volume and left ventricular filling pressure
- Hemodynamic criteria:
  - Sustained hypotension (SBP < 90mm Hg for a minimum of 30 minutes)
  - Reduced cardiac index (< 2.2 L/min per square meter)
  - Elevated pulmonary artery wedge pressure (>15mm Hg)

### 1. Etiology

- Most common is left ventricular failure due to extensive acute myocardial infarction
- According to shock trial registry

i. <i>Myocardial infarction</i>	<ul style="list-style-type: none"> <li>• Pump failure</li> <li>• Large infarction</li> <li>• Smaller infarctions with left ventricular dysfunction</li> <li>• Severe recurrent ischemia</li> <li>• Infarction expansion</li> </ul>
ii. <i>Mechanical complications</i>	<ul style="list-style-type: none"> <li>• Papillary muscle rupture leading to mitral regurgitation</li> <li>• Septal defect of ventricle</li> <li>• Free wall rupture</li> <li>• Pericardial tamponade</li> <li>• Right ventricular infarction</li> </ul>
iii. <i>Others</i>	<ul style="list-style-type: none"> <li>• End stage cardiomyopathy</li> <li>• Myocarditis</li> <li>• Septic shock</li> <li>• Aortic stenosis</li> <li>• Obstruction to left ventricular filling</li> <li>• Mitral stenosis</li> <li>• Mitral regurgitation due to chordal rupture</li> </ul>

## 2. Pathophysiology



## 3. Clinical manifestations

- Hypo perfusion manifested by
  - Sinus tachycardia
  - Low urine output
  - Cool extremities
- Patients with myocardial infarction presents with
  - Heavy substernal chest pain
  - May radiate to left arm or neck
  - Pain is atypical, can be burning, sharp or stabbing type

## 4. Investigations

- Complete blood picture
- Serum electrolytes
- Cardiac enzymes to diagnose myocardial infarction
- Creatine kinase: elevate within 10 hrs with peaks at 24 - 48 hrs
- Troponin: Peaks at 14 hrs
- Myoglobin: Rise in 4 folds over 2 hrs

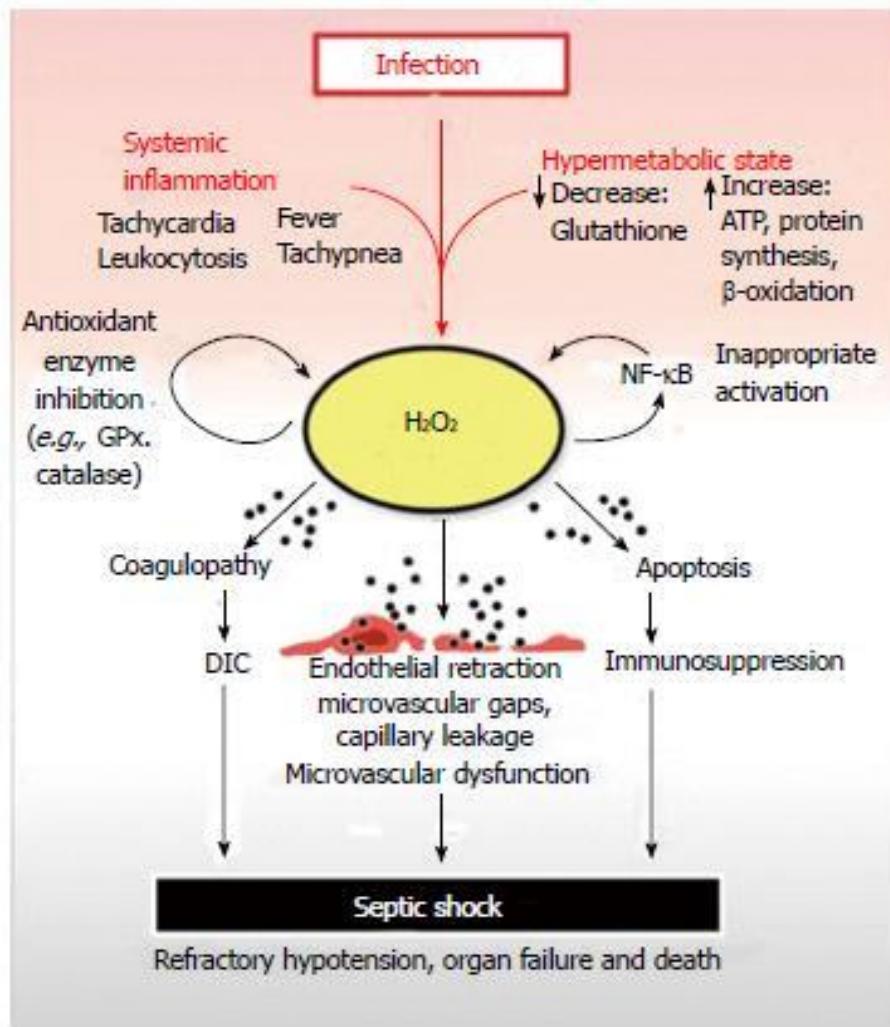
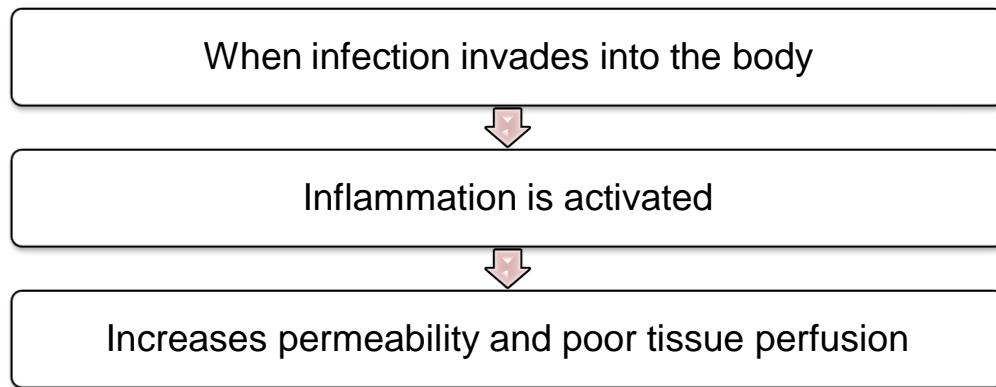
- Followed by imaging analysis

### 5. Management

<ul style="list-style-type: none"><li>Pharmacological management</li></ul>	<ul style="list-style-type: none"><li>Dopamine: stimulate adrenergic and dopaminergic receptors<ul style="list-style-type: none"><li>Low dose: 1 - 5mcg/ kg/ min IV</li><li>Medium dose: 5 -15 mcg/ kg/ minv IV</li><li>High dose: 20 - 50 mcg/ kg/ min IV</li></ul></li><li>Dobutamine: Produces systemic vasodilation and increases the inotropic state, 2 - 20 mcg/ kg/ min IV</li><li>Norepinephrine: naturally occurring catecholamine, stimulate beta 1 and alpha adrenergic receptors<ul style="list-style-type: none"><li>Dosage: 8 - 12 mcg/min IV</li><li>Maintenance dose: 2 - 4mcg/ min IV</li></ul></li><li>Vasodilators: Eg. Nitroglycerin IV</li><li>Diuretics: Eg: Furosemide</li></ul>
<ul style="list-style-type: none"><li>Intra aortic balloon pump therapy</li></ul>	
<ul style="list-style-type: none"><li>Emergency revascularization</li></ul>	
<ul style="list-style-type: none"><li>Ventricular assisted devices</li></ul>	

### III. Septic Shock

- It is also known as toxemic shock
- Septicemia or severe bacterial infections induce septic shock
- Septic shock is of 2 types,
  - Exotoxic type (gram negative septicemia)
  - Endotoxic type (gram positive septicemia)



1. Risk factors	2. Clinical manifestations
<ul style="list-style-type: none"> <li>• Diabetes</li> <li>• Diseases of genitourinary system, biliary system or intestinal system</li> <li>• Catheters</li> <li>• Immunocompromised conditions</li> </ul>	<ul style="list-style-type: none"> <li>• Redness around the infection</li> <li>• Discharge of pus or fluids from incision site</li> <li>• Warmer skin around the site of incision</li> </ul>

- Leukemia
- Long term abuse of antibiotics
- Organ or bone marrow transplantation
- Recent usage of steroids
- Chronic illness
- Malnourishment

- Increased pain
- Fever
- Fatigue

### Symptoms if septic shock affects organs of the body

- Extremities become cool and pale
- Body temperature becomes either very low or high
- Light headaches
- Little or no urine output
- Low blood pressure, Palpitations, Rapid heart rate
- Restlessness, Lethargy, Shortness of breath
- Skin rashes

### **3. Management**

- Mechanical ventilation to improve breathing
- Dialysis
- Pharmacological management to treat low blood pressure, infections, blood clotting
- Fluid management
- Oxygen supplement
- Sedatives to control the pain
- Surgery if needed
- Hemodynamic monitoring to check for heart and lungs
- Sepsis six is the name given to a list of medical therapies designed to reduce the mortality of patients with sepsis
- It consists of three diagnostic and three therapeutic steps : all should be delivered within one hour of the initial diagnosis of sepsis

- Deliver high flow oxygen
- Administer empiric intravenous antibiotics
- Measure serum lactate and perform total blood count
- Start intravenous fluid resuscitation
- Begin accurate urine output measurement

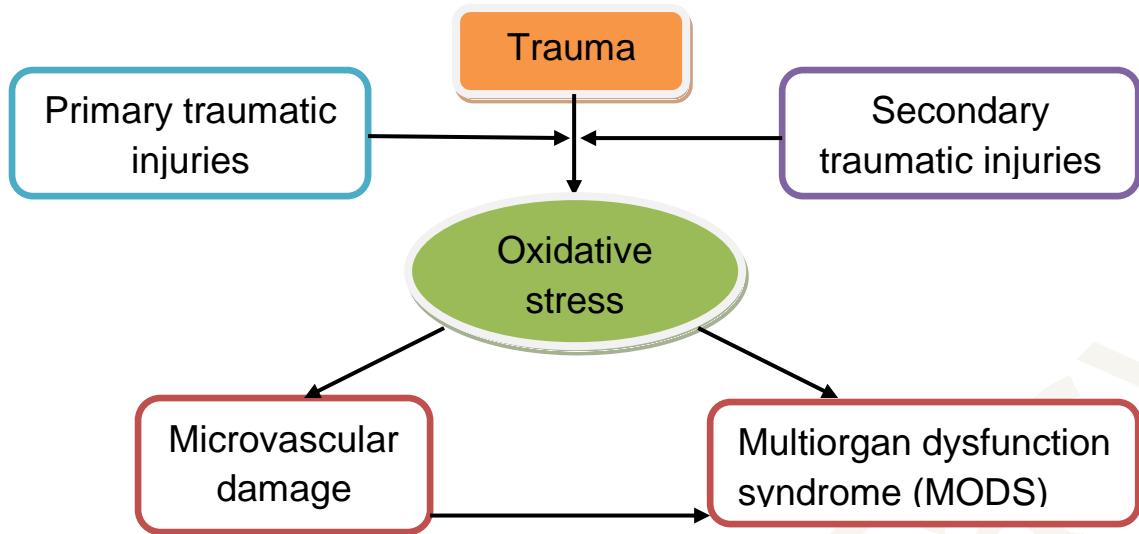
### *Management of severe sepsis*

- Initial resuscitation and management of infection issues
- Hemodynamic support and adjunctive therapy:
  - Fluid therapy
  - Vasopressors
  - Inotropic support
  - Corticosteroids
- Supportive therapy of severe sepsis
  - Administration of blood
  - Mechanical ventilation of sepsis
  - Sedation, analgesia and neuromuscular blockade
  - Glucose control
  - Renal replacement therapy
  - Stress ulcer prophylaxis
  - Nutrition

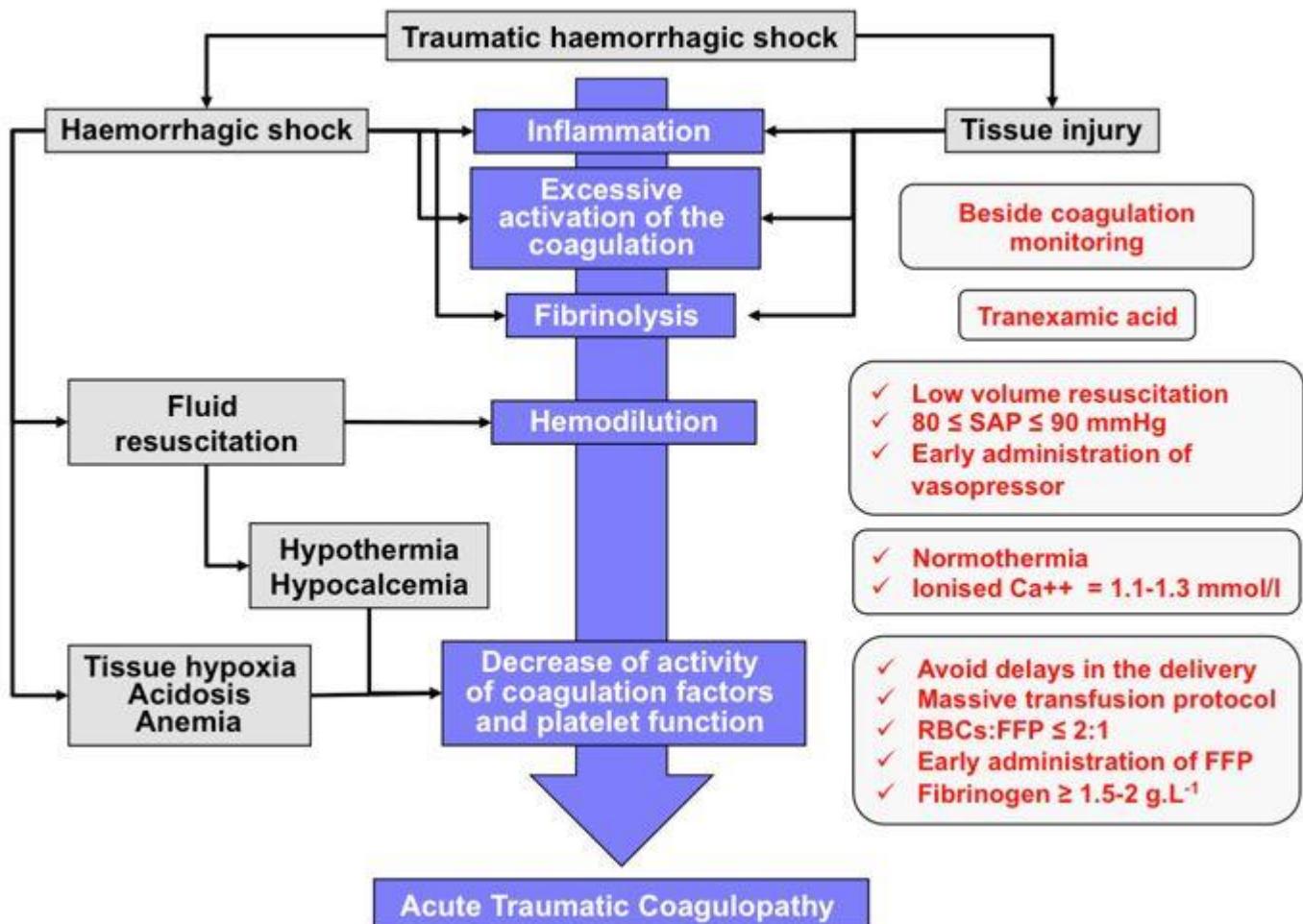
## **IV. Traumatic shock**

### **1. Etiology:** Trauma results in hypovolemia

- Even after the hemorrhage, there is loss of plasma volume into the injured tissue or interstitium
- Secondary microcirculation injury
- Third spacing



## 2. Management

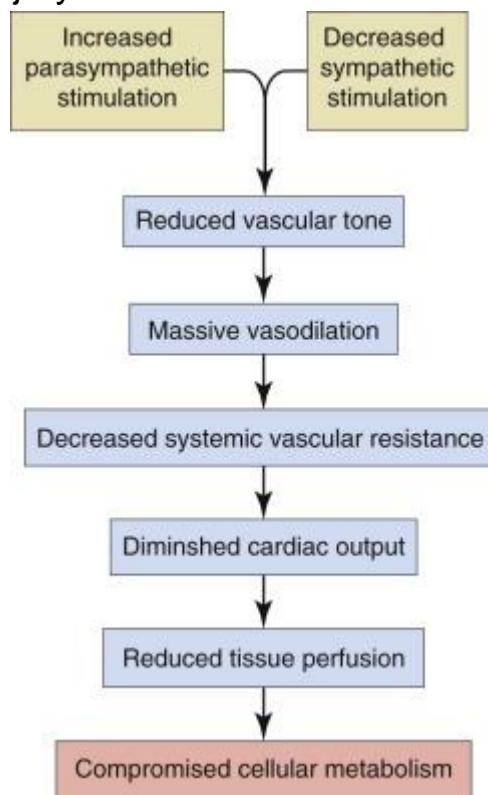


## V. Neurogenic Shock

### 1. Etiology:

- High cervical spinal cord injury
- Accidental high spinal anesthesia

## ➤ Severe head injury



**2. Pathogenesis:** Occurs due to imbalance between the sympathetic and parasympathetic stimulation

- This results in vasodilatation & fluid shifts take place, but with normal blood volume
- Finally, induces shock

**3. Management:** Vasopressors are administered to treat the condition

## VI. Hypoadrenal Shock

- Etiology:
  - Administration of high doses of glucocorticoids
  - Secondary adrenal insufficiency due to tuberculosis, metastatic diseases, bilateral adrenal haemorrhage, idiopathic adrenal atrophy)
- Hence, the patient fails to respond normally to the stress like surgery, trauma or illness

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*Please Give Your Feedback on this Answer*

### Xerostomia (May 2019, 10M)

**Management of a Xerostomia patient is a challenge to prosthodontist - Discuss (10M)**

**Role of sialogogues and antisialogogues in prosthodontics (6M)**

**Role of saliva in prosthesis retention (7M) (20M)**

### CONTENTS/SYNOPSIS

- Introduction of saliva
- Properties of saliva
- Functions of saliva
  - Defense
  - Digestion
  - Protective function
  - Buffering action
  - Lubrication
  - Excretion
- Xerostomia
  - Etiology
    - Medications
    - Systemic factors
    - Loss of electrolytes
    - Local factors
  - Signs of xerostomia
  - Symptoms of xerostomia
  - Management of xerostomia
- Sialogogues and anti sialogogues
- Prosthodontic considerations
  - Management of patients with xerostomia
    - In complete dentures
    - In removable partial dentures
    - In fixed partial dentures
  - Management of patients with Sialorrhea
    - In removable partial dentures

- Cleaning of alginate impression material
- In fixed partial dentures
- Denture base extension (in relation to salivary gland duct openings)
- Amount of saliva
- Consistency of saliva
- Role of saliva in denture retention
- Artificial salivary substitutes
  - Salivary substitutes commonly used in prosthodontics
  - Composition of salivary substitutes
  - Uses of salivary substitutes
  - Indications
  - Contraindications
  - Side effects
- Conclusion
- References

## INTRODUCTION

- Saliva is a complex fluid, produced by the salivary glands.
- Human saliva consist of organic and inorganic components and plays an essential role in mastication, in bolus formation, acts as a lubricant in swallowing, helps in speech production and protecting the mucosal surfaces of the oral cavity from desiccation.
- According to Stedman's Dictionary: Saliva is a clear, tasteless, odourless slightly acidic (pH6.8), viscid fluid, consisting of secretions from the parotid, sublingual and submandibular salivary gland and the mucous glands of the oral cavity.

## PROPERTIES OF SALIVA

- **Volume:** Daily secretion ranges between 800 -1500mL
- Contribution by each major salivary gland is:

- Parotid Gland: 25%
- Submandibular Gland: 70%
- Sublingual Gland: 5%

- **pH:** 6.0 - 7.0
- **Specific Gravity:** 1.002 - 1.012
- **Tonicity:** Hypotonic to plasma.
- **Unstimulated salivary flow:** 0.25 - 0.35 ml/ min

## FUNCTIONS OF SALIVA

### I. Defense:

- Antibacterial
- Antifungal
- Antiviral
- Immunological

- Enzymes lysozyme of saliva kills some bacteria such as *Staphylococcus*, *Streptococcus* & *Brucella*
- Proline rich proteins (poses antimicrobial property) and neutralize toxic substances such as tannins
- Tannins are found in many food substances including fruits

<b>Lactoferrin</b>	<ul style="list-style-type: none"> <li>• Antimicrobial property</li> </ul>
<b>Proline rich proteins and lactoferrin</b>	<ul style="list-style-type: none"> <li>• Provides protection to teeth by stimulating enamel formation</li> </ul>
<b>Ig A</b>	<ul style="list-style-type: none"> <li>• Antibacterial and anti-viral actions</li> </ul>
<b>Mucin</b>	<ul style="list-style-type: none"> <li>• Lubricates mucus membrane of mouth</li> </ul>

## II. Digestion

- Digestive enzymes: ptyalin, lipase
- Formation of bolus
- Taste

<b>1. Salivary amylase</b>	<b>2. Maltose</b>
<ul style="list-style-type: none"> <li>• Carbohydrate: digestive (amylolytic) enzymes</li> <li>• Converts cooked or boiled starch into dextrin and maltose</li> <li>• Cannot act on cellulose</li> <li>• Optimum pH for activation of salivary amylase is 6.</li> </ul>	<ul style="list-style-type: none"> <li>• Present in faeces</li> <li>• Converts maltose into glucose</li> </ul>
<b>3. Lingual Lipase</b>	
<ul style="list-style-type: none"> <li>• Lipid digesting (lipolytic) enzyme.</li> <li>• Secreted from serous glands situated on the posterior aspect of tongue.</li> <li>• Digests milk fats (pre - emulsified fats)</li> <li>• Hydrolyzes triglycerides into fatty acids and glycerol</li> <li>• Food taken into the mouth is moisture and dissolved by saliva</li> <li>• Mucus membrane of mouth is also moistened by saliva which facilitates chewing</li> <li>• By movement of tongue → moistened and masticated → Rolled into bolus</li> <li>• MUCIN- lubricates the bolus and facilitates swallowing</li> </ul>	

## III. Protective function:

- Protective coating for soft tissues
- Protective coating for hard tissues

- Proline rich proteins lactoferrin → protect the teeth by stimulating enamel formation
- Mucin: protects the mouth by lubricating the mucus membrane of mouth.
- Constant secretion of saliva keeps the mouth and teeth rinsed and free-off debris, shed epithelial cells and foreign particles
- Saliva prevents bacterial growth by removing materials, which may serve as culture media for the bacterial growth

#### IV. Lubrication function:

- Keeps the oral cavity moist
- Facilitates speech
- Helps in mastication and swallowing

- If mouth becomes dry – articulation and pronunciation become difficult
- Saliva helps in BOLUS formation
- Saliva keeps the food moistened and helps in mastication and swallowing

#### V. Buffering function:

1. Regulation of body temperature	2. Regulation of water balance
<ul style="list-style-type: none"> <li>• In humans, sweat glands play a major role in temperature regulation</li> <li>• Saliva does not play any role in this function</li> <li>• In dogs and cattle → excessive dripping of saliva during panting → helps in loss heat and regulation of body temperature</li> </ul>	<ul style="list-style-type: none"> <li>• Decrease body water content causes decrease in salivary secretion</li> <li>• This causes dryness of mouth</li> <li>• Induces thirst</li> <li>• When water is taken → quenches thirst → restores body water content</li> </ul>

#### VI. Excretory function:

- Organic and inorganic substances are excreted in saliva
- Excretes substances like mercury, potassium iodide, lead and thiocyanate
- Also excretes some viruses such as those causing RABIES and HUMPS
- Pathological conditions in which saliva shows components, which are not found in saliva under normal condition

- Glucose in diabetes mellitus
- Excess urea in nephritis
- Excess calcium in hyperparathyroidism

- Saliva contains large amounts of potassium and bicarbonate ions & less amounts of sodium and chloride ions when compared to plasma
- Primary secretion contains ptyalin and/or mucin in a solution of ions with concentrations similar to those of extracellular fluid

## XEROSTOMIA (DRY MOUTH)

- It is a subjective symptom of dry mouth caused due to decreased production of saliva.
- It is a symptom caused by several factors

### 1. Etiology

<i>i. Medications</i>	<ul style="list-style-type: none"><li>• Antihistamines:<ul style="list-style-type: none"><li>➢ Diphenhydramine</li><li>➢ Chlorpheniramine</li></ul></li><li>• Decongestants: pseudo ephedrine</li><li>• Anti depressants:<ul style="list-style-type: none"><li>➢ Amitriptyline</li><li>➢ Fluoxetine</li><li>➢ Paroxetine</li><li>➢ Citalopram</li></ul></li><li>• Sedative:<ul style="list-style-type: none"><li>➢ Diazepam</li><li>➢ Lorazepam</li><li>➢ Alprazolam</li></ul></li></ul>
<i>ii. Systemic factors</i>	<ul style="list-style-type: none"><li>• Sjogren's syndrome</li><li>• Radiation of head and neck</li><li>• Surgical removal of salivary glands</li><li>• Viral infections involving salivary glands (HIV, Hepatitis C)</li><li>• Anxiety, mental stress and depression</li><li>• Diabetes mellitus</li><li>• Sarcoidosis</li></ul>

	<ul style="list-style-type: none"> <li>• Parkinson's disease</li> </ul>
<i>iii. Loss of electrolyte</i>	<ul style="list-style-type: none"> <li>• Decreased intake</li> <li>• hemorrhage</li> <li>• Vomiting</li> <li>• Diarrhea</li> </ul>
<i>iv. Local factors</i>	<ul style="list-style-type: none"> <li>• Smoking</li> <li>• Excessive caffeine intake</li> <li>• Mouth breathing</li> <li>• Alcohol abuse</li> </ul>

<b>2. Symptoms</b>	<b>3. Signs</b>
<ul style="list-style-type: none"> <li>• Dryness of mouth</li> <li>• Halitosis</li> <li>• Burning sensation</li> <li>• Difficulty in swallowing</li> <li>• Loss of sense of taste</li> <li>• Tongue tends to stick to the palate</li> <li>• Denture retention is decreased</li> </ul>	<ul style="list-style-type: none"> <li>• Salivary pool disappears</li> <li>• Dryness of mucosa</li> <li>• Glossitis of tongue</li> <li>• Mucosa atrophied</li> <li>• Angular cheilitis</li> <li>• Rampant caries</li> <li>• Candidiasis</li> <li>• Periodontitis</li> </ul>

#### **4. Management of xerostomia**

- Patient education
- Changes in diet and life style
- Management of systemic diseases and usage of medication
- Prevention of dental caries and oral mucous diseases
- Palliative management of symptoms
- Sialogogues or salivary gland stimulants

### **SIALOGOGUES AND ANTISIALOGOGUES**

<b>I. Substances increasing salivary secretion (sialogogues)</b>	<b>II. Substances decreasing salivary secretion (anti sialogogues)</b>
<ul style="list-style-type: none"> <li>• Sialogogues are the agents or drugs used to increase salivation due to dryness of mouth or any other reason</li> </ul>	<ul style="list-style-type: none"> <li>• Anti sialogogues are the agents or drugs used to decrease the salivation or any other reasons</li> <li>• Sympathetic depressants like</li> </ul>

- Sympathomimetic drugs like Adrenaline & Ephedrine.
- Parasympathomimetic drugs like Acetylcholine, Pilocarpine, Physostigmine.

**Example:** Sialorrhea, ptyalism

- Ergotamine & Dibenahine.
- Parasympathetic depressants like Atropine & Scopolamine.
- Antihistamines
- Decongestants
- Antidepressants
- Sedatives
- Anti hypertensive agents
- Anti cholinergics
- Anti psychotic agents
- Radiotherapy

**Example:** Sjogren's syndrome, Xerostomia, candidiasis

## PROSTHODONTIC CONSIDERATIONS

### I. Prosthodontic management in xerostomia

#### 1. In fixed partial dentures

- In oral conditions with dry environment, fixed non tissue contacting prosthesis are indicated
- Abutments should have full coverage retainers with easily cleanable pontics and connectors are designed
- Supragingival margins are indicated to provide self cleansing

#### 2. In removable partial dentures

- Should design RPD to preserve periodontal health
- Gingivally approaching clasps are used
- Tooth supported dentures with minimal tissues coverage is indicated
- Metal denture bases are preferred as they play a vital role in transferring the senses to palate

**3. In complete dentures**

- Usage of soft liners to improve comfort
- Denture adhesives to enhance retention
- Proper hygiene instructions to avoid candida infections
- Fabrication of intraoral salivary reservoirs using artificial substitutes

**II. Prosthodontic management of patients with Sialorrhea****1. In removable partial dentures**

- Administration of antisialogogues 1 to 2 days prior treatment
- Irrigation with mouth astringent and mouth washes while making impressions
- Fast setting impression material should be used
- Absorptive strips are used during procedure to have a better operating field
- Tandem impression technique is used

**2. Cleaning of alginate impression material**

- Improper cleaning of impressions with residue of saliva leads to inaccurate cast
- Saliva in serous consistency should be washed off under cool tap or soft bristle brush with mild detergent
- In conditions with thick ropy saliva it is advised to sprinkle little gypsum product on the surface of impression

**3. In fixed partial dentures**

- It is important to maintain dry field while making an impression or cementing a fixed prosthesis.
- Can be achieved by using
  - Rubber dam
  - High volume suction
  - Saliva ejector
  - Anti sialagogues (Methantheline bromide, propantheline bromide etc)

**III. Denture base extension (in relation to salivary gland duct openings)**

- **Stenson's duct:** Very rarely maxillary denture obstructs this duct
- **Wharton's duct:** Overextension of lingual flange may obstruct the opening of wharton's duct, which may cause swelling under the tongue during mastication
- **Sublingual:** It is rare for a denture to cause obstruction to sublingual duct

#### IV. Amount of saliva

- Dry mouth: Retention is compromised, increased potential to damage mucosa
- Excess saliva: Complicates clinical steps like impression making
- Increased salivation for the first-time denture wearers is a common temporary condition, which is a response to foreign objective. Patients need to be assured about this

#### V. Consistency of saliva

- Serous type saliva is best for prosthetic management and maintenance
- Thick saliva: Compromises impressions, maxillary denture retention

#### VI. Denture retention

- Saliva plays a major role in creating retention and stability to dentures.
- The physical forces which play a major role in saliva are

- Adhesion
- Cohesion
- Interfacial surface tension
- Capillary attraction
- Peripheral seal
- Viscosity
- Surface tension

### ARTIFICIAL SALIVARY SUBSTITUTES

- Artificial saliva with properties similar to natural saliva in which salivary glycoproteins are replaced by carboxymethyl cellulose
- Available as solutions, sprays and gels

#### I. Salivary substitutes commonly used in prosthodontics

- Saliva orthana spray
- Saliva orthana gel
- Salivace
- Glandsane
- Salivix pasties
- Moisties

## II. Composition of salivary

- According to Jain M et al 2012

- Sodium carboxymethylcellulose
- Sorbital
- Potassium chloride
- Sodium chloride
- Magnesium chloride
- Calcium chloride
- Di potassium hydrogen orthophosphate
- Potassium di hydrogen orthophosphate
- Sodium fluoride
- Methyl p- hydroxybenzoate
- Spirit of lemon

## III. Uses of salivary substitutes

- Helps in retention of dentures in patients with xerostomia
- Patients with end stage renal disease with dry mouth and reduce thirst
- Patients under radiation therapy
- Sjogren's syndrome
- Antimicrobial activity
- Fluoride containing substitutes causes remineralisation, caries prevention

IV. Indications	V. Contraindications
<ul style="list-style-type: none"><li>Full mouth rehabilitations for patients undergoing radiotherapy, chemotherapy</li><li>Management of dryness in mouth and throat in conditions like<ul style="list-style-type: none"><li>➤ Xerostomia</li><li>➤ Medications</li><li>➤ Stroke</li><li>➤ HIV</li><li>➤ Sjogren's syndrome</li><li>➤ Bell's palsy</li><li>➤ Lupus aging</li></ul></li></ul>	<ul style="list-style-type: none"><li>Substitutes with carboxymethylcellulose parabens are contraindicated in patients with hypersensitivity, hypertension, pregnancy, renal failure.</li><li>Pilocarpine is contraindicated in asthmatic patients</li></ul>

- Salivary gland disorders
- Pharyngitis

**Side effects**

- Itching, tingling, sensation, swelling of face and mouth

**CONCLUSION**

- Saliva and its components act like a mirror to the health of an individual
- The knowledge in normal salivary composition, function and flow is important to diagnose any underlying physiologic or pathologic condition and create a better treatment plan.
- The role of saliva plays a critical role in edentulous patients, hence during rehabilitation with complete dentures the dentist should give attention to the nature of saliva for a better result

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**Please Give Your Feedback on this Answer**

## Antigen antibody reactions (10M)

### CONTENTS/SYNOPSIS

- Introduction
- Strength of antigen & antibody reaction
- Stages of antigen & antibody reaction
  - Primary stage
  - Secondary stage
  - Tertiary stage
- Types of antigen & antibody reaction
  - Precipitation Reaction
  - Ring Test
  - Slide Test
  - Tube Test
  - Agglutination Reaction
- Applications of antigen - antibody reactions in diagnostic pathology
- References

## INTRODUCTION

- French **word**, antigène
- From Greek root anti- "against", gen-"thing that produces or causes"
- Any substance or compounds (immunogen or a hapten) foreign to the human body that stimulates an immune response either alone or in combination with a larger molecule
- Proteins that recognize and neutralize any microbial toxins or foreign substances such as bacteria & viruses, which found in the serum and other body fluids of vertebrates that reacts specifically with the antigens
- Antibodies belong to a family of globular proteins: Immunoglobulin

## STRENGTH OF ANTIGEN - ANTIBODY REACTIONS

- Non- covalent interactions form the basis of antigen - antibody binding which includes
  - Hydrogen bond
  - Ionic bond
  - Hydrophobic interaction
  - Van der Waals interaction
- Antigen - antibody reaction requires high degree of complementarity between antigen & antibody

## STAGES OF ANTIGEN - ANTIBODY REACTION

### I. Primary Stage

- First interactions found between antigens & antibodies without any visible effects
- Reaction is rapid & reversible
- Primary reaction can be detected by estimating free & bound antigens or antibodies

### II. Secondary Stage

- Primary stage is followed by the secondary stage
- Leads to the demonstrable events

- Precipitation
- Agglutination
- Lysis of cells
- Killing of live antigens
- Neutralisation of toxins
- Fixation of complement
- Immobilization of mobile organisms
- Enhancement of phagocytosis

- Different type of antibody was responsible for each type of reaction
  - Agglutination: Agglutinin
  - Precipitation: Precipitin
- Single antibody can cause agglutination, precipitation & other serological reactions
- Antigen can evoke the production of different classes of immunoglobulin

### III. Tertiary Stage

- Antigen - antibody reactions take place in vivo, initiate chain reactions which leads to neutralization or destruction of injurious antigens or tissue damage
- Humoral immunity against infectious & immunological diseases

### **TYPES OF ANTIGEN ANTIBODY REACTION**

- Precipitation reaction
- Agglutination reaction
- Complement fixation test
- Neutralization tests
- Opsonisation
- Radio immunoassay
- Enzyme immunoassay
- Chemiluminescence immunoassay
- Immunoelectro blot techniques
- Immunochromatographic tests
- Immunoelectro microscopic tests
- Immunofluorescence

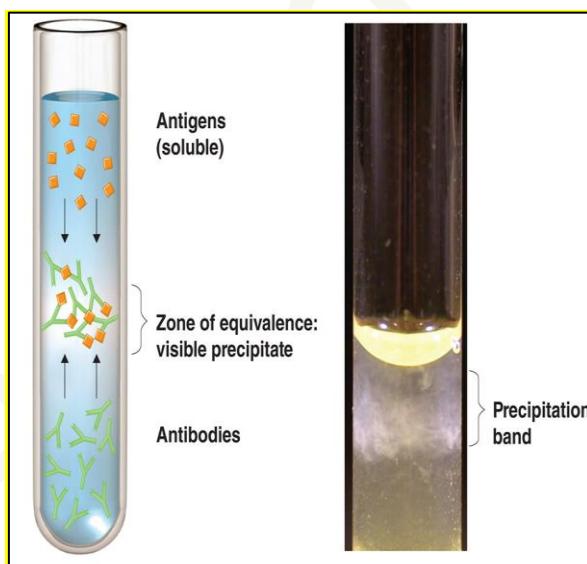
## I. Precipitation Reaction

- When a soluble antigen combines with its antibody in the presence of electrolytes at a suitable temperature & pH, the antigen - antibody complex forms an insoluble precipitate

1. Types	
Precipitation gel	<ul style="list-style-type: none"> <li>Single diffusion</li> <li>Double diffusion</li> </ul>
Precipitation in electrophoresis	<ul style="list-style-type: none"> <li>Immunoelectrophoresis</li> <li>Counter current Immunoelectrophoresis</li> </ul>

## 2. Mechanism of precipitation

- Proposed by Marrack in 1934 – Lattice hypothesis
- Multivalent antigens combine with bivalent antibodies in varying proportions
- Zone of equivalence
- Precipitation results – Large lattice formed consisting of alternating antigen & antibody molecules

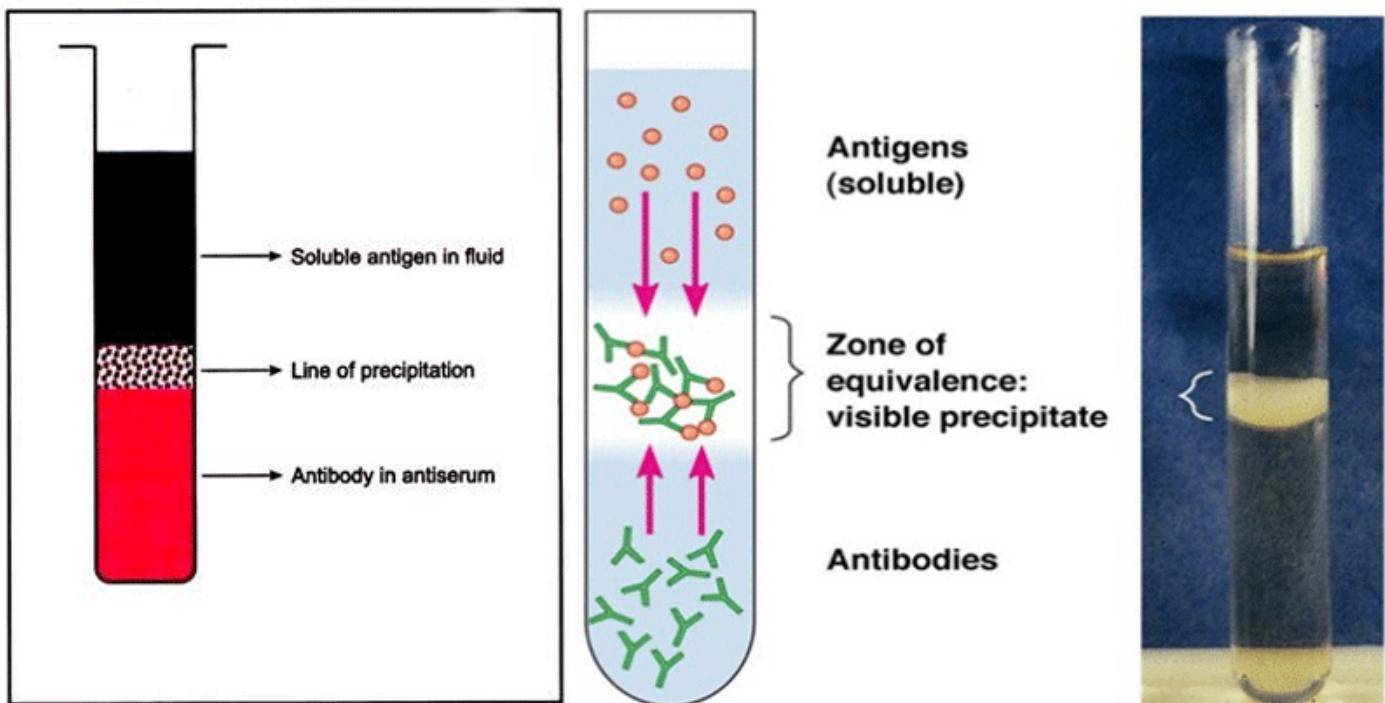


## II. Ring Test

- Simple type of precipitation test
- Consists of layering the antigen solution over a column of antiserum in a narrow tube
- Precipitate forms at the junction of the two liquids

## Clinical applications

- Used for detection of actinomycetes
- Detection of influenza virus in oral fluids
- Grouping of streptococci by Lancefield technique



### III. Slide Test

- Drop of antigen & antiserum are placed on a slide & mixed by shaking
- Floccules appears
- VDRL test for syphilis

### IV. Tube Test

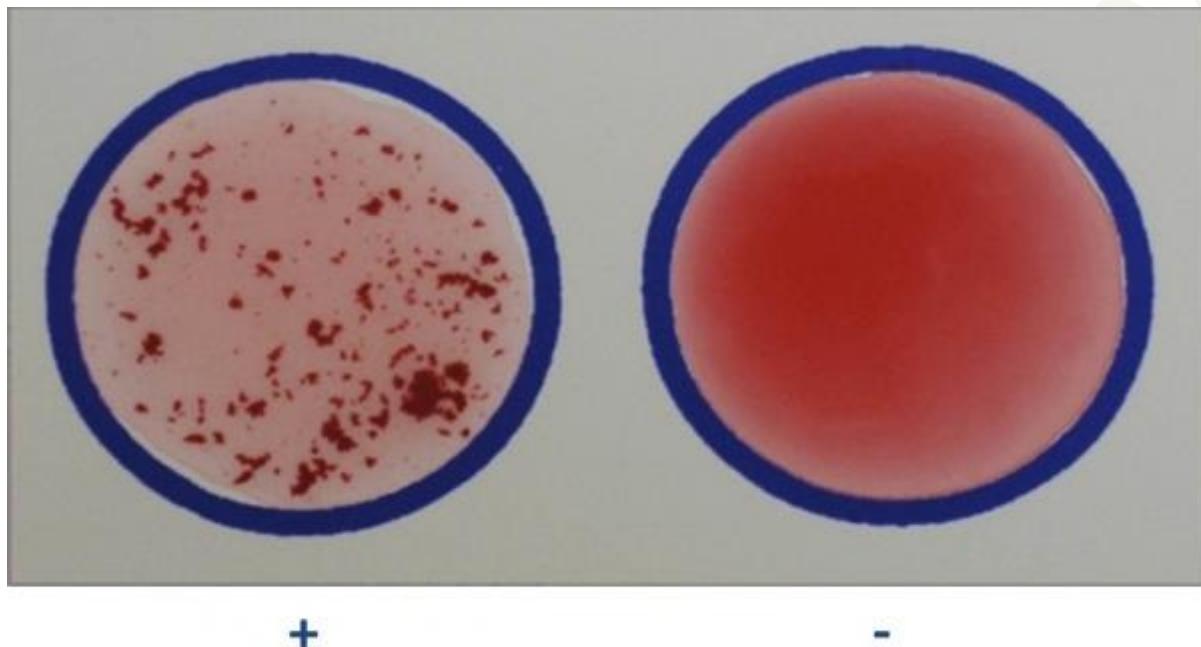
- Serial dilutions of the toxin/ toxoids are added to tubes containing a fixed quantity of the antitoxin
- Used for standardization of toxins & toxoids

### V. Agglutination Reaction

- At a suitable temperature & pH, when particulate antigen is mixed with its antibody in the presence of electrolytes
- This results in clumping or agglutination of particles
- Agglutination is more sensitive for detection of antibodies

## Slide agglutination

- Antiserum is added to a smooth uniform suspension of a particulate antigen - agglutination (clumping together)
- Mixing the antigen & antiserum with a loop
- Positive result : Clumping together
- Negative result : No clumping



## APPLICATIONS OF ANTIGEN ANTIBODY REACTIONS IN DIAGNOSTIC PATHOLOGY

- Ring test
  - Used for detection of actinomycetes
  - Detection of influenza virus in oral fluids
  - Identification of bacteria e.g.: Lancefield grouping of streptococcus
- Agglutination
  - Identification of many bacterial isolates
  - Method used for blood grouping & cross matching
- Serological diagnosis of typhoid, brucellosis & typhus fever
- Helps in,
  - Screening for the hepatitis virus
  - Early cancer detection
  - Measurement of growth hormone levels
- Forensic application in identification of human blood and seminal stains
- HIV detection

- Infectious diseases like hepatitis, EBV, cytomegalovirus, dengue IgG, influenza are detection with help of antigen antibody reactions
- Rota virus detection in faecal specimens & enterotoxin of E.coli in faeces
- Identification of food toxins like chloramphenicol, streptomycin & penicillin
- Food adulterants include E.coli, campylobacter
- Mycobacterial antibody detection in tuberculosis
- Human allergen – specific IgE & IgA ELISA

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**Please Give Your Feedback on this Answer**

## Chronic inflammation (7M)

### CONTENTS/SYNOPSIS

- Introduction
- Types of inflammation
- Signs of inflammation
- Chronic inflammation
  - Etiology
  - Pathophysiology
  - Types of chronic inflammation
  - Systemic effects of chronic inflammation
  - Risk factors associated with chronic inflammation
  - Symptoms of chronic inflammation
  - Tests for chronic inflammation
  - Management
  - Complications
  - Applied aspects
- References

## INTRODUCTION

- Inflammation, enflamme; inflammare = to set on fire
- Inflammation is a protective response intended to eliminate the initial cause of cell injury as well as the necrotic cells and tissues resulting from the original insult
- According to Robbin's, Inflammation is a complex reaction to injurious agents such as microbes & damaged, usually necrotic cells that consists of vascular responses, migration, activation of leukocytes & systemic reactions

## TYPES OF INFLAMMATION

### II. Acute inflammation

- Rapid onset
- Short duration
- Lasts for minutes, few hours or days
- Emigration of leukocytes, predominantly neutrophils

### I. Chronic inflammation

- Longer duration
- Lymphocytes and macrophages are present

## SIGNS OF INFLAMMATION

- Roman writer Celsus introduced 4 cardinal signs
  - Rubor (Redness)
  - Tumor (swelling)
  - Calor (Heat)
  - Dolor (pain)
- Virchow introduced 5<sup>th</sup> clinical sign: Loss of function (*functiolaesa*)

## CHRONIC INFLAMMATION

- It is referred to as slow, long-term inflammation lasting for prolonged periods of several months to years.
- The extent and effects of chronic inflammation vary with the cause of the injury and the ability of the body to repair and overcome the damage.

## I. Etiology

- Failure of eliminating the etiology for acute inflammation  
Eg: Infectious organisms like Mycobacterium tuberculosis, fungi, protozoa, parasites etc
- Exposure to a low concentration of foreign material for a longer duration of time, which cannot be eliminated by body host defences  
Eg: Inhalation of silica dust
- Autoimmune disorder in which host immune system is sensitized to antibodies and attacks healthy tissues  
Eg: Rheumatoid arthritis, systemic lupus erythematosus
- Recurrent episodes of acute inflammation
- Inflammatory inducers which causes oxidative stress and dysfunction of mitochondria  
Eg: Production of free radicals, uric acid crystals

## Pathophysiology

- Most of the features are similar to acute inflammation while it becomes chronic like
  - Vasodilation
  - Increase in blood flow
  - Increase in permeability of capillaries
  - Migration of neutrophils
  - Diapedesis
- But there will be a change in number of white blood cells like macrophages and lymphocytes replacing the neutrophils

### Characteristic feature of chronic inflammation

Presence if primary inflammatory cells like macrophages, lymphocytes and plasma cells at the tissue location

These cells produce inflammatory cytokines, enzymes, growth factors progressing the tissue damage

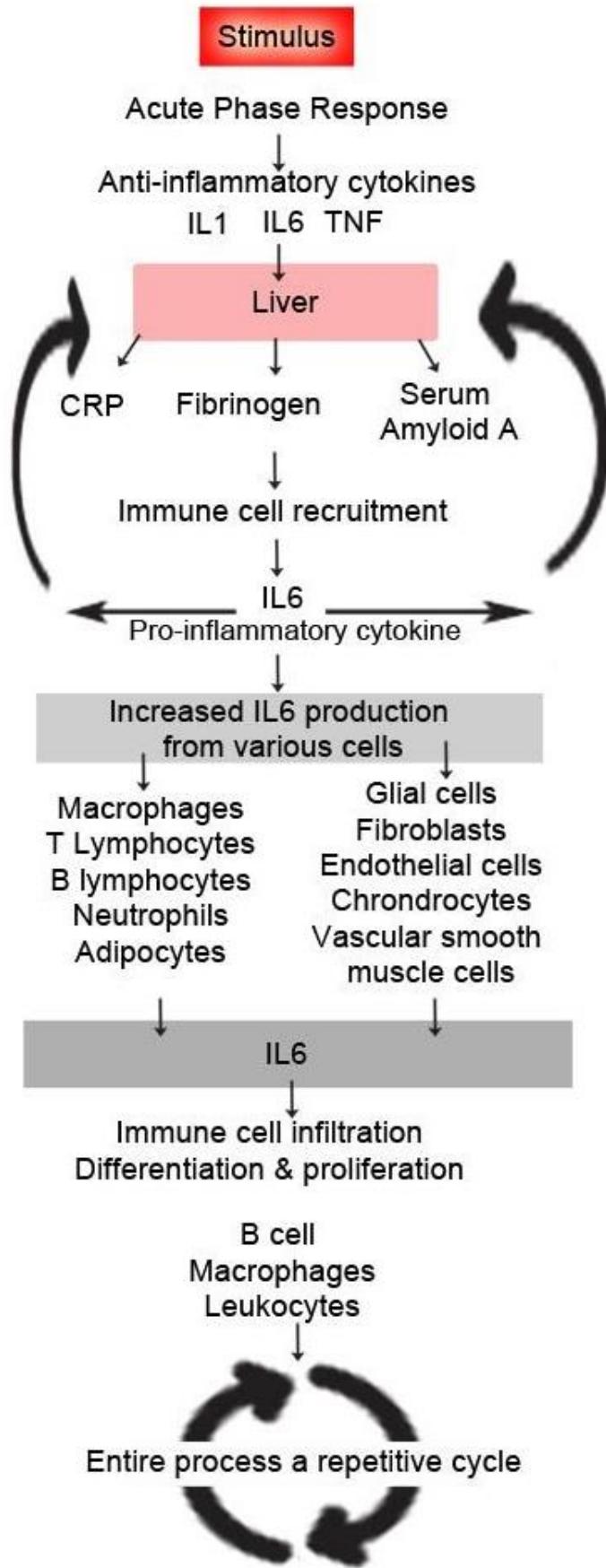
Leading to secondary repairs with fibrosis and formation of granuloma

## II. Types of chronic inflammation

1. Non specific proliferative	2. Granulomatous inflammation
<ul style="list-style-type: none"> <li>Presence of non specific granulation tissue formed by the infiltration of mononuclear cells (<u>macrophages</u>, <u>lymphocytes</u>, <u>plasma cells</u>) and proliferation of fibroblasts, connective tissue, blood vessels, epithelial cells</li> </ul> <p><b>Example:</b> Nasal polyp, cervical polyp, lung abscess</p>	<ul style="list-style-type: none"> <li>Presence of distinct nodular granulomas formed by aggregation of activated macrophages or epitheloid cells.</li> <li>Macrophages inside granulomas present as <u>langhans or giant cells</u></li> </ul> <p><b>Example:</b> Foreign body, Aschoff cells, Reed Sternberg, tumour giant cells</p> <p><b>Two types:</b></p> <ul style="list-style-type: none"> <li>Granuloma formed due to T cell mediated immune response</li> <li>Granuloma formed from chronic infections</li> </ul> <p><b>Example:</b> Leprosy, tuberculosis</p>

## III. Systemic effects of chronic inflammation

- Fever
- Anemia
- Leucocytosis
- Elevated ESR
- Amyloidosis



#### IV. Risk factors associated with chronic inflammation

<b>1. Age</b>	<ul style="list-style-type: none"> <li>With an <u>increase in age</u>, there will be <u>increase in the levels of inflammatory cells</u>.</li> <li>Leads to mitochondrial dysfunction, free radical accumulation</li> </ul>
<b>2. Obesity</b>	<ul style="list-style-type: none"> <li>Studies have reported that adipose tissue is an endocrine organ releasing adipokines and inflammatory mediators</li> </ul>
<b>3. Diet</b>	<ul style="list-style-type: none"> <li><u>Diet rich in saturated fat, trans fat, refined sugars</u> leads <u>to increased production of pro inflammatory molecules</u></li> </ul>
<b>4. Smoking</b>	<ul style="list-style-type: none"> <li>Smoking lowers the production of anti inflammatory molecules</li> </ul>
<b>5. Hormones</b>	<ul style="list-style-type: none"> <li>Hormones like testosterone and estrogens suppress the production of pro inflammatory markers and maintains the risk of inflammatory diseases</li> </ul>
<b>6. Stress and sleep disorders</b>	<ul style="list-style-type: none"> <li>Physical and emotional stress are associated with inflammatory cytokine release.</li> <li>Stress leads to sleep disorders</li> <li>Individuals with irregular sleep patterns are more likely to have chronic inflammation</li> </ul>

#### V. Symptoms of chronic inflammation

- Body pains
- Fatigue and insomnia
- Mood disturbances, anxiety, depression
- Complications in gastrointestinal tract (eg., constipation, diarrhea, acid reflux)
- Frequent infections
- Weight gain

#### VI. Tests used for chronic inflammation

- Not many effective laboratory measures are there to assess the patients for chronic inflammation

## 1. Serum electrophoresis (SPE)

- Detects hypoalbuminemia and increase in gamma globulins: Confirms chronic inflammation clinically

## 2. Blood tests

- Inexpensive, highly sensitive and efficient markers of C-reactive protein (hsCRP) and fibrinogen

### Normal values

i. hsCRP	Males: < 0.55mg/L Women: < 1.0mg/L
ii. Fibrinogen	200 - 300 mg/dl

## 3. Detection of pro inflammatory cytokines:

- Expensive, but detects the specific factor for chronic inflammation. Detects cytokines like
  - Tumor necrosis factor - alpha (TNF - alpha)
  - Interleukin 1 beta (IL-1beta)
  - Interleukin - 6 (IL - 6)
  - Interleukin - 8 (IL - 8)

## VII. Management

### 1. Modification in dietary habits

i. Low glycemic diet	<ul style="list-style-type: none"> <li>Diet with a higher glycemic index acts as a risk factor for stroke, coronary heart disease, type 2 diabetes mellitus</li> </ul>
ii. Reduction of intake of fatty foods	<ul style="list-style-type: none"> <li>Saturated and trans fats aggravates inflammation.</li> <li>Omega 3 polyunsaturated fats are anti inflammatory</li> </ul>
iii. Fruits and vegetables	<ul style="list-style-type: none"> <li>Antioxidants rich foods like berries, apples, brussel sprouts, broccoli, cabbage, cauliflower are advised</li> <li>Antioxidants and polyphenols protects against inflammatory agents</li> </ul>
iv. Fibers and nuts	<ul style="list-style-type: none"> <li>High intake of soluble dietary fibers are associated in lowering interleukins and tumor necrosis factors</li> <li>Nuts are associated in lowering the risk of</li> </ul>

	cardiac problems
v. <i>Micronutrients</i>	<ul style="list-style-type: none"> <li>• Magnesium, vitamin E, vitamin D, zinc and selenium.</li> <li>• Magnesium is one of the most active anti inflammatory factor in diet, as it lowers hsCRP, IL 6, TNF alpha activity</li> <li>• Vitamin D applies its anti inflammatory property and suppresses the inflammatory mediators</li> </ul>

## 2. Physical activity

- Improving physical activity lowers pro inflammatory agents

## 3. Conventional drugs

- Non steroidal anti inflammatory drugs, metformins, corticosteroids are used as anti inflammatory agents

## VIII. Complications

- **Cardiovascular diseases:** atherosclerosis leads to conditions like myocardial infarction, stroke etc
- **Cancer:** chronic inflammation participates in cancer of organs like kidneys, ovaries, hepatocellular, pancreas, lungs and mesothelioma
- **Diabetes:** Macrophages infiltrates pancreatic cells releasing pro inflammatory molecules
- Rheumatoid arthritis
- Allergic asthma
- Chronic obstructive pulmonary disease
- Chronic kidney disease
- Inflammatory bowel disease

## IX. Applied aspect

### 1. Periapical granuloma

- It is a misnomer, it is not a granulomatous reaction.
- Mass of chronically inflamed granulation tissue at apex of non-vital teeth, designed to wall off bacterial invasion at apex.
- Associated with chronic apical periodontitis

## 2. *Periapical cyst*

- Also called as apical periodontal cyst, radicular cyst.
- Inflammatory odontogenic cyst, induced by cell rests of malassez (Hertwigs Epithelial Root Sheath remnants) proliferation.
- Radiolucency at periapex of non-vital teeth
- To differentiate from a granuloma, it must be tested histologically

## CONCLUSION

- There are several chronic inflammatory diseases with no cure and are managed with symptomatic therapy.
- Trigger factors can be controlled with modifications in lifestyle, diet and physical activity.

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**Please Give Your Feedback on this Answer**

**Define edema. Discuss the pathology of various types of edema (10M)**

## CONTENTS/SYNOPSIS

- Introduction
- Edema
- Pathogenesis of edema
  - Increased hydrostatic pressure
  - Reduced plasma oncotic pressure
  - Increased permeability of blood vessel
  - Obstruction of fluid clearance in lymphatic system
  - Changes in water retaining properties of the tissues
- Types of edema
  - Generalized edema
  - Localized edema
- Conclusion
- References

## INTRODUCTION

- 60% of total body weight consists of water (2/3rd intracellular and 1/3rd is extracellular)
- The movement of body fluid between vasculature is controlled by opposing effects of :
  - Vascular hydrostatic pressure
  - Plasma colloid osmotic pressure
- Residual amount of excess interstitial fluid is drained by lymphatics

## EDEMA

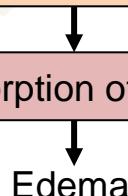
- Edema is an abnormal and excessive accumulation of fluid in the tissues, either within cells or the collagen-mucopolysaccharide matrix distributed in the interstitial spaces
- It is a normal response of the body in conditions of inflammation or injury

## PATHOGENESIS OF EDEMA

- Factors contributing to the formation of edema are

### I. Increased hydrostatic pressure

Rise in hydrostatic pressure at the capillaries of vein to a greater level than plasma oncotic pressure



### II. Reduced plasma oncotic pressure

Reduced albumin synthesis in liver/ protein malnutrition

Decline in plasma oncotic pressure

Net movement of fluid into interstitial tissues



### III. Increased permeability of blood vessel

Injury to endothelium of blood vessel by toxins/ histamine

↓  
Endothelial group

Increase in capillary permeability to plasma proteins

Decrease in plasma oncotic pressure

↓  
Edema

### IV. Obstruction of fluid clearance in lymphatic system

- Impaired lymphatic drainage due to mastectomy of carcinoma of breast, pressure on main lymphatic ducts, inflammation of lymphatics, occluded lymphatics (filariasis, tumor cells)

↓  
Localized lymphodema

### V. Changes in water retaining properties of the tissues

- Sodium and water retention due to reduced glomerular filtration rate, hormones (aldosterone) leading to formation of edema

#### **TYPES OF OEDEMA**

<b>I. According to Pathophysiological mechanism</b>	<ul style="list-style-type: none"> <li>Transudate</li> <li>Exudate</li> </ul>
<b>II. According to location</b>	<ul style="list-style-type: none"> <li>Localized</li> <li>Generalized</li> </ul>
<b>III. According to clinical finding</b>	<ul style="list-style-type: none"> <li>Pitting</li> <li>Non pitting edema</li> </ul>

<b>Generalized edema</b>	<b>Localized edema</b>
<ul style="list-style-type: none"> <li>It is a condition with swelling, puffiness and water retention</li> <li>Seen in abdomen, arms, legs, feet, face</li> </ul> <p><b>Symptoms:</b></p>	<ul style="list-style-type: none"> <li>It is an edematous condition which is localized to a particular part or body organ</li> </ul> <p><b>Causes:</b></p> <ul style="list-style-type: none"> <li>Trauma</li> </ul>

<ul style="list-style-type: none"> <li>Bloating, tightening of skin, pitted skin</li> </ul> <p><b>Causes:</b></p> <ul style="list-style-type: none"> <li>Congestive heart failure</li> <li>Nephrotic syndrome</li> <li>Cirrhosis of liver</li> <li>Systemic infections</li> </ul>	<ul style="list-style-type: none"> <li>Infection</li> <li>Venous obstruction (Eg., thrombosis)</li> <li>Lymphatic obstruction (Eg., Filariasis)</li> <li>Allergy</li> <li>Emancipation of old age</li> </ul>
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<b>Pitting edema</b>	<b>Non pitting edema</b>
<ul style="list-style-type: none"> <li>Also called cutaneous edema</li> <li>On application of pressure, indentation persists after the pressure is relieved</li> <li>Peripheral pitting edema is most commonly seen due to retention of water</li> </ul> <p><b>Causes:</b></p> <ul style="list-style-type: none"> <li>Systemic diseases</li> <li>Pregnancy</li> <li>Heart failure</li> <li>Varicose veins</li> <li>Thrombophlebitis</li> <li>Dermatitis</li> <li>Insect bite</li> </ul>	<ul style="list-style-type: none"> <li>On application of pressure, indentation does not persist after the pressure is relieved</li> </ul> <p><b>Causes:</b></p> <ul style="list-style-type: none"> <li>Lymphedema</li> <li>Lipedema</li> <li>Myxoedema</li> </ul>

## CONCLUSION

- Edema occurs as a result of disturbed balance between fluid outflow from vascular system and inflow of fluid into vascular and lymphatic system.
- There are several types of edemas associated with various conditions.
- Hence a proper knowledge in the pathogenesis of edema may give a pathway towards the right diagnosis

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*Please Give Your Feedback on this Answer*

**Healing and repair - role of vitamin C (6M)****Wound healing (7M)****Discuss in detail the primary and secondary wound healing and add a note on osseointegration (20M)****Healing of extraction socket (7M)****CONTENTS/SYNOPSIS**

- Introduction
- Classification of wounds
- Wound healing
  - Factors affecting the wound healing
    - Local factors
    - Systemic factors
  - Types of wound healing
    - Healing by primary intention
      - Initial haemorrhage
      - Acute inflammatory response
      - Epithelial changes
      - Organization
      - Suture tracks
    - Healing by secondary intention
      - Initial haemorrhage
      - Inflammatory phase
      - Epithelial changes
      - Granulation tissue
      - Wound contraction
      - Presence of infection
    - Complications
  - Healing of extraction socket
    - First week wound
    - Second week wound
    - Third week wound
    - Fourth week wound

- Complications of healing extraction wounds
- Healing of jaw fracture
  - Primary intention
  - Secondary intention
  - Process of healing in jaw fracture
  - Complications of fracture healing
- Wound healing around dental implant
  - Healing after placement of implant
  - Peri-implant soft tissue healing
  - Peri-implant mucosa interface
  - Peri-implant hard tissue healing
- References

## INTRODUCTION

- Wound is a discontinuity or break of the surface
- Trauma to any of the tissues of the body, especially that caused by physical means & with interruption of continuity
- A surgical incision

## CLASSIFICATION OF WOUNDS

- There is no standard classification for wounds.
- However there are several different ways in which wounds can be classified to address the wound and its management.

### I. Classification 1

<b>1. Injury</b>	<ul style="list-style-type: none"> <li>• Clean, incised</li> <li>• Shearing or degloving</li> <li>• Crushing</li> <li>• Burns</li> <li>• Contaminated</li> </ul>
<b>2. Timing</b>	<ul style="list-style-type: none"> <li>• Acute &lt; 6 hours</li> <li>• Early &lt; 24 hours</li> <li>• Late &gt; 24 hours</li> </ul>
<b>3. Depth</b>	<ul style="list-style-type: none"> <li>• Superficial</li> <li>• Deep dermal</li> <li>• Full thickness</li> </ul>

### II. Classification 2

<b>1. Incised wound</b>	<ul style="list-style-type: none"> <li>• Caused by sharp knife or glass</li> <li>• Relatively clean</li> </ul>
<b>2. Lacerated wound</b>	<ul style="list-style-type: none"> <li>• Caused by road traffic accidents</li> <li>• Has jagged edges</li> </ul>
<b>3. Penetrating wound</b>	<ul style="list-style-type: none"> <li>• Similar to incised wounds- except that its depth is more</li> </ul>
<b>4. Crushed wound</b>	<ul style="list-style-type: none"> <li>• Edema, necrotic tissue, tension deep to deep fascia are the features</li> </ul>

### III. Rank & Wakefield classification of wounds:

1. <i>Tidy wounds</i>	2. <i>Untidy wounds</i>
<ul style="list-style-type: none"> <li>Caused by sharp instruments</li> <li>No devitalized tissue</li> </ul>	<ul style="list-style-type: none"> <li>Result from crushing, tearing, avulsion, vascular injury or burns</li> <li>Contain devitalized tissue</li> </ul>

### WOUND HEALING

- Word “healing” means the replacement of destroyed tissue by active tissue, to restore function
- Wound healing is a dynamic, interactive process involves soluble mediators, extracellular matrix, blood cells and parenchymal cells

### Factors affecting wound healing

1. <i>Local factors</i>	2. <i>Systemic factors</i>
<ul style="list-style-type: none"> <li>Infection</li> <li>Poor blood supply</li> <li>Foreign bodies</li> <li>Movement</li> <li>Exposure to ionizing radiation</li> <li>Type, size &amp; location of injury</li> </ul>	<ul style="list-style-type: none"> <li>Age</li> <li>Nutrition</li> <li>Systemic infection</li> <li>Administration of glucocorticoids</li> <li>Uncontrolled diabetes</li> <li>Hematologic abnormalities</li> </ul>

### Role of Vitamin C:

- Plays an important role in collagen formation: collagen protein requires vitamin C for hydroxylation. Thereby facilitating cross linkage of collagen fibers and increases its strength
- Helps in bone formation

### TYPES OF WOUND HEALING

- Based on the nature of the wound, healing can occur:
  - Healing by first intention
  - Healing by second intention

## I. Healing by first intention

### Characteristics of wound

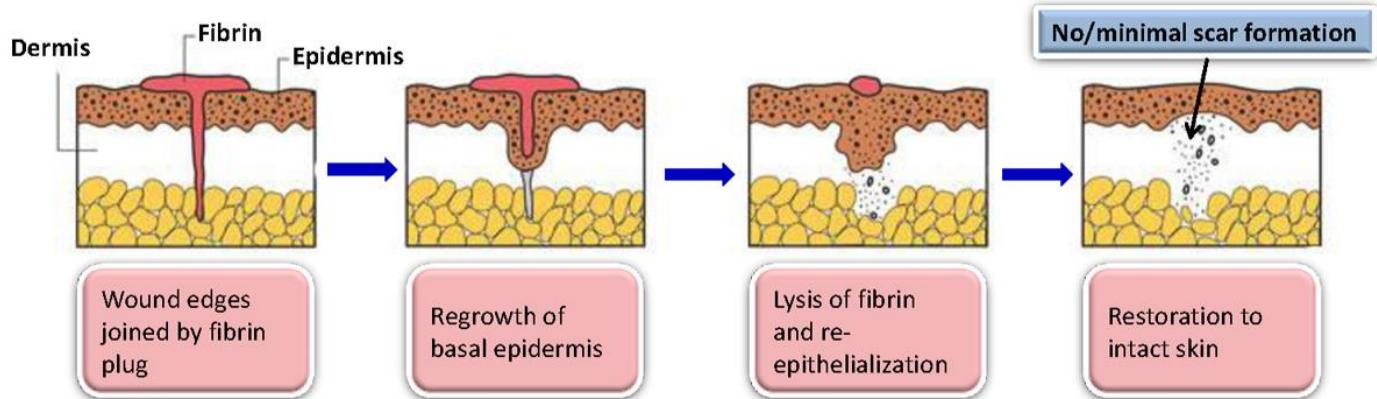
- Clean and uninfected
- Surgically incised
- Without much loss of cells and tissue
- Edges of wound are approximated by surgical sutures
- Wounds with opposed edges

### Steps

<b>1. Initial haemorrhage</b>	<ul style="list-style-type: none"> <li>• Immediately after the trauma or injury, there will be the space found between the incised tissues are filled with blood</li> <li>• Then finally clots formed and it seals the wound against the dehydration ad infections</li> </ul>
<b>2. Acute inflammatory response</b>	<ul style="list-style-type: none"> <li>• Within 24hours, polymorphonuclear leucocytes appear at the incisional margin, then moves towards fibrin clot</li> <li>• By 3<sup>rd</sup> day, these neutrophils are replaced by macrophages</li> <li>• Granulation tissue progressively invades incisional space</li> <li>• Epithelial cellular proliferation continues and thickening epidermal covering layer</li> </ul>
<b>3. Epithelial changes</b>	<ul style="list-style-type: none"> <li>• Proliferation of basal cells of epidermis from cut margin begins and migrates towards to the incisional spaces in the form of epithelial spur</li> <li>• Within 48 hours, well approximated wound is covered by layer of epithelium</li> <li>• These migrated epithelial cells separate viable dermis from the overlying necrotic material &amp; clot</li> <li>• Division of basal cells from the margin occurs</li> <li>• During, 5<sup>th</sup> day multilayered epidermis is formed which is differentiated into superficial and deep layer</li> </ul>
<b>4. Organization</b>	<ul style="list-style-type: none"> <li>• By 3<sup>rd</sup> day - fibroblast also invade wound area</li> </ul>

	<ul style="list-style-type: none"> <li>By 5<sup>th</sup> day –new collagen fibers begins till healing is completed</li> <li>By 4<sup>th</sup> weeks, scar tissue is formed</li> <li>This consists of cellular &amp; vascular elements with few inflammatory cells</li> </ul>
<b>5. Suture tracks</b>	<ul style="list-style-type: none"> <li>Scar tissue formed is neat due to the close apposition of wound margins</li> <li>Use of adhesive tapes avoids removal of stitches</li> </ul>

### Healing by Primary Intention



## II. Healing by second intention

### Characteristics of the wound

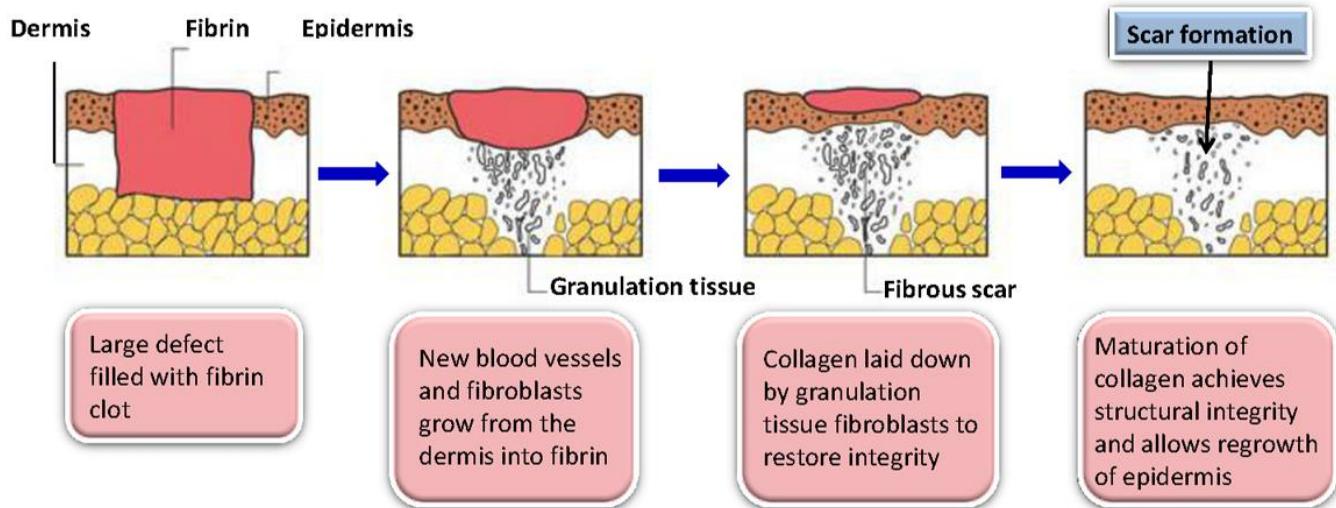
- Open with large tissue defect
- With much loss of cells and tissue
- Clean and infected
- Edges of wound are not approximated by surgical sutures

### Steps:

<b>1. Initial hemorrhage</b>	<ul style="list-style-type: none"> <li>Due to the injury, the space is filled with blood &amp; fibrin clot which formed is dried</li> </ul>
<b>2. Inflammatory phase</b>	<ul style="list-style-type: none"> <li>Within 24hours, polymorphonuclear leucocytes appear at the incisional margin, then moves towards fibrin clot</li> </ul>

	<ul style="list-style-type: none"> <li>• By 3<sup>rd</sup> day, these neutrophils are replaced by macrophages</li> <li>• Granulation tissue progressively invades incisional space</li> <li>• Epithelial cellular proliferation continues and thickening epidermal covering</li> </ul>
<b>3. Epithelial changes</b>	<ul style="list-style-type: none"> <li>• Similar to primary union, the epithelial cells do not cover the surface completely until the granulation tissue from base</li> <li>• In this way the viable connective tissue separated from the necrotic material and fibrin clot on the surface</li> <li>• Finally, the regenerated epidermis becomes stratified and keratinized</li> </ul>
<b>4. Granulation tissue</b>	<ul style="list-style-type: none"> <li>• Formation of granulation tissue is formed by proliferation of fibroblast</li> <li>• Neovascularization from the adjoining viable elements occurs</li> <li>• In time, scar on maturation becomes pale and white due to raised in collagen and decreased vascularity</li> </ul>
<b>5. Wound contraction</b>	<ul style="list-style-type: none"> <li>• It is an significant feature of secondary union</li> <li>• The wound contracts to 1/3<sup>rd</sup> to 1/4 th of wound of original size</li> <li>• When active Granulation tissue is being formed, wound contraction occurs</li> </ul>
<b>6. Presence of infection</b>	<ul style="list-style-type: none"> <li>• Any contamination with infections like bacteria in open wound delays the process of wound healing due to the bacterial toxins released which provoke</li> <li>• Necrosis</li> <li>• Suppuration</li> <li>• Thrombosis</li> <li>• Surgical removal of dead and necrosed tissue helps in preventing the bacterial infection of open wound</li> </ul>

### Healing by Secondary Intention



### III. Complications

- Infection
- Implantation cyst
- Pigmentation
- Deficient scar formation
- Incisional hernia
- Excessive contraction
- Keloid formation

## HEALING OF EXTRACTION SOCKET

- The healing of an extraction socket is the best example for healing by secondary intention
- Immediate reaction following extraction:
  - Bleeding and clot formation in the socket RBCs entrapped in the fine fibrin meshwork ends of torn blood vessels becomes sealed off
  - First 24-48 hrs: vasodilation and engorgement of BV, mobilization of
  - Leukocytes

### I. First Week wound

- Proliferation of fibroblasts from connective tissue cells in the remnants of PDL into the clot around the entire periphery
- Clot is gradually replaced by granulation tissue

- Epithelium shows evidence of proliferation at the periphery
- Crest of alveolar bone shows beginning of osteoclastic activity
- Endothelial cell proliferation PDL

## II. Second Week wound

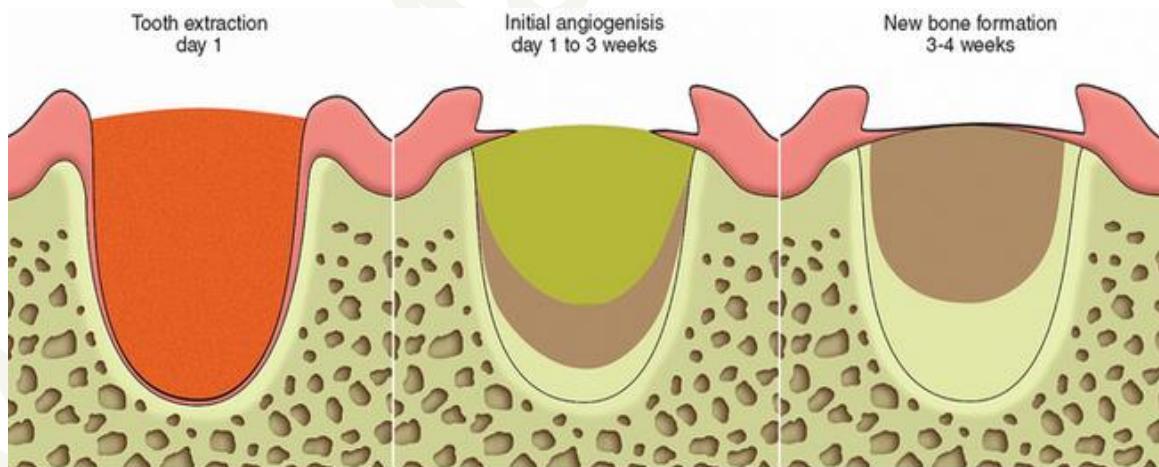
- New delicate capillaries penetrated to the centre of the clot
- The wall of socket appears frayed due to degeneration of PDL
- Trabeculae of osteoid can be seen
- Considerable epithelial proliferation over the surface of wound or completed if small socket is present
- Origin of alveolar socket shows prominent osteoclastic resorption

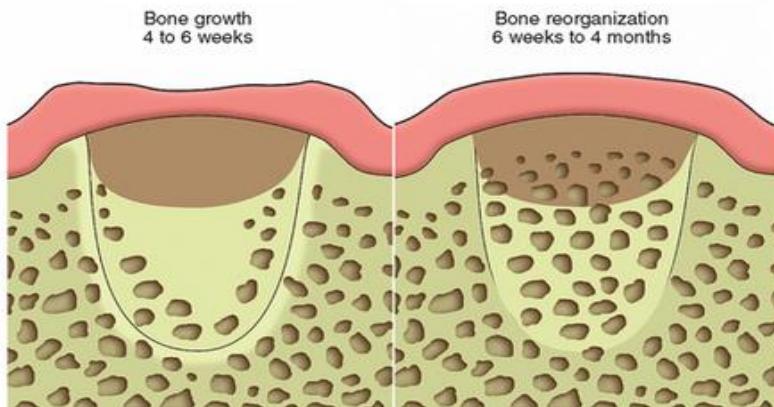
## III. Third Week wound

- Clot is replaced almost completely by organized mature granulation tissue
- Young trabeculae of osteoid tissue is forming around the entire periphery
- Crest of alveolar bone rounded off by osteoclasts
- Surface of wound becomes completely epithelialized

## IV. Fourth week wound

- Wound is in final stage of healing , there is continuous deposition and remodeling resorption of the bone filling the alveolar socket roentgenographic evidence of bone becomes prominent after 6th to 8th week





## Complications of extraction wound healing

### 1. *Dry socket*

- Most frequent complication
- It is focal osteomyelitis due to the blood clot disintegrate or lost which results in production of a foul odour and severe pain but no suppuration
- Occurs due to the traumatic extractions with clot dislodgement & subsequent infection of exposed bone
- Frequently found in lower premolars and molar sockets
- It is extremely painful & foul odour
- Exposed bone is necrotic with the presence of sequestration of fragments
- Socket packed with obtundent material like Zinc oxide eugenol paste on iodoform gauze

### 2. *Fibrous healing of extraction wound*

- It is asymptomatic & uncommon complication
- Take place following difficult or complicated extraction
- Loss of both the cortical plates (lingual and labial or buccal) with loss of periosteum
- It is well circumscribed radiolucent lesion found in the site of a previous extraction wound
- Histopathologically, it is characterized by dense bundles of collagen fibers with only few fibrocytes and blood vessels

## HEALING OF JAW FRACTURE

- Healing of jaw fracture is of two types

III. Primary healing	IV. Secondary healing
<ul style="list-style-type: none"> <li>Primary union of fractures occurs in a few special situations when the ends of fracture are approximated as is done by application of compression clamps.</li> <li>In these cases, bony union takes place with formation of medullar callus without periosteal callus formation.</li> <li>The patient can be made ambulatory early but there is more extensive bone necrosis and slow healing.</li> </ul>	<ul style="list-style-type: none"> <li>Secondary union is the more common process of fracture healing.</li> <li>Though it is a continuous process, secondary bone union is described under the following 3 headings: <ul style="list-style-type: none"> <li>➤ Procallus formation</li> <li>➤ Osseous callus formation</li> <li>➤ Remodelling</li> </ul> </li> </ul>

### 1. Procallus formation.

- Steps involved in the formation of procallus are as follows:

i. <i>Hematoma</i>	<ul style="list-style-type: none"> <li>Haematoma forms due to bleeding from torn blood vessels, filling the area surrounding the fracture.</li> <li>Loose meshwork is formed by blood and fibrin clot which acts as framework for subsequent granulation tissue formation.</li> </ul>
ii. <i>Local inflammatory response</i>	<ul style="list-style-type: none"> <li>It occurs at the site of injury with exudation of fibrin, polymorphs and macrophages.</li> <li>The macrophages clear away the fibrin, red blood cells, inflammatory exudate and debris.</li> <li>Fragments of necrosed bone are scavenged by macrophages and osteoclasts.</li> </ul>
iii. <i>Ingrowth of granulation tissue</i>	<ul style="list-style-type: none"> <li>It begins with neovascularisation and proliferation of mesenchymal cells from periosteum and endosteum.</li> <li>A soft tissue callus is thus formed which joins the ends of fractured bone without much strength.</li> </ul>

iv. *Callus composed of woven bone and cartilage*

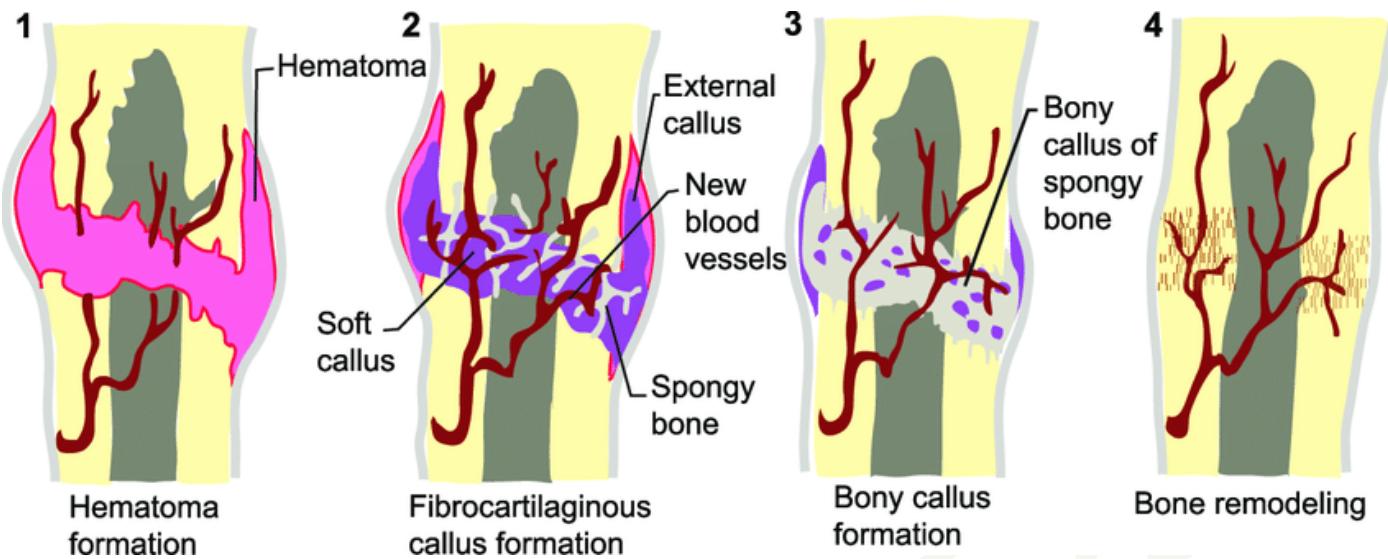
- It starts within the first few days.
- The cells of inner layer of the periosteum have osteogenic potential and lay down collagen as well as osteoid matrix in the granulation tissue.
- The osteoid undergoes calcification and is called *woven bone callus*.
- A much wider zone over the cortex on either side of fractured ends is covered by the woven bone callus and united to bridge the gap between the ends, giving spindle shaped or fusiform appearance to the union.
- In poorly immobilized fractures (e.g. fracture ribs), the subperiosteal osteoblasts may form cartilage at the fracture site.
- At times, callus is composed of woven bone as well as cartilage, temporarily immobilizing the bone ends.

## 2. *Osseous callus formation*

- The procillus acts as scaffolding on which osseous callus composed of lamellar bone is formed.
- The woven bone is cleared away by incoming osteoclasts and the calcified cartilage disintegrates.
- In their place, newly-formed blood vessels and osteoblasts invade, laying down osteoid which is calcified and lamellar bone is formed by developing Haversian system concentrically around the blood vessels.

## 3. *Remodeling*

- During the formation of lamellar bone, osteoblastic laying and osteoclastic removal are taking place remodeling the united bone ends, which after sometime, is indistinguishable from normal bone.
- The external callus is cleared away, compact bone (cortex) is formed in place of intermediate callus and the bone marrow cavity develops in internal callus.



### III. Complications of fracture healing

- **Fibrous union** may result instead of osseous union if the immobilization of fractured bone is not done. Occasionally, a false joint may develop at the fracture site (pseudoarthrosis).
- **Non-union** may result if some soft tissue is interposed between the fractured ends.
- **Delayed union** may occur from causes of delayed wound healing in general such as infection, inadequate blood supply, poor nutrition, movement and old age.

## WOUND HEALING AROUND DENTAL IMPLANT

### I. Healing following placement of implant

- After the implant placement, soft and hard tissue healing leads to a marginal soft tissue attachment and osseointegration.
- **Marginal soft tissue attachment** plays a vital role in creating a physical seal between oral environment and the bone surrounding the implant

#### Advantages:

- Limits the migration of microbes to reach the bone
- Prevents the leaching of contaminated products
- Reduces the risk of peri implantitis and implant failure
- Allows for functional loading

## II. Healing of peri implant soft tissue

- Formation of peri implant mucosal attachment with the implant surface is 3 - 4 mm high.
- Consists of a junctional epithelium (60 % mucosal attachment, 40% connective tissue) supported by connective tissue coronal to the alveolar bone

### Characteristics of peri implant mucosa:

i. External surface	<ul style="list-style-type: none"> <li>Keratinized oral epithelium</li> </ul>
ii. Peri implant sulcus	<ul style="list-style-type: none"> <li>Peri implant sulcular epithelium (consists of desmosomes)</li> <li>Desquamation due to microbial insult leads to loss of sulcular epithelium</li> </ul>
iii. Connective tissue	<ul style="list-style-type: none"> <li>Consists of fibroblasts, inflammatory cells, vertically directed collagen fibrils</li> </ul>
iv. Connective tissue attachment	<ul style="list-style-type: none"> <li>Located apical to the junctional epithelium</li> </ul>
	<ul style="list-style-type: none"> <li>Collagen fibers originate from crest of the bone and run parallel to the implant surface either circumferentially or in apico coronal direction.</li> <li>Blood vessels are in continuity with supra alveolar arteries in the outer zone and are larger in size</li> </ul>

## III. Peri implant hard tissue healing

- Primary mechanical stability is established when a direct contact occurs between vital bone and surface of implant
- Based on the implant design the inner parts of threads make limited or no contact with the bone bead.
- The space where there was no contact leads to accumulation of coagulum containing fibrin, erythrocytes, polymorphonuclear neutrophils and few macrophages.
- In the early healing stages, cortical and trabecular bone debris is also found in bone bed
- Vascularization of coagulum bed along with fibroblasts followed by formation of granulation tissue and angiogenesis

i. 4 days	<ul style="list-style-type: none"> <li>• Signs of bone formation within 4 days</li> </ul>
ii. 1 week	<ul style="list-style-type: none"> <li>• After 1 week osteoclasts migrate to undergo osteoclastic resorption and remodeling followed by <u>formation of woven bone</u></li> <li>• Replacement of blood coagulum and granulation tissue with connective tissue matrix leading to formation of collagen fiber bundles</li> <li>• Fibroblast like mesenchymal cells differentiates into osteoblasts</li> <li>• Newly formed woven bone extends from old lamellar bone forming a bone matrix which mineralizes and gradually advances towards the implant surface</li> </ul>
iii. 4 weeks	<ul style="list-style-type: none"> <li>• After 4 weeks of healing, the <u>newly formed bone extends from the bone bed onto the surface of the implant</u></li> </ul>
iv. 1 - 3 months	<ul style="list-style-type: none"> <li>• In 1 - 3 months <u>the woven bone is remodeled by lamellar bone</u> with an increase in tissue mineralization allowing for functional loading of implants</li> </ul>
v. 1 year	<ul style="list-style-type: none"> <li>• <u>Bone modeling and remodeling continues for the first year</u> if implant placement which contributes to implant resistance to shear forces</li> </ul>

#### IV. Healing to clinical application

- After the healing, it allows to the formation of stable interface between hard and soft tissues and implants
- Allows the loading of implants with prosthesis

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*Please Give Your Feedback on this Answer*

## Management of bleeding disorders in prosthodontics (6M)

Describe the coagulation of blood and enumerate blood investigations to diagnose bleeding and clotting disorders (10M)

### CONTENTS/SYNOPSIS

- Introduction
- Haemostasis process
  - Vasoconstriction
  - Formation of temporary haemostatic plug formation
    - Platelet adhesion
    - Platelet activation
    - Platelet aggregation
    - Formation of temporary haemostatic plug
    - Inhibition of further plug formation
  - Formation of definitive haemostatic plug formation
    - Coagulation of blood
    - Clotting factors
- Mechanism of coagulation
  - Intrinsic pathway
  - Extrinsic pathway
  - Conversion of prothrombin to thrombin
  - Thrombin
  - Fibrinogen to fibrin
  - Blood clot retraction
  - Role of calcium
  - Role of vitamin k
  - Role of liver
  - Role of blood vessels
    - Endothelium
    - Sub endothelial tissue
    - Velocity of circulation
    - Surface effect of endothelium (glycocalyx)
    - Circulatory anticoagulants
    - Fibrinolytic mechanism
    - Removal of activated clotting factors
- Thrombosis

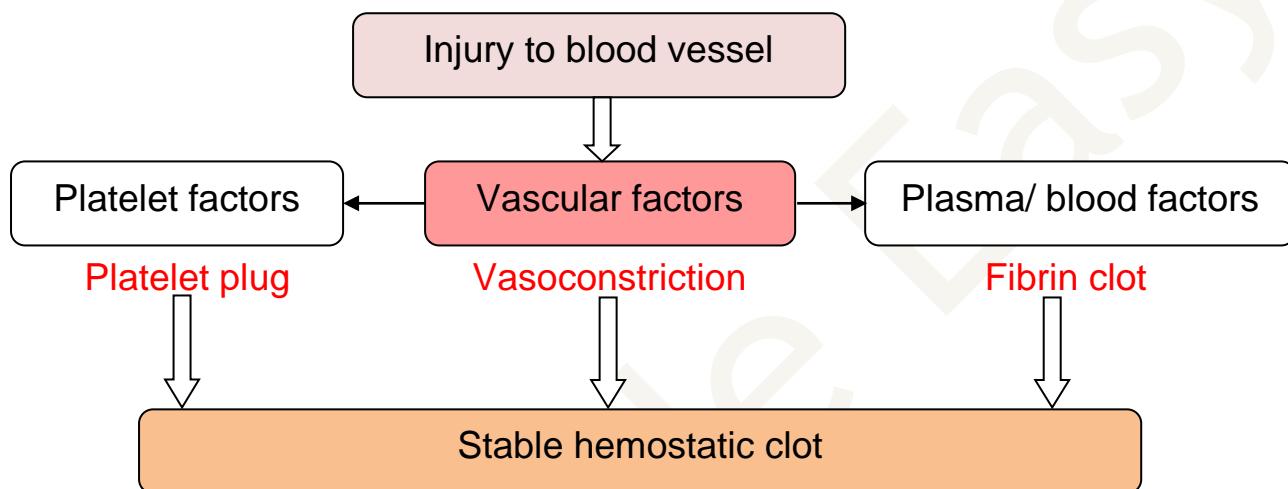
- Endothelial injury
- Alteration of blood flow
- Hypercoagulability of blood
- Effects of thrombi
- Prevention of thrombi
- Clinical implications
  - Hemophilia
  - Von Willebrnad's disease
  - Purpura
  - Others
- Laboratory investigations
- References

## INTRODUCTION

- Coagulation or clotting is defined as the process in which blood loses its fluidity and becomes a jelly like mass few minutes after it is shed out or collected in a container.

## HAEMOSTASIS

- Spontaneous arrest or stoppage of bleeding from injured blood vessel by physiological process. There are 3 processes:



### I. Vasoconstriction

- Immediate constriction of damaged blood vessels is caused by vasoconstrictors released by endothelium cells which leads to temporary decrease in flow of blood within the injured vessel

### II. Formation of temporary haemostatic plug formation

#### 1. Platelet adhesion

- After injury, platelets contacts with collagen & damaged endothelium
- Swell, becomes irregular & protrudes Pseudopodia
- Contractile proteins contracts & releases granules
- Platelets becomes sticky & adhere to collagen

#### 2. Platelet activation

- Platelets secretes ADP & Thromboxane A2 which activates other platelets and cycle continues

#### 3. Platelet aggregation

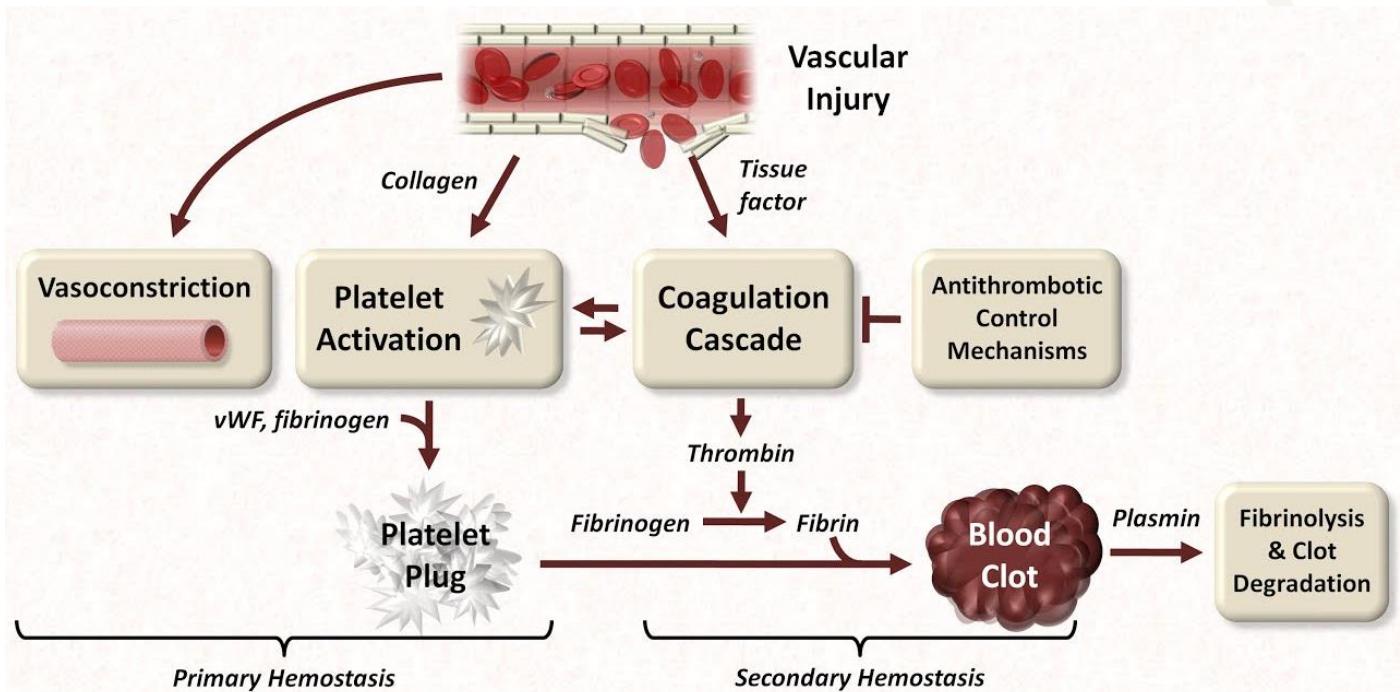
- Activated sticky platelets stick to each other & forms Aggregation
- It is also increased by Platelet Activating Factor (PAF) released by neutrophils, monocyte & platelets cell membrane lipids

#### 4. Formation of temporary Haemostatic plug

- Platelet adhesion – Platelet aggregation – Fairy loose plug

#### 5. Inhibition of further plug formation

- Prostacycline from membrane phospholipids
- Inhibit Thromboxane formation



### III. Formation of Definitive haemostatic plug formation

- Temporary plug converted to definitive plug by process of blood coagulation which results in formation of tight unyielding seal

#### 1. Coagulation of blood

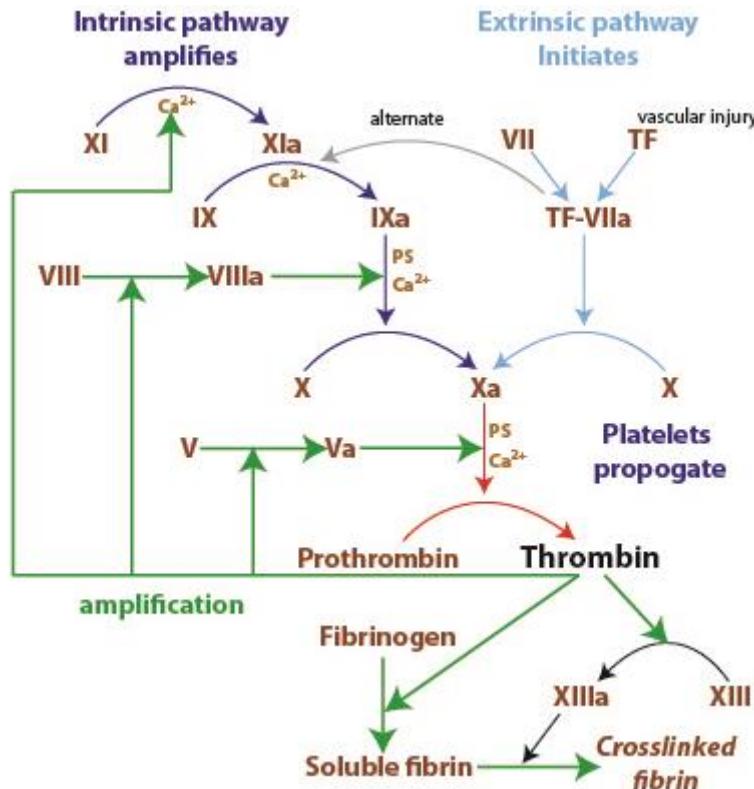
- During the platelet plug formation, collagen and tissue factors which are exposed causes a series of reaction.
- Also known as coagulation cascade which ends in the formation of fibrin polymer
- The fibrin protein mesh helps in stabilization of platelet plug to become a blood clot
- Clotting cascade has two pathways

<i>i. Intrinsic pathway</i>	<i>ii. Extrinsic pathway</i>
<ul style="list-style-type: none"> <li>Contact activation pathway</li> <li>Activates collagen that is exposed at the site of injury and binds with</li> </ul>	<ul style="list-style-type: none"> <li>Tissue factor pathway</li> <li>Stimulated by tissue factor which is exposed by the tissue injury and</li> </ul>

factor XII to initiate this coagulation cascade

factor VII activation

- The two pathways later merges into one common pathway where thrombin converts fibrinogen to fibrin and then final clot formation takes place



## 2. Factors involved in blood coagulation

- Factor 1: Fibrinogen
- Factor 2: Prothrombin
- Factor 3: Thromboplastin
- Factor 4: Calcium
- Factor 5: Labile factor / Proaccelerin
- Factor 6: Stable factor / Proconvertin
- Factor 7: Anti-haemophilic factor A / Anti-haemophilic globulin
- Factor 8: Anti-haemophilic factor B/ Plasma thromboplastic component
- Factor 9: Stuart- Prower factor
- Factor 10: Plasma thromboplastin antecedent / Anti-haemophilic factor C
- Factor 11: Hageman factor/ Glass factor / Contact factor
- Factor 12: Fibrin stabilizing factor / Fibrinase / Laki Lorand factor

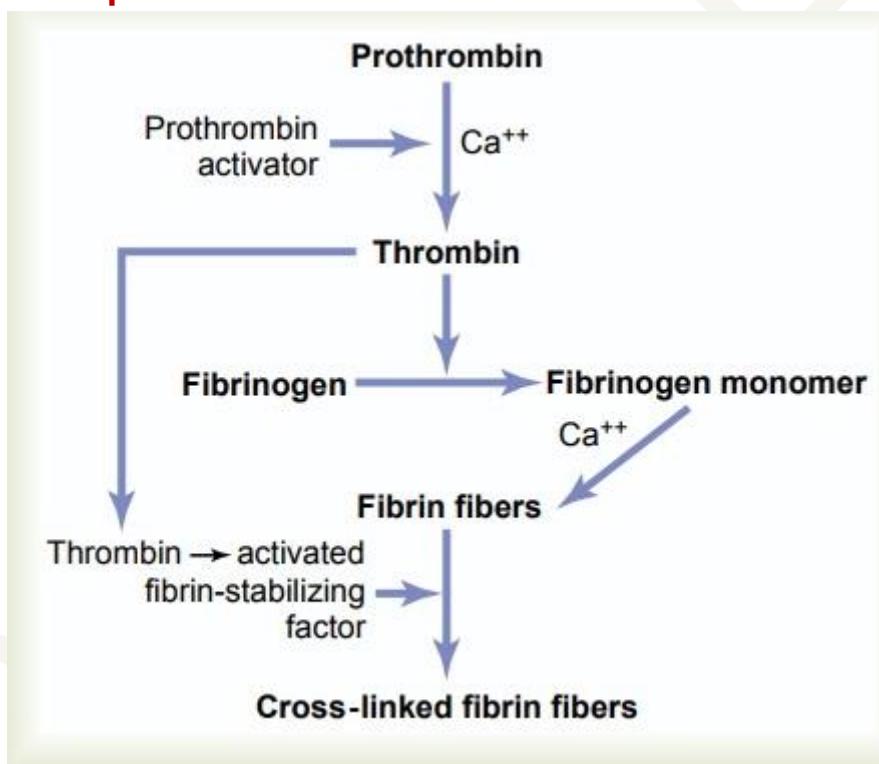
## MECHANISMS OF CLOT FORMATION

- Clotting occurs in three stages
  - Formation of Prothrombin activator
  - Conversion of Prothrombin into thrombin
  - Conversion of fibrinogen into fibrin

### I. Formation of prothrombin activator

- Blood clotting commences with formation of prothrombin activator.
- Formation of prothrombin activator occurs through two pathways:-
  - Intrinsic pathway
  - Extrinsic pathway

### II. Conversion of prothrombin into thrombin



### III. Conversion of fibrinogen into fibrin

- Proteolysis
- Polymerization
- Stabilization of fibrin polymers

## Factors affecting

i. <i>Blood Clot Retraction</i>	<ul style="list-style-type: none"> <li>Clot is meshwork of fibrin with entrapped blood cells, platelets &amp; plasma</li> <li>Contractile proteins: Actin, myosin &amp; thrombosthenin</li> <li>Compress fibrin meshwork squeeze out serum</li> <li>Clot reduced to 40% of original volume</li> </ul>
ii. <i>Role Of Calcium</i>	<ul style="list-style-type: none"> <li>Except for first 2 steps Ca required for all steps</li> <li>Ca removal causes Anticoagulation e.g. use of oxalates &amp; citrates</li> </ul>
iii. <i>Role Of Vitamin K</i>	<ul style="list-style-type: none"> <li>Synthesis of coagulants like Prothrombin</li> <li>Factor VII, IX &amp; X &amp; circulatory anticoagulant protein</li> <li>Deficiency causes serious hemorrhages</li> </ul>
iv. <i>Role Of Liver</i>	<ul style="list-style-type: none"> <li>Synthesis of procoagulants: site of synthesis of factor V, VII, IX, X, prothrombin &amp; fibrinogen</li> <li>Removal of activated procoagulants</li> <li>Synthesis of anticoagulants like: heparin, anti-thrombin III &amp; protein C</li> </ul>
v. <i>Role Of Blood Vessels</i>	<ul style="list-style-type: none"> <li>Anticoagulant role <ul style="list-style-type: none"> <li>Barrier</li> <li>Produces heparin &amp; <math>\alpha</math>-2 macroglobulin</li> <li>Smoothness prevents aggregation</li> <li>Produces PGI2 prevent aggregation</li> </ul> </li> <li>Coagulant role <ul style="list-style-type: none"> <li>Von Willebrand factor (VWF)</li> <li>Tissue factor</li> <li>Plasminogen activator</li> </ul> </li> <li>Sub endothelial tissue – collagen fibres <ul style="list-style-type: none"> <li>Causes platelet aggregation</li> <li>Intrinsic pathway activation</li> </ul> </li> </ul>
vi. <i>Velocity Of Circulation</i>	<ul style="list-style-type: none"> <li>Blood is in constant motion due to pumping by heart &amp; at constant velocity</li> <li>Decrease in velocity causes Intravascular clotting.</li> </ul>
vii. <i>Circulatory</i>	<ul style="list-style-type: none"> <li>Natural anti-coagulant</li> </ul>

<i>Anticoagulants</i>	<ul style="list-style-type: none"> <li>• Heparin</li> <li>• Antithrombin-III</li> <li>• Alpha 2 macroglobulin</li> <li>• Protein C</li> </ul>
<i>viii. Fibrinolytic Mechanism</i>	<ul style="list-style-type: none"> <li>• Protein C inactivates inhibitor of TPA which increases plasmin formation and acts as Fibrinolytic</li> </ul>
<i>ix. Removal Of Activated Clotting Factors</i>	<ul style="list-style-type: none"> <li>• Liver plays an important role</li> <li>• Removes activated clotting factors</li> <li>• Prevents Intravascular Clotting</li> </ul>

## CLINICAL IMPLICATIONS

### I. Haemophilia

- Sex-linked inherited blood disorder
- Characterized by prolonged clotting time
- Easy Bruising
- Haemorrhage in muscles and joints

<b>1. Causes of Haemophilia</b>	<b>2. Symptoms of Haemophilia</b>
<ul style="list-style-type: none"> <li>• Occurs due to lack of formation of prothrombin activator</li> <li>• Due to factor IX,X &amp; XI deficiency</li> <li>• Hence, prolonged coagulation time</li> </ul>	<ul style="list-style-type: none"> <li>• Spontaneous bleeding</li> <li>• It is characterized by bleeding from multiple sites, commonly manifested in the mouth as gingival &amp;post-extraction haemorrhages</li> <li>• Prolonged bleeding following tooth extraction, surgery, cuts.</li> <li>• Hemorrhage in gastrointestinal and urinary tracts.</li> <li>• Appearance of blood in urine.</li> </ul>

### 3. Types of Hemophilia

Classified into three types:

#### i. *Hemophilia A or classic Hemophilia*

Deficiency of Factor VIII.

85% of people with hemophilia are affected by Hemophilia A.

**ii. *Hemophilia B or Christmas Disease***

Deficiency of factor IX.

15% of people with hemophilia are affected by hemophilia B.

**iii. *Hemophilia C***

Factor XI deficiency, very rare bleeding disorders.

**4. Treatment:** Replacement of missing clotting factor.

**II. *Von Willebrand's disease***

- Due to deficiency of von Willebrand factor.
- Von Willebrand factor is a protein produced by endothelium of damaged blood vessels during hemostasis after an injury.
- Responsible for the survival and maintenance of factor VIII in plasma.
- Excess bleeding after a mild injury
- Spontaneous Gingival bleeding
- Spontaneous bleeding occurred only after brushing of the teeth
- Prolonged and excessive bleeding after extraction

**III. *Purpura***

- Disorder characterized by prolonged bleeding time.
- Clotting time is normal.

**1. *Characteristic features***

- Spontaneous bleeding under the skin
- Tiny hemorrhage spots.
- Hemorrhage spots under skin are called PURPURIC SPOTS
- Blood also sometimes collects in large area beneath the skin which is also called Ecchymoses.

**2. *Types and causes of purpura***

i. <i>Thrombocytopenic purpura</i>	<ul style="list-style-type: none"><li>• It is due to deficiency of platelets (thrombocytopenia).</li></ul>
ii. <i>Idiopathic thrombocytopenic</i>	<ul style="list-style-type: none"><li>• Purpura due to unknown cause.</li></ul>

<i>purpura</i>	<ul style="list-style-type: none"> <li>Platelet count decreases due to the development of antibodies against platelets.</li> <li>It occurs after blood transfusion.</li> </ul>
<i>iii. Thrombosthenic purpura</i>	<ul style="list-style-type: none"> <li>Occurs due to structural or functional abnormality of platelets.</li> <li>Platelet count is normal.</li> <li>Normal clotting time</li> <li>Normal or prolonged bleeding time</li> <li>Defective clot retraction.</li> </ul>

#### IV. Others

- Platelet deficiencies can cause petechiae or ecchymosis in oral mucosa
- It can induce spontaneous gingival bleeding
- These disorders can be found alone or in association with gingival hyperplasia in cases of leukaemia
- Hemosiderin and other blood degradation products result in brown deposits on the tooth surface due to chronic bleeding.
- Hemarthrosis of the temporomandibular joint is uncommon
- Dental caries and periodontal diseases will be higher in patients with bleeding disorders
- Due to plasminogen deficiency
  - The second most commonly affected site with ligneous lesions is the mouth.
  - The lesions are not painful and appear as nodular ulcerations or gingival hyperplasia and often result in loss of dental integrity

#### INVESTIGATIONS

Test	Mechanism tested	Normal value	Disorder
<b>Bleeding time (BT)</b>	Hemostasis, capillary and platelet functions	3 - 7 minutes	Thrombocytopenia, von willebrand disease
<b>Platelet count</b>	Platelet number	1,50,000 - 4,50,000 / mm <sup>3</sup>	Thrombocytopenia
<b>Prothrombin time (PT)</b>	Extrinsic and common pathways	< 12 sec 12 - 18 sec in	Defect in vitamin K dependent factor,

		neonates	liver disease, DIC
<b>Activated partial thromboplastin time (APTT)</b>	Intrinsic and common pathways	25 - 40 sec, 70 sec in neonate	Hemophilia, von willebrand disease, DIC

### Diagnosis of bleeding disorders by the screening tests

Platelet count	Bleeding time	APTI	Prothrombin	Presumptive diagnosis
Decreased	Prolonged	Norm.	Norm.	<i>Thrombocytopenia</i>
Norm.	Prolonged	Prolonged	Norm.	<i>von Willebrand's disease</i>
Norm./increased	Prolonged	Norm.	Norm.	<i>Thrombocytopathia</i>
Norm.	Norm.	Prolonged	Norm.	<i>„intrinsic" pathway abnormality (FVIII, IX, XI, XII)</i>
Norm.	Norm.	Norm.	Prolonged	<i>„extrinsic" pathway abnormality (FVII)</i>
Norm.	Norm.	Prolonged	Prolonged	<i>„common" pathway abnorm. (F1, II, V, X.)</i>
Norm.	Norm.	Norm.	Norm.	<i>- /FXIII deficiency/ mild bleeding disorder</i>

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**Please Give Your Feedback on this Answer**

## HIV tests (7M)

### CONTENTS/SYNOPSIS

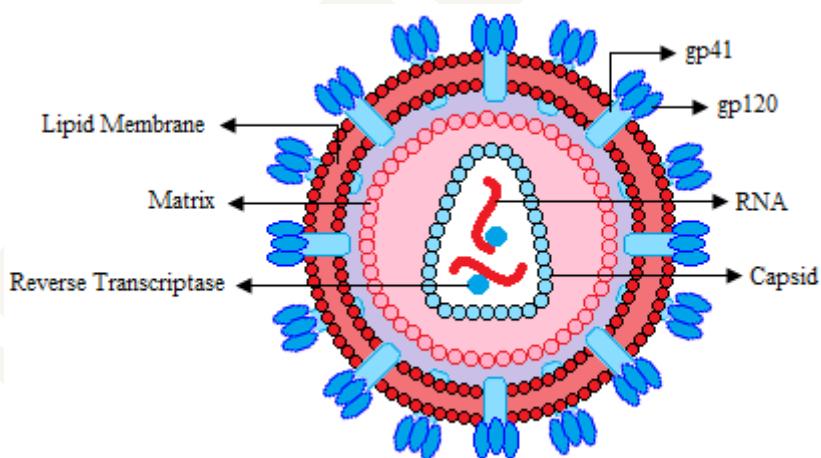
- Introduction
- Virion structure
- Replication process
- Pathogenesis
- Routes of transmission
- Phases of HIV infection
  - Primary infection
  - Symptomatic contamination
  - AIDS
- Objectives of HIV testing
- Challenges in HIV testing
- Types of HIV diagnostic tests
  - Enzyme Immunoassays (EIAs)
  - ELISA
    - Mechanism
    - Interpretation of ELISA results
    - Factors that may affect the result of ELISA test
    - Causes of a false positive results
    - Causes of false negative results
  - Rapid anti HIV tests
    - Tests
    - Advantages
    - Disadvantages
  - Western blot
  - HIV Antibody test
  - HIV p24 Antigen
    - EIA detects p24 antigen before antibody can be detected
    - Used
    - Draw backs
- Standard precautions and safe laboratory practices:
- References

## INTRODUCTION

- HIV is a virus that belongs to retroviridae family, which is considered as highly evolved.
- Characteristic feature is the presence of Reverse Transcriptase enzyme.

## VIRION STRUCTURE

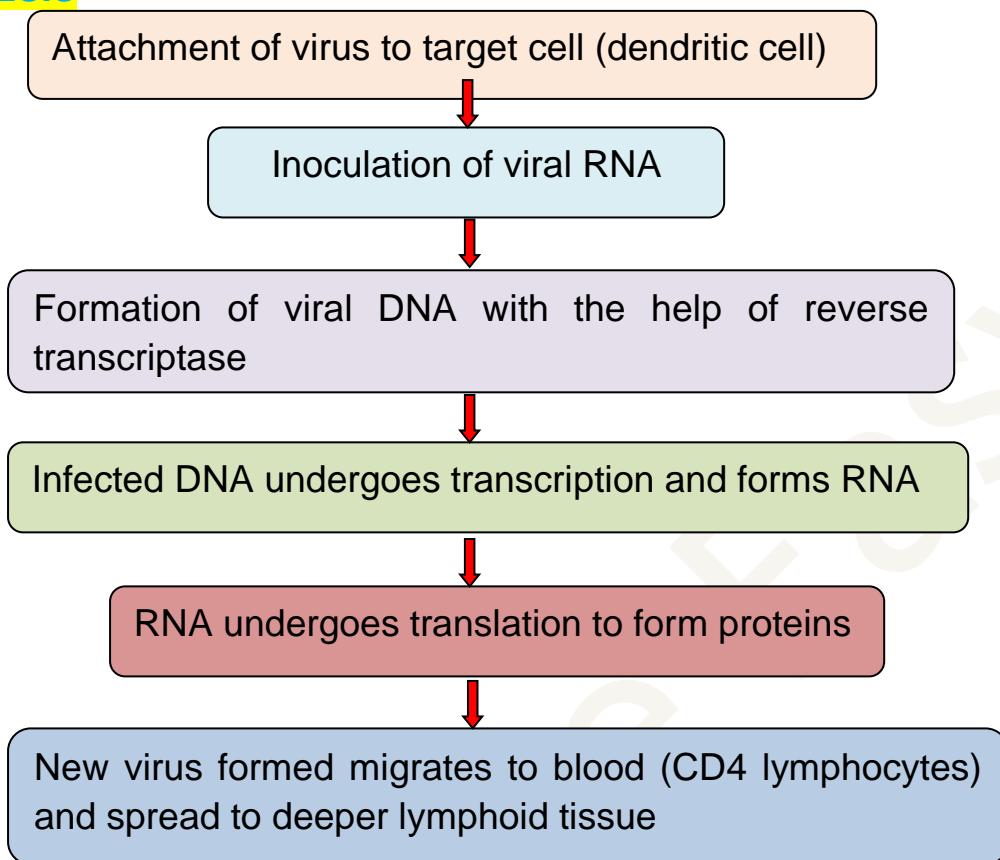
- 120 nm in diameter
- Icosahedral in shape
- Enveloped, outer lipid bilayer with uniformly arranged 72 spikes of gp 120 & gp 41.
- It contains core protein p24 and p18.
- 2 strands of genomic RNA.
- Reverse transcriptase, Integrase and Protease enzymes are found which help in viral replication and maturation.
- Reverse transcriptase copies the viral RNA into DNA, integrates into host cell chromosome.



## REPLICATION PROCESS

- HIV virus only replicate in human cells.
- Replication of HIV takes place in the following steps
- Entry, Reverse transcription, Integration, Transcription, Translation, Assembly, Release, Maturation

## PATHOGENESIS



## ROUTES OF TRANSMISSION

- Human being is the reservoir of host
- HIV transmission is through
  - Blood/blood products
  - Vaginal fluid
  - Seminal fluid
  - Breast milk
  - Other body fluids.
- Infects other uninfected person through
  - Unprotected sexual contact
  - Transfusion of contaminated blood and blood products
  - Use of unsterilized syringes, needles and other instruments
- Mother to child transmission
  - In - utero
  - During delivery
  - During breast feeding

## PHASES OF HIV INFECTION

### I. Primary infection

- Clinically asymptomatic stage

### II. Symptomatic contamination

- Movement from HIV to AIDS

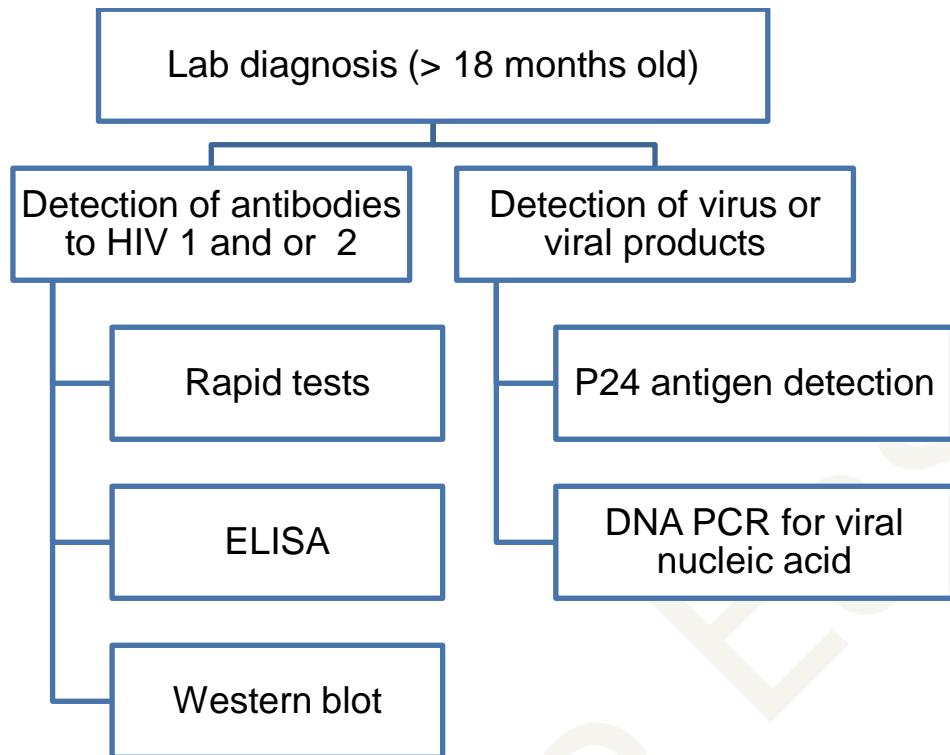
### III. AIDS

- Disease caused by Human Immunodeficiency Virus characterized by profound immunosuppression that leads to life threatening opportunistic infections, malignancies, neurologic diseases.
- Patient is confirmed to have AIDS when CD4 counts less than 200 Cells/cubic mm.

OBJECTIVES OF HIV TESTING	CHALLENGES IN HIV TESTING
<ul style="list-style-type: none"><li>• Blood and blood products safety</li><li>• Diagnosis of HIV infections in suspected cases</li><li>• Screening of sperms, organs and tissue donors</li><li>• Voluntary testing after counseling</li><li>• Epidemiological surveillance</li><li>• Research</li></ul>	<ul style="list-style-type: none"><li>• Early detection of seroconversion</li><li>• Early detection in infants born to HIV positive mothers</li><li>• Impact of oral health conditions</li><li>• Technical skill</li></ul>

## TYPES OF HIV DIAGNOSTIC TESTS

- **HIV antibodies:** Most common test used to establish infection
- **HIV 1 RNA:** Used to detect acute HIV
- **HIV p24 Antigen:** Rarely used



## I. Enzyme Immunoassays (EIAs)

### 1. Quantitative assay to measure HIV antibodies

- Detects antibodies to HIV 1 and HIV 2
- Antigens coated in microwells
- HIV antigen/ antibody reactions are detected by colour changes
- Intensity of colour reflects amount of antibodies present

#### Drawbacks

- Should have skilled lab technician
- Large volume testing
- Properly maintained equipments are needed
- Generations of EIAs tests

### HIV Assay Diagnostic Testing Evolution

Assay progression	Indirect ELISA (HIV-1,2)		Sandwich ELISA HIV1,2 IgG & IgM		Sandwich ELISA HIV1,2 IgG & IgM + p24 Ag	
	1985	1987	1991	1997	2015	
Year	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	
Generation	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	
Antigen (Ag) Source	Virus Infected Cell Lysate	Lysate & Recombinant	Recombinant & Synthetic peptides	Recombinant & Synthetic peptides	Recombinant & Synthetic peptides	
Specificity	95-98%	>99%	>99.5%	99.5%	99.5%	
Sensitivity	99%	>99.5%	>99.5%	>99.8%	100%	
Negative Window	8-10 weeks	4-6 weeks	2-3 weeks	2 weeks	2 weeks	
Detects Antibody (Ab) and Ag	IgG Anti HIV-1	IgG anti HIV-1 and IgG anti HIV-2	IgG and IgM anti HIV-1, HIV-2 and Group O	IgG and IgM anti HIV-1, HIV-2 and Group O. Also detects HIV-1 p24 Ag	IgG and IgM anti HIV-1, HIV-2 and Group O. Also detects HIV-1 p24 Ag	
Results	Single result	Single result	Single result	Single result; does not differentiate Ab from Ag positivity	Separate HIV-1 and HIV 2 Ab and Ag results	
Confirming Tests	HIV-1 western blot (WB) or immunofluorescence (IFA)	HIV-1 WB or IFA, HIV-2 ELISA and WB if HIV-1 confirm is negative	HIV-1 WB or IFA, HIV-2 ELISA and WB if HIV-1 confirm is negative	HIV-1.2 differentiation Assay followed by qualitative HIV-1 RNA PCR if differentiation assay is negative	Not determined at the time of this writing	

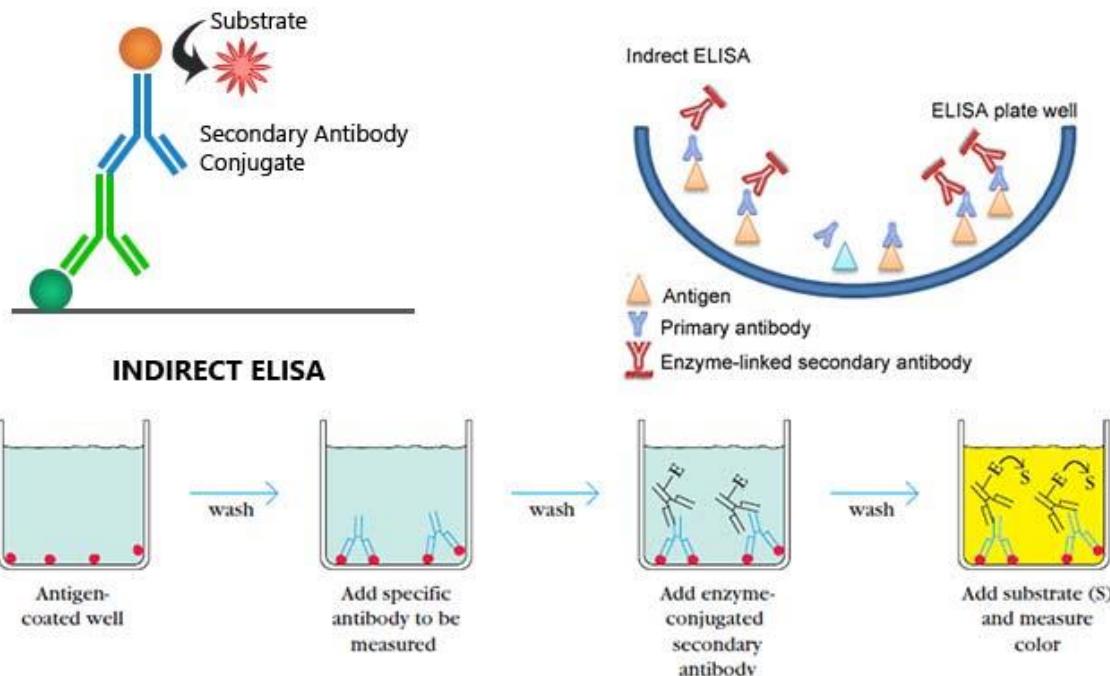
## II. ELISA

- ELISA is most commonly used for screening of blood samples for hepatitis B and C viruses and HIV.
- There are 3 types of ELISA test- direct, indirect and sandwich technique.
- Indirect ELISA technique is the most commonly employed as described below

### 1. Mechanism

- A serum from patient's blood sample, containing Abs, is added to ELISA plate which is then washed for inactive Abs (that will not bind to Ag).
- A second layer of Abs called a conjugate is added to detect primary Abs from the human serum.
- Excess Abs are washed off and a substrate (chromogen) is added
- If positive, enzyme on Abs , once bound to Ag will act on substrate, changing its color.

- If negative, no Abs will bind to Ag, so no enzyme will be present to change color of the substrate



## 2. Interpretation of ELISA results

- Kit controls and previously given positive and negative controls should be used irrespective of type of ELISA used
- Each test must be validated according to the validation criteria given in the kit

## 3. Factors that may affect the result of ELISA test

Pre analytical	Analytical
<ul style="list-style-type: none"> <li>• Haemolysed sample</li> <li>• Repeated freezing and thawing done</li> <li>• Contamination of samples and reagents</li> <li>• Improper storage of reagents</li> <li>• Expired and deteriorated reagents</li> </ul>	<ul style="list-style-type: none"> <li>• Errors in pipetting</li> <li>• Improper incubation time</li> <li>• Improper temperature</li> <li>• Improper washing procedures</li> <li>• Carry over from adjacent specimen</li> <li>• Malfunctioning of equipment</li> <li>• Calculation errors</li> </ul>
<i>Post analytical</i>	
<ul style="list-style-type: none"> <li>• Transcription errors</li> </ul>	

## 4. Causes of a false positive result

- Autoimmune diseases
- Hepatitis

## 5. Causes of false negative results

- Technical errors
- During window period and at end

<ul style="list-style-type: none"> <li>• Primary biliary cirrhosis</li> <li>• Pregnancies (multiple)</li> <li>• Leprosy</li> </ul>	stage of disease
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### III. Rapid anti HIV tests

- Uses recombinant or synthetic antigens
- Qualitative assay to detect HIV antibodies
- Most tests detect HIV 1 and HIV 2

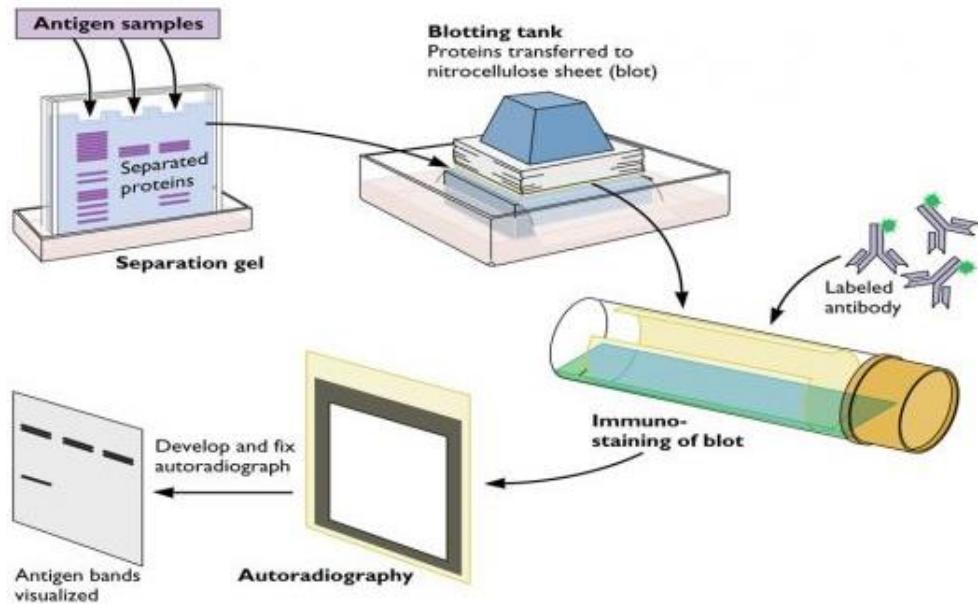
#### 1. Tests

- Blot immunoassay
- Immunochromatographic
- Particle agglutination
- Dipstick and comb assay based on WIA

2. Advantages	3. Disadvantages
<ul style="list-style-type: none"> <li>• No need of special equipment</li> <li>• Available in smaller test packs</li> <li>• Simple to perform</li> <li>• Sensitivity and specificity is similar to ELISA</li> <li>• Few rapid tests can be stored at room temperature</li> </ul>	<ul style="list-style-type: none"> <li>• Small numbers of tests can be run</li> <li>• Quality control is needed at multiple sites</li> <li>• Test performance may vary by product</li> <li>• Variability in interpretation of results</li> <li>• Limited end point stability of test results</li> </ul>

### IV. Western blot

- Western blot is most commonly used to confirm infection caused by HIV, initially diagnosed by ELISA.
- It uses gel electrophoresis to separate native proteins by 3-D structure or denatured proteins by the length of the polypeptide.
- The proteins are then transferred to a membrane (typically nitrocellulose or PVDF), where they are stained with antibodies specific to the target protein.
- The gel electrophoresis step is included in western blot analysis to resolve the issue of the cross-reactivity of antibodies.



## V. HIV Antibody test

Causes for false negative antibody tests	Causes for false positive antibody tests
<ul style="list-style-type: none"> <li>• Acute HIV infection</li> <li>• Advanced HIV infection</li> <li>• Antiretroviral therapy</li> </ul>	<ul style="list-style-type: none"> <li>• Viral diseases</li> <li>• Autoimmune disorders</li> <li>• Bleeding disorders</li> <li>• Liver diseases</li> <li>• Immunizations</li> </ul>

## VI. HIV p24 Antigen

- It is a core protein of the virus
- Positive p24 tests confirm HIV, however a negative test does not rule out HIV

### 1. EIA detects p24 antigen before antibody can be detected

- Detected 2 to 3 weeks after HIV infection
- Detected about 6 days before antibody tests are reactive

2. Used	3. Draw backs
<ul style="list-style-type: none"> <li>• Diagnosis of pediatric HIV 1 infections</li> <li>• Safety of blood bank</li> </ul>	<ul style="list-style-type: none"> <li>• Complex procedure Level 4</li> <li>• Need properly maintained equipment</li> </ul>

**STANDARD PRECAUTIONS AND SAFE LABORATORY PRACTICES:**

- Blood, bodily fluids, materials contaminated are considered infectious
- Appropriate precautions are to be taken to prevent exposure to skin and mucous membranes
- Special care while handling sharp objects
- Wash hands thoroughly with water and soap
- Disinfection of work surfaces with 0.1% sodium hypochlorite solution
- Laboratory personnel should refrain from mouth pipetting, eating, drinking in the work station
- Access to lab should be limited to trained personnel only
- All HCPs must be immunized against HBV

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5. Venkataraman BK, Iyengar AR, Ganapathy KS, Mohan CV and Nagesh KS. Diagnostic oral medicine. 3rd edition Lippincott Williams and Wilkins. 2013.

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**Please Give Your Feedback on this Answer**

**Describe control of cross infection in prosthodontics (7M) (6M)**

**Sterilization method of impression obtained from patient for prosthodontic treatment (7M)**

**Discuss cross infection control in prosthodontics (20M) (10M)**

**Disinfection of impressions (6M) (7M)**

**Discuss infection control in prosthodontics (20M) (6M)**

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- References

## INFECTION CONTROL

Also called “exposure control plan” by OSHA is a required office program that is designed to protect personnel against risks of exposure to infection

## TERMINOLOGIES

<b>Sterilization</b>	<ul style="list-style-type: none"> <li>• Use of a physical or chemical procedure to destroy all microorganisms including substantial numbers of resistant bacteria spores</li> <li>• Sterilization means the destruction of all life forms</li> <li>• Sterilization is the process of killing or removing all viable organisms</li> </ul>
<b>Sterile</b>	<ul style="list-style-type: none"> <li>• Free from all living microorganisms; usually described as a probability (e.g., the probability of a surviving microorganism being 1 in 1 million)</li> </ul>
<b>Disinfection</b>	<ul style="list-style-type: none"> <li>• Destruction of pathogenic and other kinds of microorganisms by physical or chemical means</li> <li>• Disinfection is less lethal than sterilization, because it destroys the majority of recognized pathogenic microorganisms, but not necessarily all microbial forms (e.g., bacterial spores)</li> <li>• Disinfection is a process of removing or killing most, but not all, viable organisms</li> </ul>
<b>Disinfectant</b>	<ul style="list-style-type: none"> <li>• A chemical agent used on inanimate objects to destroy virtually all recognized pathogenic microorganisms, but not necessarily all microbial forms (e.g., bacterial endospores).</li> </ul>
<b>Asepsis</b>	<ul style="list-style-type: none"> <li>• Prevention of microbial contamination of living tissues or sterile materials by excluding, removing or killing microorganisms</li> </ul>

## MODES OF DISEASES TRANSMISSION

- Direct contact with blood or body fluids
- Indirect contact with a contaminated instrument or surface
- Contact of mucosa of the eyes, nose, or mouth with droplets or spatter
- Inhalation of airborne microorganisms

### Six links in chain of transmission of infection

- Susceptible host, Infectious agent, Reservoirs, Chain of infection, Portal of entry, Portal of exit, Means of transmission

## OBJECTIVES OF INFECTION CONTROL

- Reduce, Implement, Simplify and Protect
- Dental staff and patients may be exposed to a wide variety of pathogenic microorganisms
- Each member of the dental team must follow the recommended guidelines

## DISEASES TRANSMISSION IN DENTAL OFFICE

- The dental office should have an infection control program to prevent the transmission of disease from the following:
  - Patient to dental team
  - Dental team to patient
  - Patient to patient
  - Dental office to community (include dental team's family)
  - Community to dental office
- To prevent such infections, following is a list of all those procedures and precautions that together constitute infection control
- These guidelines should be followed each time treatment is performed

## UNIVERSAL PRECAUTIONS

- Introduced by the Centres for Disease Control (CDC) in 1985, mostly in response to the human immunodeficiency virus (HIV) epidemic
- Universal precautions are:
  - standard set of guidelines aimed at preventing the transmission of blood borne pathogens from exposure to blood and other potentially infectious materials (OPIM).
- OPIM is defined by the Occupational Safety and Health Administration (OSHA) as:
  - The following human body fluids: semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva in dental procedures, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult or impossible to differentiate between body fluids;
  - Any unfixed tissue or organ (other than intact skin) from a human (living or dead); and
  - HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.

- Universal precautions **do not** apply to sputum, feces, sweat, vomit, tears, urine, or nasal secretions
  - unless they are visibly contaminated with blood
  - as their transmission of Hepatitis B or HIV is extremely low or non-existent.

### Body Substance Isolation

- Avoidance of direct physical contact with “all moist and potentially infectious body substances,” even if blood is not visible.
- **Limitation:** emphasized hand washing after removal of gloves only if the hands were visibly soiled.

#### **CDC Guideline for Isolation Precautions in Hospitals (1996):**

- Prepared by the Healthcare Infection Control Practices Advisory Committee (HICPAC)
- combined Universal Precaution and Body Substance Isolation  
→ Standard Precautions.
- introduced three transmission-based precautions: airborne, droplet, and contact.
- All transmission-based precautions are to be used in conjunction with standard precautions.

### STANDARD PRECAUTIONS

- Specific precautions designed to prevent harmful bacteria and viruses from infecting people who are providing first aid or health care.
- Defined by CDC as:
  - Set of practices designed to prevent the transmission of HIV, Hepatitis B and other blood borne pathogens (bacteria and viruses).
- Standard precautions apply to the care of **all patients**, irrespective of their disease state.
- These precautions apply when there is a risk of potential exposure to
  - Blood
  - All body fluids, secretions, and excretions, except sweat, regardless of whether or not they contain visible blood;
  - Non-intact skin,
  - Mucous membranes.

- Body Fluids include:
  - Blood
  - Drainage and secretions from cuts, scrapes, wounds or sores
  - Vomit,
  - Saliva
  - Stool
  - Mucous
  - Urine
  - Sputum
  - Vaginal secretions and Semen
- Under standard precautions, blood and other body fluids of all patients are considered potentially infectious.

### Steps for Standard Precaution

1. Personal Protective Equipment
2. Decontamination
3. Hand Washing
4. Waste Disposal

#### **1. Personal Protective Equipment (PPE)**

- Specialized clothing or equipment worn by an employee for protection against infectious materials
- Personal protective equipment is used as a barrier to protect skin, mucous membranes, airway, and clothing.
- Includes:
  - Gloves
  - Aprons
  - Gowns
  - Protective eyewear
  - Face shields
  - Masks
- Factors Influencing PPE Selection
  - Type of exposure anticipated
  - Splash/spray versus touch
  - Category of isolation precautions

i. <b>Gloves</b>	<ul style="list-style-type: none"> <li>Must be worn when touching blood, body fluids, secretions, excretions, mucous membranes, or non-intact skin.</li> <li>Change when there is contact with potentially infected material in the same patient to avoid cross-contamination.</li> <li>Remove before touching surfaces and clean items.</li> <li>Wearing gloves does not mitigate the need for proper hand hygiene.</li> </ul>
ii. <b>Mask, Goggles/Eye Visor, and/or Face Shield</b>	<ul style="list-style-type: none"> <li>mandatory during procedures that may spray or splash blood, body fluids, secretions, or excretions.</li> </ul>
iii. <b>Gown</b>	<ul style="list-style-type: none"> <li>Wear to protect skin or clothing during procedures that may spray or splash blood, body fluids, secretions, or excretions.</li> </ul>

#### *Sequence for Donning PPE (CDC Recommended)*

- Gown → mask or respirator → goggles or face shield → gloves

#### *Sequence for Removing PPE (CDC Recommended)*

- Gloves → Face shield or goggles → Gown → Mask or respirator

## **2. Decontamination**

- With approved quaternary disinfectant
- Clorox wipes and Lysol type products will kill many infectious organisms but will not kill blood borne pathogens.

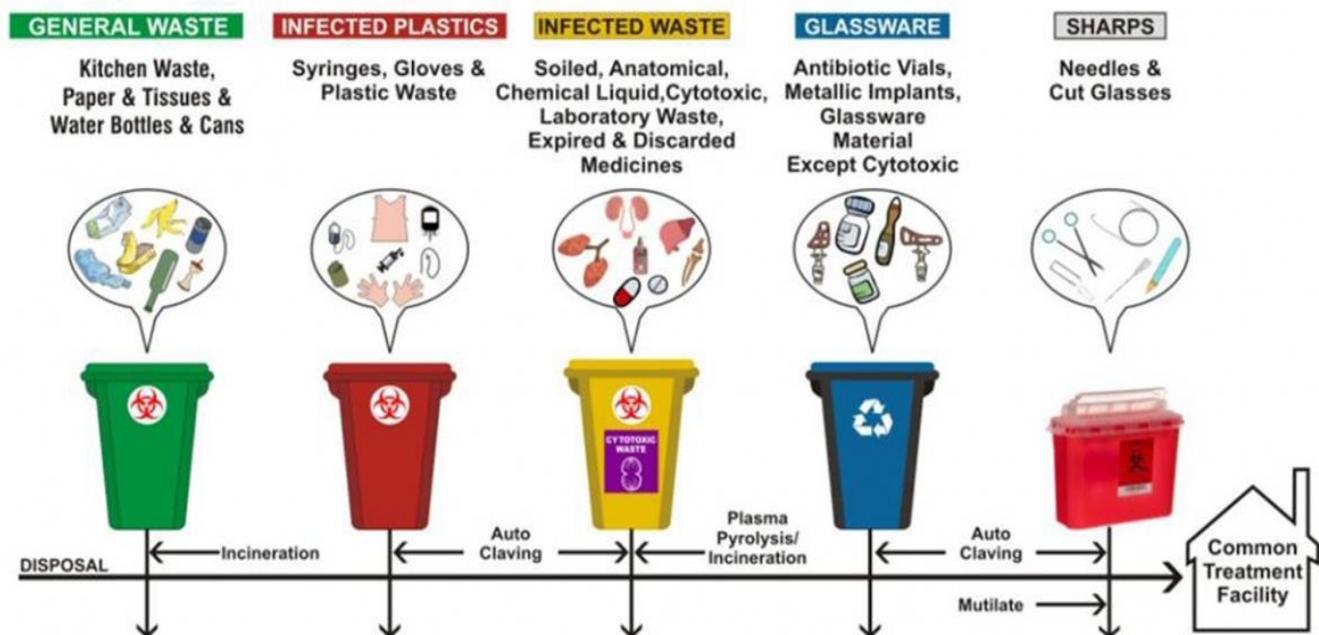
## **3. Hand washing**

- The most important step
- Before and after any direct patient contact and between patients, whether or not gloves are worn.
- Immediately after gloves are removed.
- Before handling an invasive device.
- After touching blood, body fluids, secretions, excretions, non-intact skin, and contaminated items, even if gloves are worn.

- During patient care, when moving from a contaminated to a clean body site of the patient.
- After contact with inanimate objects in the immediate vicinity of the patient.
- Hand washing with soap and water for at least 40 to 60 seconds
  - do not use clean hands to turn off the faucet
- Hand rubbing with alcohol applied generously to cover hands completely should be performed and hands rubbed until dry.

#### 4. Waste Disposal

### SEGREGATION OF HOSPITAL BIO-MEDICAL WASTE



- Double bag technique: Bag and tie → Place in second bag and tie again
- Place all sharps (used needles) in sharps container.

### TRANSMISSION-BASED PRECAUTIONS

#### I. Airborne Precautions

- used in patients with known or suspected infection with pathogens that are spread by airborne transmission – eg : Tuberculosis
- Examples:
  - airborne droplet nuclei (small-particle residue {5 um or smaller in size} of evaporated droplets that may remain suspended in the air for long periods of time)
  - dust particles containing the infectious agent.

1. Patient Placement	2. PPE	3. Transport
<ul style="list-style-type: none"> <li>Placed in negative pressure isolation room → minimum of 6 to 12 air changes per hour.</li> <li>Cohorting: placing patients with active infection with same pathogen, and no other infection, together</li> </ul>	<ul style="list-style-type: none"> <li>Respirators that filter at least 95% of airborne particles must be worn over the nose and mouth, eg: N95 respirator or powered air-purifying respirator (PAPR) with a high-efficiency particular air (HEPA) filter.</li> </ul>	<ul style="list-style-type: none"> <li>When necessary, patients being transported out of their rooms should wear a surgical mask.</li> </ul>

## II. Droplet Precautions

- Used in patients with known or suspected infection with pathogens that are spread by droplet transmission. eg: Diphtheria
- Droplets are particles of respiratory secretions +/- 5 microns.
- Droplets remain suspended in the air for limited periods.
- Transmission is associated with exposure within **three to six feet** (one to two meters) of the source.

1. Patient placement	2. PPE	3. Transport
<ul style="list-style-type: none"> <li>Isolation or cohorting</li> <li>If not possible, Infected patient should be placed at least 3 feet away from other patients and visitors.</li> </ul>	<ul style="list-style-type: none"> <li>Surgical masks should be worn while <u>within 6 feet</u> of the patient.</li> </ul>	<ul style="list-style-type: none"> <li>When necessary, patients being transported out of their rooms should wear a surgical mask.</li> </ul>

## III. Contact Precautions

- Used in patients with known or suspected infection or colonization with pathogens that are spread by direct and indirect patient contact eg: Hep A, Herpes simplex.
  - Indirect patient contact occurs when physical contact is made with items or surfaces in the patient's environment.

1. Patient Placement	2. PPE	3. Patient Equipment
<ul style="list-style-type: none"> <li>Isolation or cohorting</li> </ul>	<ul style="list-style-type: none"> <li>Gloves and gowns should be donned prior to entering the patient's room, and removed before leaving.</li> <li>Hand hygiene should be performed immediately afterward.</li> <li>Care should be taken not to touch any potentially contaminated surface upon leaving the room.</li> </ul>	<ul style="list-style-type: none"> <li>Single-patient-use items preferable.</li> <li>If not available, then they should be cleaned and disinfected before use on another patient.</li> </ul>

## OPERATORY ASEPSIS

- In the dental operatory, environmental surfaces (i.e., a surface or equipment that does not contact patients directly) can become contaminated during patient care
- Certain surfaces, especially ones touched frequently (e.g., light handles, unit switches, and drawer knobs) can serve as reservoirs of microbial contamination, although they have not been associated directly with transmission of infection to either personnel or patients
- Transfer of microorganisms from contaminated environmental surfaces to patients occurs primarily through personnel hand contact

### I. Infection Control during the Pre-treatment period

- The process of infection control begins during the period of preparation for clinical treatment
  - Paying attention to infection control at this time has several payoffs
  - In addition to reducing the risk of transmission of infectious agents during patient care, thinking ahead will make the treatment session more efficient and will also make the post treatment infection control process easier and more effective
- Remove unnecessary items from the dental procedure area. The dental procedure area should be arranged to facilitate a thorough cleaning following each patient

## 2. Pre-plan the materials needed during treatment

- Set out all instruments, medications, impression materials and other items that are needed for a procedure
- Thinking ahead minimizes the need to search for additional items or to enter cabinets and drawers once gloves have become contaminated

3. Utilize disposable items whenever possible: The use of disposable items saves time during clean-up and decontamination and solves the problem of proper reprocessing

4. Use of prearranged tray set-ups for routine or frequently performed procedures – Helps to eliminate the need to go into cabinets once a procedure is started

5. Use of individualized, sterilized bur blocks for each procedure - Using individualized bur blocks containing only the burs required for that procedure helps to eliminate the contamination of other unneeded burs and to make clean-up easier

6. If indicated, have the rubber dam setup on the tray. When a rubber dam will be used during a clinical procedure, it also should be included on the tray setup. In addition, include those items needed for high-velocity evacuation

## 7. Identify those items that will become contaminated during treatment

- While preparing the dental procedure area prior to beginning a clinical procedure, consider which items will become contaminated during treatment
- Examples of such surfaces include countertops, light handles, X-ray unit heads, tray tables etc.
- Decide whether to use a barrier, e.g., plastic wrap to prevent contamination of these surfaces and items or to disinfect them when the procedure is complete. 38

Surface barriers: Surface barriers are used to prevent contamination on the surface underneath. All the surface barriers should be resistant to fluids in order to prevent microorganisms in saliva, blood, and other liquids from soaking through the barrier and reach the surface underneath.

## 8. Review patient records before initiating treatment and place radiographs on the view box

- Do not leave the record on the countertop or handle it after beginning treatment
- Place the record in a drawer or out of the dental procedure area, so that it doesn't become contaminated

- Entries into the record should be done before and after the procedure
9. Prepare personnel involved in patient care
- An essential pre-treatment procedure is the preparation of all personnel involved in patient care
  - This includes the utilization of personal protective equipment (gown, eyewear, mask and gloves) and hand hygiene

## **II. Infection control during the treatment period (Chair side Infection Control)**

- The infection control procedures described in the previous period will help to reduce the risk of transmission of infectious agents.
- During treatment there are additional precautions that can be taken to further reduce infection risks.
  - Use care when receiving, handling, or passing sharp instruments
  - Take special precautions with syringes and needles
  - Use a rubber dam whenever possible
  - Avoid touching unprotected switches, handles and other equipment once gloves have been contaminated
  - Avoid entering cabinets once gloves have been contaminated

## **III. Infection control during the Post-Treatment period**

- Continue to wear personal protective equipment during clean-up: After patient care is completed, begin the cleaning and disinfection process by removing contaminated gloves used during treatment, wash your hands and use the utility gloves before beginning the clean-up. Continue to wear protective eyewear, mask, and gown
- Remove all disposable barriers: All of the barriers placed before treatment, including light handle covers and countertop barriers, should be removed
- Clean and disinfect all items not protected by barriers
- Cleaning and disinfection of the equipment used, dental treatment room surfaces, impressions are important components in an effective infection control program
- The laboratory studies have proved that microorganisms may survive on environmental surfaces for long time. For example, *Mycobacterium tuberculosis* may survive for weeks

## STERILIZATION AND DISINFECTION OF DENTAL INSTRUMENTS

### I. Dental instruments

Classification of Dental instruments based on risk of transmission and need of sterilization:

#### 1. *Critical instruments*

- Penetrate mucous membranes or contact bone, bloodstream, or other normally sterile tissues
- Heat sterilize between uses or use sterile single-use, disposable devices
- Examples include surgical instruments, scalpel blades, periodontal scalers, and surgical dental burs

#### 2. *Semi-critical instruments*

- Contact mucous membranes but do not penetrate soft tissue
- Heat sterilize or high-level disinfect
- Examples: dental mouth mirrors, amalgam condensers, and dental hand pieces

#### 3. *Non-critical instruments and devices*

- Contact intact skin
- Clean and disinfect using a low to intermediate level disinfectant
- Examples: X-ray heads, facebows, pulse oximeter, blood pressure cuff

### II. Sterilization

Stages for instrument sterilization are:

- Pre-soaking
- Cleaning
- Corrosion control and lubrication
- Packaging
- Sterilization
- Handling sterile instruments
- Storage
- Distribution

Agents used in sterilization are:

- **Physical agents:**

- Sunlight
- Drying
- Dry heat: flaming, incineration, hot air
- Moist heat: pasteurization, boiling, steam under pressure, steam under normal pressure
- Filtration: candles asbestos pads, membranes
- Radiation
- Ultrasonic and sonic vibrations

- **Chemical agents:**

- Alcohols: ethyl, isopropyl, tri-chloro butanol
- Aldehydes: formaldehyde, glutaraldehyde
- Dyes
- Halogens
- Phenols
- Surface-active agents
- Metallic salts
- Gases: ethylene oxide, formaldehyde, beta propiolactone

The four accepted methods of sterilization are:

- Steam pressure sterilization (autoclave)
- Chemical vapour pressure sterilization (chemiclave)
- Dry heat sterilization (dryclave)
- Ethylene oxide sterilization

### III. Sterilization Monitoring

#### Types of Indicators

- i. **Mechanical:** Measure time, temperature, pressure
- ii. **Chemical:** Change in color when physical parameter is reached
- iii. **Biological** (spore tests): Use biological spores to assess the sterilization process directly

Sterilization method	Spore type	Incubation temperature
Autoclave	Bacillus stearothermophilus	56°C
Chemical vapour		
Dry heat	Bacillus subtilis	37°C
Ethylene Oxide		
Gamma radiation	B. Pumilus E601	37°C

Sterilization monitoring has four components:

1. A sterilization indicator on the instrument bag, stamped with the date it is sterilized
2. Daily color-change process-indicator strips
3. Weekly biologic spore test, and
4. Documentation notebook

#### IV. Storage and care of sterile instruments

- Storage areas should be dust proof, dry, well ventilated and easily accessible for routine dental use
- Sterile materials should be stored at least 8-10 inches from the floor, at least 18 inches from the ceiling, and at least 2 inches from the outside walls
- Items are not stored in any location where they can become wet
- Items should be positioned so that packaged items are not crushed, bent, crushed, compressed or punctured
- Outside shipping containers and corrugated cartons should not be used as containers in sterile storage areas
- Ultra violet chambers and formalin chambers are now commonly used for storage of instruments

#### DISINFECTION OF DENTAL UNIT AND ENVIRONMENTAL SURFACES

- Disinfection is always at least a two-step procedure
  - The initial step involves vigorous scrubbing of the surfaces to be disinfected and wiping them clean
  - The second step involves wetting the surface with a disinfectant and leaving it wet for the time prescribed by the manufacturer
- The ideal disinfectant has the following properties:
  - Broad spectrum of activity
  - Acts rapidly
  - Non corrosive

- Environment friendly
- Is free of volatile organic compounds
- Nontoxic & non-staining

<b>I. High-level disinfection</b>	<ul style="list-style-type: none"> <li>• Disinfection process that inactivates vegetative bacteria, mycobacteria, fungi, and viruses but not necessarily high numbers of bacterial spores</li> </ul>
<b>II. Intermediate-level disinfection</b>	<ul style="list-style-type: none"> <li>• Disinfection process that inactivates vegetative bacteria, the majority of fungi, mycobacteria, and the majority of viruses (particularly enveloped viruses) but not bacterial spores</li> </ul>
<b>III. Low-level disinfectant:</b>	<ul style="list-style-type: none"> <li>• Liquid chemical germicide. OSHA requires low-level hospital disinfectants also to have a label claim for potency against HIV and HBV.</li> <li>• Gigasept which contains succindialdehyde and dimethoxy tetrahydrofuran are used for disinfection of plastic and rubber materials Eg: dental chair</li> </ul>

## BASICS OF LABORATORY

- Need coordination between dental office and lab
- Use of proper methods/materials for handling and decontaminating soiled incoming items
- All contaminated incoming items should be cleaned and disinfected before being handled by lab personnel, and before being returned to the patient

Incoming items	Outgoing items
<ul style="list-style-type: none"> <li>• Rinse under running tap water to remove blood/saliva</li> <li>• Disinfect as appropriate</li> <li>• Rinse thoroughly with tap water to remove residual disinfectant</li> <li>• No single disinfectant is ideal or compatible with all items</li> </ul>	<ul style="list-style-type: none"> <li>• Clean and disinfect before delivery to patient</li> <li>• After disinfection: rinse and place in plastic bag with diluted mouthwash until insertion</li> <li>• Do not store in disinfectant before insertion</li> <li>• Label the plastic bag</li> </ul>

### Disinfection of impression materials:

- To avoid cross infection following protocols are to be followed to disinfect impressions for proper transport to laboratory

Material	Method	Recommended Disinfectant	Comments
Alginate	Immersion with caution Use only disinfectant for a short-term exposure time (<10 min for alginate)	Chlorine compounds or iodophors	Short-term glutaraldehyde has been shown to be acceptable, but time is inadequate for disinfection.
Agar			Do not immerse in alkaline glutaraldehyde!
Polysulfide and silicone	Immersion	Glutaraldehydes, chlorine compounds, iodophors, phenolics	Disinfectants requiring more than 30-min exposure times are not recommended.
Polyether	Immerse with caution Use disinfectant only for a short exposure time (<10 min)	Chlorine compounds or iodophors	ADA recommends any of the disinfectant classes; however, short-term exposures are essential to avoid distortion.
ZOE impression paste	Immersion preferred; spraying can be used for bite registrations	Glutaraldehydes or iodophors	Not compatible with chlorine compounds! Phenolic spray can be used.
Impression compound		Iodophors or chlorine compounds	Phenolic spray can be used.

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**Please Give Your Feedback on this Answer**

## **Sterilization method of impression obtained from patient for prosthodontic treatment (7M)**

### **Sterilization (10M)**

### **Disinfection of impressions (6M) (7M)**

#### **CONTENTS/SYNOPSIS**

- Introduction
- Need for sterilization
- Factors influencing the degree of killing
- Processes of sterilization
  - Physical methods
    - Thermal
      - ✓ Dry Heat
      - ✓ Moist Heat
    - Radiation
    - Filtration
  - Chemical methods
    - Gases
    - Solids and Liquids
- Factors influencing the activity of disinfectants
- Disinfection of dental unit and environmental surfaces
  - High-level disinfection
  - Intermediate-level disinfection
  - Low-level disinfectant
- Disinfection of impression materials
- Basics of laboratory
  - Incoming items
  - Outgoing items
- References

## INTRODUCTION

- Complete elimination of all forms of microbial life including bacteria, fungi, spores, etc. it is an absolute state
- Three types:
  - critical
  - semi-critical
  - non-critical
- Disinfection is the technique of removal of pathogenic organisms, may not be all forms of microbial life. It is a relative term. It is referred to lifeless objects

## NEED FOR STERILIZATION

- To prevent infection
- To prevent transmission of diseases from operator to patient
- To prevent transmission of diseases from one patient to another
- To prevent supra-infections and secondary procedures / antibiotic therapy.

## FACTORS INFLUENCING THE DEGREE OF KILLING

- Type of organisms
- Number of organisms present
- Time & temperature of exposure
- Concentration of sterilizing agent
- Amount of organic soil present

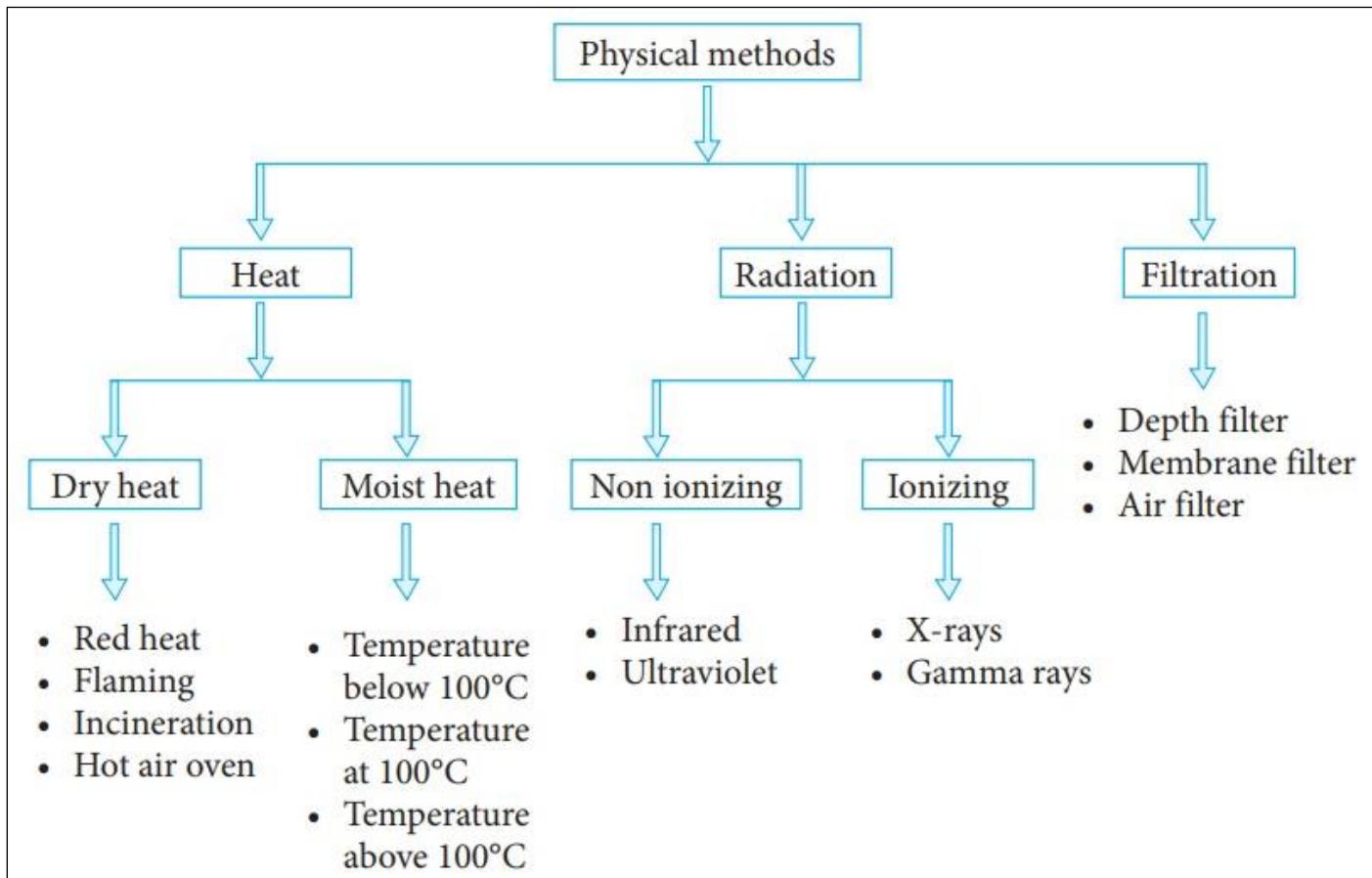
## PROCESSES OF STERILIZATION

- There are three types of sterilization/ disinfection
  - Physical method
  - Chemical method
  - Chemicomechanical method

### I. Physical Methods

#### 1. Heat:

- Most widely used
- Reliable.
- It can be dry or wet.
- **Demerit:** The prerequisites of materials to be sterilized by this method are that they should be thermostable.



Materials that can be sterilized by thermal methods:

<ul style="list-style-type: none"> <li>Operation theatre appliance like mops, instruments, clothes, bedspreads and drapes</li> </ul>	<ul style="list-style-type: none"> <li>Autoclave</li> </ul>
<ul style="list-style-type: none"> <li>Syringes</li> </ul>	<ul style="list-style-type: none"> <li>Autoclave, hot air oven and gamma radiation</li> </ul>
<ul style="list-style-type: none"> <li>Soiled dressings, tissues</li> </ul>	<ul style="list-style-type: none"> <li>Incineration</li> </ul>

### i. Dry heat

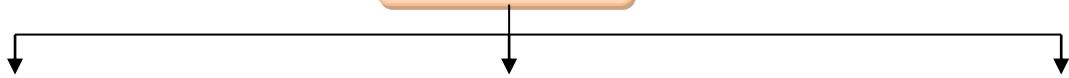
Advantage	Temperature	Mode of Action
<ul style="list-style-type: none"> <li>Good penetration</li> <li>Non-corrosive nature.</li> <li>Especially helpful for sterilizing glass</li> </ul>	<ul style="list-style-type: none"> <li>160 deg C to several 1000 deg C</li> </ul>	<ul style="list-style-type: none"> <li>Protein Denaturation</li> <li>Oxidative Damage</li> <li>Toxic Effect of Electrolytes</li> </ul>

Red heat	<ul style="list-style-type: none"> <li>• Held in the flame of a bunsen burner.</li> <li>• Instant sterilization</li> <li>• Inoculating wires, tip of forceps, needles, scalpels</li> </ul>
Hot air oven	<ul style="list-style-type: none"> <li>• Circulated air transfers heat to the materials within chamber</li> </ul> <p><b>Materials:</b> Glassware, Surgical Instruments, Chemicals</p> <p><b>Temperature:</b></p> <ul style="list-style-type: none"> <li>• 150 deg C for 2 hours</li> <li>• 160 deg C for 1 hour</li> <li>• 180 deg C for 30 minutes</li> </ul> <p><b>Precautions:</b></p> <ul style="list-style-type: none"> <li>• Should not be overloaded</li> <li>• Materials should be dry</li> <li>• Oven must be cooled for &gt;2 hours before opening.</li> </ul>
Incineration	<ul style="list-style-type: none"> <li>• Done in an incinerator which burns materials into ashes.</li> </ul> <p><b>Materials:</b> hospital wastes, animal carcasses, culture materials, dressings etc</p> <p><b>Limitations:</b></p> <ul style="list-style-type: none"> <li>• Polluting</li> <li>• Ash difficult to contain</li> <li>• Toxic emissions</li> <li>• Expensive</li> </ul>
Glass bead sterilizer	<ul style="list-style-type: none"> <li>• For sterilization of endodontic files, burs and small instruments.</li> </ul> <p><b>Temperature achieved:</b> 204 deg C</p> <p><b>Duration:</b> 12 - 14 min</p> <p><b>Media used:</b> glass beads, molten metal or salt kept in cup or crucible.</p>

## ii. Wet heat

- Presence of water increases the efficiency of heat to kill microorganisms

Moist heat



Temperature < 100°C  
Inspissation

Temperature - 100°C  
Tyndallisation

Temperature > 100°C  
Autoclave

**Mode of Action:**

- Denaturation of Proteins
- Coagulation of Proteins

**Moist Heat Sterilization - Sub-Boiling Temperature****Insprissation:**

- Temperature: 85° C
- Time: 3 successive days for 30 minutes
- Interval period: incubated at temperature conducive for spore germination.
- Used for Heat labile materials

**Moist Heat Sterilization - Temperature At 100° C****1. Boiling**

- Materials to be sterilized are placed in boiling water (90-99°C)
- Kills most of the bacteria but not spores and viruses
- Used to disinfect syringes, utensils

**2. Tyndallisation:**

- Temperature: 100° C
- Time: 3 successive days for 20 minutes
- Interval Period: incubated at room temperature
- Used for sterilizing materials that cannot withstand pressurized heating. Eg: serum, sugar containing media.

**Moist Heat Sterilization - Temperature > 100° C****1. Autoclave**

- Saturated Steam above 100 deg C is used at pressures greater than atmospheric pressure.

Principle	<ul style="list-style-type: none"> <li>• Heat is the killing agent</li> <li>• Steam at sea level is 100° C (212° F) as pressure is increased the temperature of the steam increases</li> <li>• Steam is the vector that supplies the heat and promotes penetration of the heat</li> </ul>			
Materials sterilized	<ul style="list-style-type: none"> <li>• Most surgical instruments and equipment, drapes and gowns, suture materials, sponges and some plastics and rubbers</li> </ul>			
Temperature & Duration (At 15lb / sq	°C	°F	Time(mins)	
	121	250	15	

inch pr)		126	257	10	
		134	272	03	
Tests for efficiency	<ul style="list-style-type: none"> <li>• <u>Spore testing</u>: done once a week; using Geobacillus stearothermophilus strips or vials. Other biological indicators also used eg: Bacillus subtilis</li> <li>• <u>Thermocouple</u>: one placed inside a test pack of towels and second in chamber drain. It measures the voltage proportional to the temp difference b/w either end of conductor</li> <li>• <u>Brown's test</u>: a chemical indicator which changes its color from red through amber to green.</li> <li>• <u>Bowie dick</u> heat sensitive stickers</li> </ul>				

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Consistently achieves complete sterility</li> <li>• Inexpensive and easy to operate</li> <li>• Safe for patients and personnel</li> <li>• Established protocols and quality control indicators are easy to access</li> </ul>	<ul style="list-style-type: none"> <li>• Operator sensitive</li> <li>• Sterility depends on saturated steam of the appropriate temperature having contact with all objects within the unit for a sufficient length of time</li> <li>• Requires a thorough understanding of technique</li> </ul>

## 2. Hydroclave

- A hospital waste management system which utilizes steam, similar to an autoclave but much faster with even heat penetration

## 2. Radiation

- Many types of radiation → Ultraviolet and gamma rays most common

i. Mode of Action	<ul style="list-style-type: none"> <li>• Ionization of water → which forms highly reactive hydroxyl radicals which in turn react with the DNA, killing the cell.</li> <li>• Cold sterilization.</li> <li>• No residual radiation is left post-sterilization</li> <li>• <u>UV light</u> has lesser penetration and is thus useful for disinfecting operation theatres and disinfecting water.</li> </ul>
ii. Materials	<ul style="list-style-type: none"> <li>• best suited for bulk sterilization</li> </ul>

	<ul style="list-style-type: none"> <li>• Pharmaceuticals, plastic syringes, suturing materials, catheters</li> </ul>
<i>iii. Demerits</i>	<ul style="list-style-type: none"> <li>• Undesirable changes in color (darkening of glass) and corrosion of metal. Time consuming</li> </ul>

### 3. Filtration

- Method of separating microorganisms from the desired material
- It can be used to clear liquids or gaseous materials like heat sensitive injections, ophthalmic solutions and biological products
- Also, they are used in venting systems of hot air oven and freeze driers
- **Types :**
  - Depth Filters
  - Membrane filters
  - Air filters

#### *i. Depth filters*

- Microorganisms removed by physical screening and entrapment.
- **Types:**
  - Candle filters
  - Asbestos filters
  - Sintered glass filters

#### *ii. Membrane filters*

- Reduces the microbial load of by passing through a screen like material with tiny pores
- **Pore Size:**  $0.1\mu\text{m}-0.5\mu\text{m}$
- **Types:**
  - Capillary Pore Membranes
  - Labyrinthine Pore Membranes
- **Use:**
  - Heat sensitive vaccines
  - Bacteria free filtrates for virus isolation

#### *iii. Air filters*

- **HEPA:** high efficiency particle absorption filters are 99.97% to 99.997% effective in removing particles with diameters greater than  $0.3\mu\text{m}$
- **Surgical masks**

- Special masks are available that are designed to protect personnel from animal pathogens
- Must fit snugly, stay dry and be changed every 3 to 4 hours to remain effective
- protects against microorganisms with >95% bacterial filtration efficiency, and also protects from large-particle droplet spatter that might contain blood borne pathogens or other infectious microorganisms (Miller, 1998).

## II. Chemical Methods

### 1. Gaseous

#### i. Ethylene oxide

- Highly penetrative, non-corrosive agent with cidal action against bacteria, spores and viruses.
- Destroys microorganisms by alkylation and causes denaturation of nucleic acids.
- It is highly flammable but when mixed with carbon dioxide or freon, danger is minimized.
- Once exposed to gas, some objects such as plastic require 1-7 days to degas.
- Sterilization process: **specialized gas chamber.**
- After sterilization: **aeration cell.**

Uses	Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• For cellulose and plastics irradiation, usually in sealed packages.</li> <li>• Wide range of plastics: petri dishes, pipettes, syringes, medical devices, etc. and other materials</li> </ul>	<ul style="list-style-type: none"> <li>• Highly penetrating</li> <li>• Can be used at low temp.</li> <li>• Heat sensitive articles can be sterilized.</li> </ul>	<ul style="list-style-type: none"> <li>• High cost</li> <li>• Toxicity of gas</li> <li>• Explosive and inflammable</li> <li>• Longer period of aeration</li> <li>• Potentially mutagenic and carcinogenic, can cause skin and mucous membrane irritation</li> </ul>

#### ii. Formaldehyde

- Widely employed for fumigation of operation theatres.

- Formaldehyde gas is generated by adding 150gm of  $\text{KMnO}_4$  to 280ml formalin for every 1000 cu. Ft. of room volume.
- Doors should not be opened for 48 hrs.

### *iii. Low temperature gas plasma (Ltg)*

- 4<sup>th</sup> state of matter.
- liquid hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) :
  - energized with radio frequency waves into gas plasma.
  - leads to the generation of free radicals and other chemical species, which destroy organisms.
- commercially available:
  - Sterrad 100s sterilizer.
  - Plazlyte sterilizer

## **2. Aldehydes**

### *i. Glutaraldehyde(gta)*

- Less toxic than formaldehyde.
- Microbicidal, fungicidal, virucidal, tuberculocidal
- **Mechanism of action:** Aldehyde groups of glutaraldehyde react strongly with the free amino groups of proteins
- **Uses:** 'cold sterilization' or the high-level disinfection of equipment (such as fibre optic instruments, corrugated rubber anaesthetic tubing, face masks, metal instruments).

### *ii. Per acetic acid*

- Produced by reacting hydrogen peroxide with acetic acid.
- Broadly effective against microorganisms and is not deactivated by catalase and peroxidase, the enzymes that break down hydrogen peroxide.
- It also breaks down to safe and environmentally friendly residues (acetic acid and hydrogen peroxide).
- It can be used over a wide temperature range (0-40°C), wide pH range (3.0-7.5) and is not affected by protein residues.

## STERILIZATION AND DISINFECTION OF DENTAL INSTRUMENTS

### I. Dental instruments

Classification of Dental instruments based on risk of transmission and need of sterilization:

#### 1. Critical instruments

- Penetrate mucous membranes or contact bone, bloodstream, or other normally sterile tissues
- Heat sterilize between uses or use sterile single-use, disposable devices
- Examples include surgical instruments, scalpel blades, periodontal scalers, and surgical dental burs

#### 2. Semi-critical instruments

- Contact mucous membranes but do not penetrate soft tissue
- Heat sterilize or high-level disinfect
- Examples: dental mouth mirrors, amalgam condensers, and dental hand pieces

#### 3. Non-critical instruments and devices

- Contact intact skin
- Clean and disinfect using a low to intermediate level disinfectant
- Examples: X-ray heads, facebows, pulse oximeter, blood pressure cuff

### II. Sterilization

Stages for instrument sterilization are:

- Pre-soaking
- Cleaning
- Corrosion control and lubrication
- Packaging
- Sterilization
- Handling sterile instruments
- Storage
- Distribution

Agents used in sterilization are:

- **Physical agents:**

- Sunlight
- Drying
- Dry heat: flaming, incineration, hot air
- Moist heat: pasteurization, boiling, steam under pressure, steam under normal pressure
- Filtration: candles asbestos pads, membranes
- Radiation
- Ultrasonic and sonic vibrations

- **Chemical agents:**

- Alcohols: ethyl, isopropyl, tri-chloro butanol
- Aldehydes: formaldehyde, glutaraldehyde
- Dyes
- Halogens
- Phenols
- Surface-active agents
- Metallic salts
- Gases: ethylene oxide, formaldehyde, beta propiolactone

The four accepted methods of sterilization are:

- Steam pressure sterilization (autoclave)
- Chemical vapour pressure sterilization (chemiclave)
- Dry heat sterilization (dryclave)
- Ethylene oxide sterilization

### III. Sterilization Monitoring

#### Types of Indicators

- Mechanical** : Measure time, temperature, pressure
- Chemical** : Change in color when physical parameter is reached
- Biological** (spore tests) : Use biological spores to assess the sterilization process directly

Sterilization method	Spore type	Incubation temperature
Autoclave	Bacillus stearothermophilus	56°C
Chemical vapour		
Dry heat	Bacillus subtilis	37°C
Ethylene Oxide		
Gamma radiation	B. Pumilus E601	37°C

Sterilization monitoring has four components:

1. A sterilization indicator on the instrument bag, stamped with the date it is sterilized
2. Daily color-change process-indicator strips
3. Weekly biologic spore test, and
4. Documentation notebook

#### **IV. Storage and care of sterile instruments**

- Storage areas should be dust proof, dry, well ventilated and easily accessible for routine dental use
- Sterile materials should be stored at least 8-10 inches from the floor, at least 18 inches from the ceiling, and at least 2 inches from the outside walls
- Items are not stored in any location where they can become wet
- Items should be positioned so that packaged items are not crushed, bent, crushed, compressed or punctured
- Outside shipping containers and corrugated cartons should not be used as containers in sterile storage areas
- Ultra violet chambers and formalin chambers are now commonly used for storage of instruments

#### **DISINFECTION OF DENTAL UNIT AND ENVIRONMENTAL SURFACES**

- Disinfection is always at least a two-step procedure
  - The initial step involves vigorous scrubbing of the surfaces to be disinfected and wiping them clean
  - The second step involves wetting the surface with a disinfectant and leaving it wet for the time prescribed by the manufacturer
- The ideal disinfectant has the following properties:
  - Broad spectrum of activity
  - Acts rapidly
  - Non corrosive
  - Environment friendly
  - Is free of volatile organic compounds
  - Nontoxic & non-staining

<b>I. High-level disinfection</b>	<ul style="list-style-type: none"><li>• Disinfection process that inactivates vegetative bacteria, mycobacteria, fungi, and viruses but not necessarily high numbers of bacterial spores</li></ul>
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<b>II. Intermediate-level disinfection</b>	<ul style="list-style-type: none"> <li>Disinfection process that inactivates vegetative bacteria, the majority of fungi, mycobacteria, and the majority of viruses (particularly enveloped viruses) but not bacterial spores</li> </ul>
<b>III. Low-level disinfectant:</b>	<ul style="list-style-type: none"> <li>Liquid chemical germicide. OSHA requires low-level hospital disinfectants also to have a label claim for potency against HIV and HBV.</li> <li>Gigasept which contains succindialdehyde and dimethoxy tetrahydrofuran are used for disinfection of plastic and rubber materials Eg: dental chair</li> </ul>

### **Disinfection of impression materials:**

- To avoid cross infection following protocols are to be followed to disinfect impressions for proper transport to laboratory

Material	Method	Recommended Disinfectant	Comments
Alginate	Immersion with caution Use only disinfectant for a short-term exposure time (<10 min for alginate)	Chlorine compounds or iodophors	Short-term glutaraldehyde has been shown to be acceptable, but time is inadequate for disinfection.
Agar			Do not immerse in alkaline glutaraldehyde!
Polysulfide and silicone	Immersion	Glutaraldehydes, chlorine compounds, iodophors, phenolics	Disinfectants requiring more than 30-min exposure times are not recommended.
Polyether	Immerse with caution Use disinfectant only for a short exposure time (<10 min)	Chlorine compounds or iodophors	ADA recommends any of the disinfectant classes; however, short-term exposures are essential to avoid distortion.
ZOE impression paste	Immersion preferred; spraying can be used for bite registrations	Glutaraldehydes or iodophors	Not compatible with chlorine compounds! Phenolic spray can be used.
Impression compound		Iodophors or chlorine compounds	Phenolic spray can be used.

### **BASICS OF LABORATORY**

- Need coordination between dental office and lab
- Use of proper methods/materials for handling and decontaminating soiled incoming items
- All contaminated incoming items should be cleaned and disinfected before being handled by lab personnel, and before being returned to the patient

Incoming items	Outgoing items
<ul style="list-style-type: none"> <li>• Rinse under running tap water to remove blood/saliva</li> <li>• Disinfect as appropriate</li> <li>• Rinse thoroughly with tap water to remove residual disinfectant</li> <li>• No single disinfectant is ideal or compatible with all items</li> </ul>	<ul style="list-style-type: none"> <li>• Clean and disinfect before delivery to patient</li> <li>• After disinfection: rinse and place in plastic bag with diluted mouthwash until insertion</li> <li>• Do not store in disinfectant before insertion</li> <li>• Label the plastic bag</li> </ul>

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1. Heymann, Harald, Edward J. Swift, Andre V. Ritter, and Clifford M. Sturdevant. 2013. Sturdevant's art and science of operative dentistry. St. Louis, Mo: Elsevier/Mosby.
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Please Give Your Feedback on this Answer

**Discuss in detail about waste disposal in prosthodontics. (20M)**

## CONTENTS/SYNOPSIS

- Waste management
- Categories of waste
- Containers and identification
- Types of waste
  - Types of regulated waste
  - Infectious waste
    - Blood
    - Pathogenic waste
    - Anatomical waste (human tissue)
    - Blood soaked dripping gauges
    - Dental amalgam
    - Sharps
    - Chemicals, disinfectants and sterilizing agents
    - X-ray fixer and developer
    - Contaminated laundry
- References

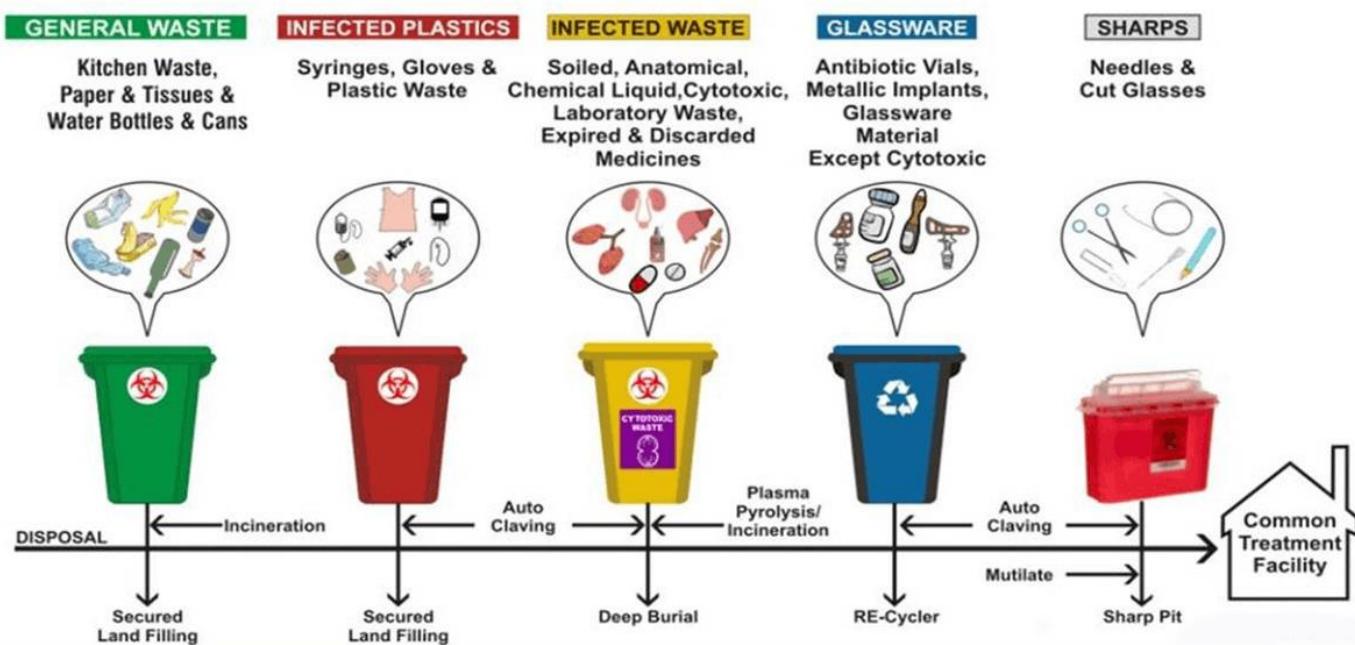
## WASTE MANAGEMENT

- Waste Management is collection, transport, processing, recycling or disposal of waste material. This term usually relates to materials produced by human activity and is generally undertaken to reduce effect on health, the environment and aesthetics
- Practice of waste management may differ in developing nation to under developing nation, urban to rural area and residential to industrial setup

## CATEGORIES OF WASTE

- Discarded sharps
- Laboratory and associated waste
- Human tissue including solutions containing blood
- Cytotoxic waste
- Pharmaceutical waste
- Chemical waste
- Radiation waste
- General waste

## SEGREGATION OF HOSPITAL BIO-MEDICAL WASTE



## CONTAINERS AND IDENTIFICATION

- I. **Clinical waste:** Must be placed in yellow bags and containers identified with the Biohazard symbol and the words “CLINICAL WASTE” marked prominently and permanently in black
- II. **Cytotoxic waste:** Requires careful handling and containment. All cytotoxic waste must be placed into purple bags and containers that are identified with the cell in telophase symbol and the wording “CYTOTOXIC WASTE” in white
- III. **Radioactive waste:** Must be placed into red bags and containers that are marked with the radiation warning symbol and the words “RADIOACTIVE WASTE” in black

## TYPES OF WASTE

- Regulated Medical Waste (Hospital waste and Infectious medical waste – this require special care and is nearly 3% of the total waste)
- Non regulated medical waste

### Types of regulated waste

- Contaminated Waste: items came in contact with blood or blood products
- Hazardous waste: posing a risk to human being or environment
- Infectious waste: capable of causing an infectious disease
- Medical waste: any solid waste that is generated in the diagnosis treatment or immunization
- Regulated waste: needs special handling and disposal
- Toxic waste: having a poisonous effect

### Infectious waste

- Bulk blood or blood products
- Pathogenic waste
- Sharps
- Saliva

#### 1. Blood

- Blood mixed with saliva and other fluids evacuated in the dental office as waste water system
- Rinse sink traps and evacuation lines daily with disinfected solution
- Carefully pour blood, suction fluids into the drain connected to the sewer system (meeting local regulatory guidelines) in an acceptable method

## 2. Pathogenic waste

- Teeth and other tissues
- Potentially infectious. Disposal should be in a color labeled container (many areas allow in house neutralization of such items)
- Disposal of treated tooth and other tissue are as per the local guidelines
- Pathologic waste is hidden from public and its disposal should be in a secured manner

## 3. Anatomical waste (human tissue)

- Human tissue waste generation is normally limited to oral surgeons and periodontists for example in the course of harvesting of human tissue for treatment
- Collect human tissue in red liners that are marked with a universal biohazard symbol
- Store anatomical waste in an enclosed storage area that is locked and separated from other supply areas. Anatomical waste should be stored at a temperature at or below 4 degrees centigrade. The storage area must be marked as Biomedical Waste Storage Area and must display the universal symbol
- Once accumulated, contact an approved biomedical waste carrier for disposal

## 4. Blood soaked dripping gauge

- It is a biomedical hazardous waste
- Should be enclosed in a yellow biomedical waste bag, covered with double bag and labeled with biohazardous symbol and refrigerated for more than 4 days
- Once accumulated can be disposed

## 5. Dental amalgam

- Amalgam restored teeth can be disinfected before disposal with sterilizing chemical for 30 minutes and should rinse treated teeth well. Teeth with amalgam restoration must not be heat sterilized to avoid the possibility of mercury vapor release during the sterilization procedure
- Extracted teeth should not ordinarily be returned to patients, however, it can be soaked first in sodium hypochlorite for 10 minutes and returned to the patient

## 6. Sharps

- Sharps waste is in the form of medical waste in the form of devices or objects used to puncture or lacerate the skin
- Sharps waste is designated as biohazard and is to be carefully handled
- Contaminated sharps are capable of transmitting the disease from injection needles, orthodontic bands, burs, scalpel blades, sutures, instruments and broken glass
- Sterilization of sharp containers:
  - Use labeled and specified container
  - Spore test the sterilizer
  - Label the disposable containers as to local regulations
  - Keep containers in upright position
  - Process containers for 40- 60 minutes
  - Leave containers vent open
- Handling of sharps
  - Needles should not be bent, broke, or manipulated for the avoidance of accidents in clinic
  - Protective cap holdings devices capping sheath by scoop technique
  - Size of sharp container also influences overall efficacy of sterilization

## 7. X-ray fixer and developer

- Separate fixer and developer solutions in the container provided by the approved waste carrier and supplier
- Label the container
- Once the container is full contact appropriate waste carrier for disposal

## 8. Chemicals, disinfectants and sterilizing agents

- Staff handling these materials should be trained according to workplace hazardous materials information system (WHMIS)
- Steam or dry heat are used to sterilize dental instruments
- Non chlorinated plastic containers should be used
- Ignitable sterilants should not be disposed into drain as they have detrimental effects on environment

## 9. Contaminated laundry

- Contaminated laundry is to be placed and transported in bags containers that are color coded or labeled with a biohazard symbol.

- If the contaminated laundry is sent off site for cleaning, it must be placed in bags or containers that are color coded or labeled with a biohazard symbol, unless the laundry uses universal precautions in handling all soiled laundry

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*Please Give Your Feedback on this Answer*

## Aphthous stomatitis (10M)

### CONTENTS/SYNOPSIS

- Introduction
- Etiology
- Epidemiology
- Pathophysiology
- Classification
- Clinical features
- Investigations
- Differential diagnosis
- Management
- References

## INTRODUCTION

- It is a common disorder characterized by recurring ulcers affecting the non keratinized oral mucosa with no other signs of systemic diseases
- Also called canker sores

## ETIOLOGY

- It is an idiopathic and multifactorial, involves cell mediated immune system
- More prevalent in nonsmokers and smokers who quit recently
- Improper oral hygiene products

- Trauma: self inflicted bite wounds, tooth brushing, dental procedures, needle injections, surgical procedures
- Physiological and emotional stress
- Abnormalities in immunity
- Deficiencies of iron, folic acid, vitamin b 12
- Endocrine conditions: during premenstrual period and post ovulation period
- Allergy or sensitivity: Eg., oral hygiene products, tooth pastes, foods like cinnamon, cheese, toxins, oral microbia
- Gastrointestinal problems: Malabsorption, enteropathy, celiac diseases

## EPIDEMIOLOGY

- Affects almost 20% of the general population
- More commonly seen in girls and women
- Age of onset is during childhood, second and third decade of life
- It can be a manifestation of

- Behcet syndrome
- Systemic lupus erythematosus
- Reactive arthritis
- Inflammatory bowel disease

## PATHOPHYSIOLOGY

Dysfunction of T cell mediated immunity, neutrophils and mast cell mediated destruction of mucosa



Formation of lesions which may vary based on types of intercellular mediators.

Eg: Interferon gamma, tumor necrosis factor - alpha, interleukins IL - 2, IL - 4 and IL - 5



Inflammatory process leads to formation of a pseudo membrane consisting of fibrin exudate, inflammatory cells, bacteria and necrotic mucosal cells

- Ulcers are seen on non keratinized oral mucosa like labial or buccal surfaces, soft palate, floor of the mouth, ventral or lateral surface of the tongue, tonsillar pillar, marginal gingiva, alveolar gingiva, vestibular areas

## CLASSIFICATION

### I. Based on complexity

- Simple ulcers
- Complex ulcers

### II. Based on Clinical type

- Recurrent aphthous minor
- Recurrent aphthous major
- Recurrent herpetiform ulcerations

## CLINICAL FEATURES

- Prodrome symptoms like burning sensation is noticed a day or two before the onset of ulcerations
- No signs of fever
- Dehydration in infants and children
- Ulcers are well defined lesions with central necrotic ulcer and grayish fibrinous exudate around an erythematous halo

- **Locations:** Buccal, labial mucosa, floor of the mouth, ventral or lateral surfaces of the tongue, soft palate

	<b>Minor</b>	<b>Major</b>	<b>Herpetiform</b>
Peak age of onset (decade)	Second	First and second	Third
Number of ulcers	1-5	1-3	5-20 (up to 100)
Size of ulcers (mm)	<10	>10	1-2
Duration	7-14 days	2 weeks-3 months	7-14 days
Heal with scarring	No	Yes	No
Site	Non-keratinized mucosa especially labial/buccal mucosa. Dorsum and lateral borders of the tongue	Keratinized and non-keratinized mucosa, particularly soft palate	Non-keratinized mucosa but particularly floor of the mouth and ventral surface of the tongue

## INVESTIGATIONS

- To diagnose aphthous stomatitis there is no need for clinical and laboratory testing, but testing can be done in persistent, recurrent and severe cases
- A complete blood count with signs of anemia suggests deficiency of iron, folate
- Cyclic neutropenia may cause ulcerations, checked for neutrophils and lymphocytes
- Cytological smear shows Antischkow cells
- Should consider HIV testing in cases with recurrent and severe major aphthous stomatitis or herpetiform ulcers

## DIFFERENTIAL DIAGNOSIS

- Contact dermatitis
- Herpes simplex
- Lupus
- Erosive lichen planus
- Cyclic neutropenia
- Squamous cell carcinoma
- Drug induced lesions
- Bednar's aphthae

## MANAGEMENT

- Symptomatic management like relieving the pain, improve healing and preventing recurrence
- Adequate hydration and intake of proper nutrition and supplements
- Topical application of local anesthetics, coating or occlusive agents, antiseptics, anti-inflammatory and immunomodulatory agents can be given
- Tetracycline mouth rinse: Dosage: 250 mg per 5 ml, usually taken diluted with water and gargled in mouth four times a day for upto 5 - 7days

I. Minor ulcerations	II. Major ulcerations	III. Severe & persistent ulcerations
<ul style="list-style-type: none"><li>• Topical anesthetics, antiseptics</li></ul>	<ul style="list-style-type: none"><li>• Topical anesthetics, antiseptics followed by application of topical steroids</li></ul>	<ul style="list-style-type: none"><li>• Systemic steroids, immunomodulatory agents, laser therapy has shown to be effective recently</li></ul>

- Dietary supplementation and maintainence of good oral hygiene habits

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*Please Give Your Feedback on this Answer*

**Write briefly about the different types of benign tumors of the jaws (10M)**

## CONTENTS/SYNOPSIS

- Introduction
- Classification
  - Benign tumors of jaw/ Odontogenic tumors according to WHO
    - Odontogenic epithelium
    - Odontogenic epithelium with odontogenic ectomesenchyme
    - Odontogenic ectomesenchyme
- Ameloblastoma
  - Follicular ameloblastoma
  - Plexiform ameloblastoma
  - Acanthomatous ameloblastoma
  - Granular cell ameloblastoma
  - Basal cell ameloblastoma
  - Desmoplastic ameloblastoma
  - Unicystic ameloblastoma
  - Other rare variants
- Calcifying epithelium odontogenic tumour
- Odontoma
- Ameloblastic fibroma
- Ameloblastic fibro odontoma
- Adenomatoid odontogenic tumour
- Odontogenic myxoma
- Benign cementoblastoma
- Reference

## INTRODUCTION

- A benign tumor is a new uncoordinated slowly growing and spread directly.

## Characteristics:

- Resemble the tissue of origin histologically
- Insidious onset
- Slow growth
- Does not invade the surrounding tissues
- No metastasis

## CLASSIFICATION

### Benign tumors of jaw/ Odontogenic tumors according to WHO

#### 1. *Odontogenic epithelium*

- Ameloblastoma
- Squamous odontogenic tumor
- Calcifying epithelial odontogenic tumor (Pindborg's tumor)
- Clear cell odontogenic tumor

#### 2. *Odontogenic epithelium with odontogenic ectomesenchyme*

- Ameloblastic fibroma
- Ameloblastic fibro dentinoma and ameloblastic fibro odontoma
- Odontoameloblastoma
- Adenomatoid odontogenic tumor
- Calcifying odontogenic cyst
- Complex odontoma
- Compound odontoma

#### 3. *Odontogenic ectomesenchyme*

- Odontogenic fibroma
- Myxoma/ odontogenic myxofibroma
- Benign cementoblastoma (True cementoblastoma)

## AMELOBLASTOMA

- Ameloblastoma is a benign odontogenic tumour of enamel organ type tissue which does not undergo differentiation to the point of enamel formation.
- 2<sup>nd</sup> most common odontogenic neoplasm in the world and most common odontogenic neoplasm in India.

### I. Origin

- Ameloblastic epithelium has been hypothesized to arise from:
  - Cells from the rests of enamel organ,
  - Cells of the sheet of Hertwig's or epithelial cell rest of Malassez, epithelial boundary of an odontogenic cyst, particularly a dentigerous cyst
  - Basal cells of the oral mucosa,
  - Heterotopic epithelial from other parts of the body, perhaps pituitary

### II. Clinical features

- **Age:** 20 - 40 years
- **Location:** Mandible is more frequently affected than maxilla
- It is a slow growing, painless, bony expansion
- Tennis ball like consistency
- Egg shell like cracking
- Jaw bone enlargement and paresthesia

### III. Radiographic features

- Location: Molar - ramus region of the mandible, may extend to Symphyseal area
- **Features:**
  - Well defined periphery,
  - Delineated cortical border
  - Shape is indistinguishable from a cyst
  - Periphery is ill defined in maxilla
  - Radiolucent to mixed
  - Consists of septa forming internal compartments - Honeycomb or soap bubble appearance

### IV. Histopathologically

- Resembles normal odontogenic/ enamel epithelium and ectomesenchyme.

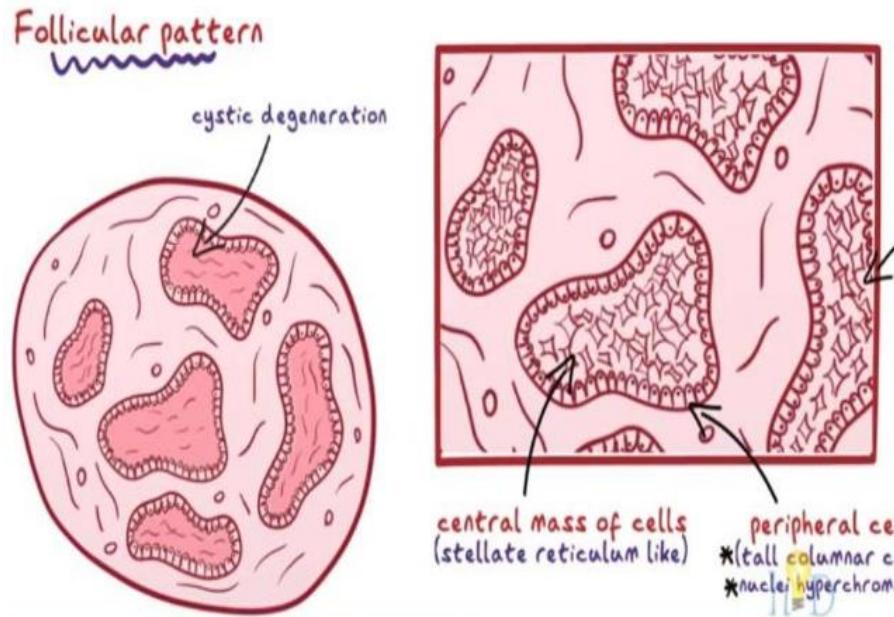
- 6 subtypes: follicular, plexiform, acanthomatous, basal cell, unicystic and desmoplastic ameloblastoma
- Mixtures of different patterns are often seen in a single lesion and the classification is based on the predominant pattern present.
- The 2005 WHO classification for ameloblastomas includes four subtypes:
  - Solid/ multicystic → most common type,
  - Unicystic type
    - Intraluminal
    - Intramural
  - extra osseous ameloblastoma
  - desmoplastic type
- Malignant subtypes of ameloblastomas are not included in the WHO classification.

## V. Vickers and Gorlin criteria for ameloblastoma

- Tall columnar cell
- Hyperchromatic nucleus
- Palisade nuclei
- Reverse polarity of the nuclei
- Sub-nuclear vacuole formation

### 1. Follicular ameloblastoma

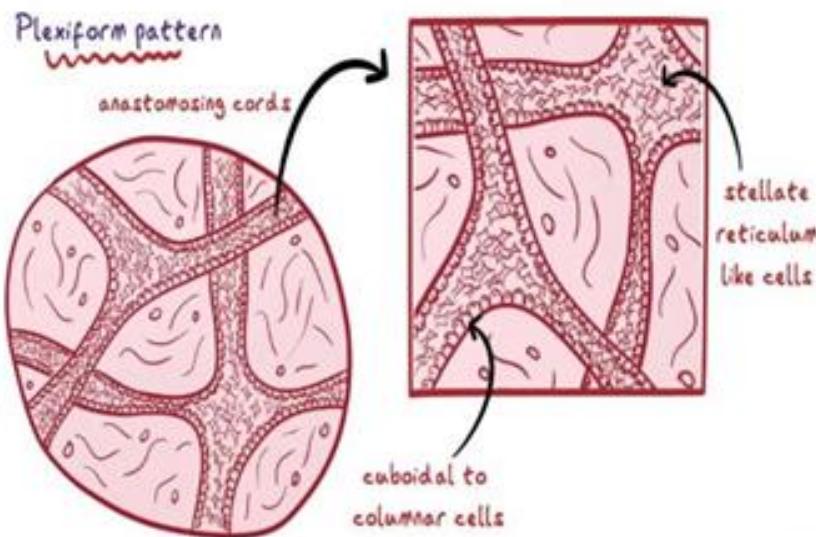
- Easily recognizable and common type of ameloblastoma histologically.
- Consists of islands of epithelial cells with a central mass of polyhedral cells or loosely arranged angular cells resembling stellate reticulum
- Surrounded by well-organized single layer of cuboidal or tall columnar cells with nuclei placed at the opposite pole of basement membrane resembling pre-ameloblasts.



- The peripheral cell layer tends to show cytoplasmic vacuolization.
- Cystic formation is often seen in the centre of the epithelial islands due to degeneration of stellate reticulum like cells.

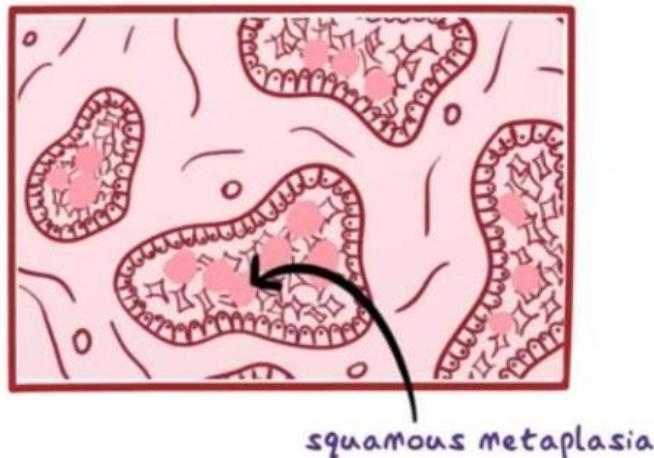
## 2. Plexiform ameloblastoma

- The tumour epithelium is arranged in form of network/ trabeculae → bound by a layer of cuboidal or columnar cells
- stellate reticulum like areas are usually minimal.
- Cyst formation occurs but is usually due to stromal degeneration rather than cystic change in the epithelium.
- The stroma consists of loose, vascular sparsely cellular connective tissue.



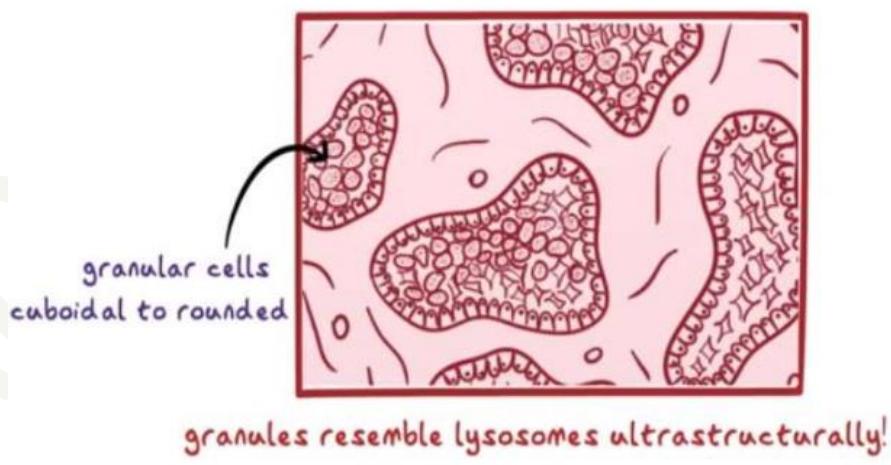
### 3. Acanthomatous ameloblastoma

- It resembles a typical follicular ameloblastoma except it shows extensive squamous metaplasia sometimes with keratin formation within the epithelial islands.



### 4. Granular cell ameloblastoma

- When the central stellate reticulum cells show extensive granular cell transformation → of sheets of large eosinophilic granular cells.
- May be so extensive that the peripheral columnar cells may also be replaced making the diagnosis difficult
- Ultrastructurally, it is seen that the granules consist of pleomorphic, lysosome like organelles.

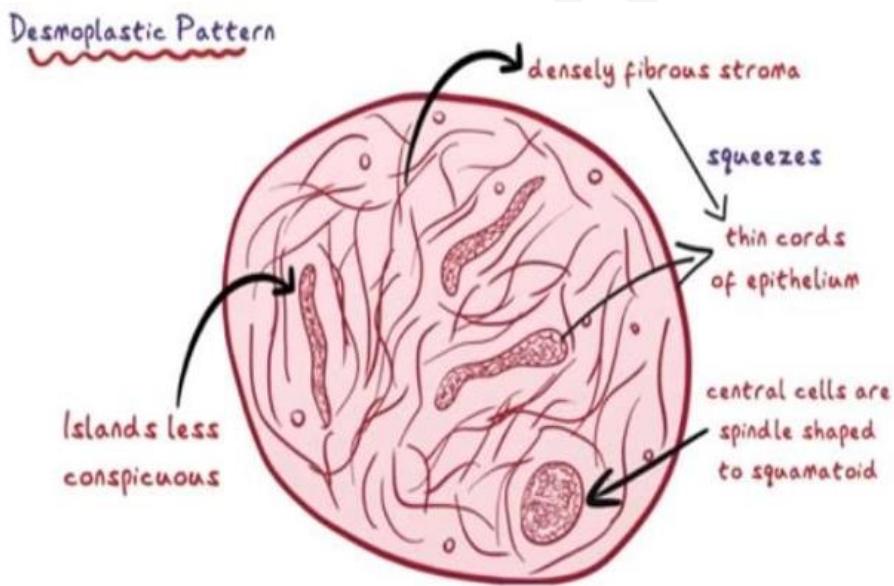


### 5. Basal cell ameloblastoma

- This variant shows predominant basaloid pattern → darkly stained cells with minimal cytoplasm and little evidence of palisading at the periphery resembling those in basal cell carcinoma

## 6. Desmoplastic ameloblastoma

- First described in detail by Eversole et al. in 1984
- Characterized by extensive stromal collagenization or desmoplasia surrounding compressed small/ irregular islands of odontogenic epithelium.
- Cyst formation is common and ameloblast like areas are present only in small foci.
- Calcification in the fibrous stroma and occasional bone formation can also be seen.
- Histochemical evaluation of the collagen: dense stroma is not scar tissue but represents active denovo synthesis of extracellular matrix proteins.
- It typically presents radiographically as a mixed radiolucency and radiopacity mimicking a fibroosseous lesion.
- In contrast to typical ameloblastoma, this variant frequents the maxilla and the anterior region of the jaws.



## 7. Unicystic ameloblastoma

- This is considered as an in-situ or superficially invasive form of ameloblastoma.
- Consists of a single cyst lined by ameloblastic epithelium.
- Clinically similar to a dentigerous cyst and is usually associated with an impacted tooth (usually 3rd molars).
- They are usually seen in younger patients in mandibles
- Can be easily identified histologically as they demonstrate a single cystic sac lined by odontogenic epithelium
- Ackermann et al. classified this entity into 3 histological groups:

<i>Group I: Luminal UA</i>	<ul style="list-style-type: none"> <li>• Tumour confined to the luminal surface of the cyst.</li> </ul>
<i>Group II: Intraluminal / Plexiform UA</i>	<ul style="list-style-type: none"> <li>• Nodular proliferation into the lumen without infiltration of tumour cells into the connective tissue wall</li> </ul>
<i>Group III: Mural UA</i>	<ul style="list-style-type: none"> <li>• Invasive islands of ameloblastomatous epithelium in the connective tissue wall not involving the entire epithelium</li> </ul>

- Modified by Philipsen and Reichart :
  - Subgroup 1: Luminal UA
  - Subgroup 1.2: Luminal and intraluminal
  - Subgroup 1.2.3: Luminal, intraluminal and intramural
  - Subgroup 1.3: Luminal and intramural

### 8. Peripheral ameloblastoma

- Present with follicular or plexiform pattern as well as acanthomatous pattern.
- Most cases → tumour is well separated from the overlying epithelium but maybe confluent with the overlying mucosa.

### Other rare variants

<i>i. Clear cell variant</i>	<ul style="list-style-type: none"> <li>• Contains clear PAS positive cells are localized in the stellate reticulum like areas.</li> </ul>
<i>ii. Papilliferous keratoameloblastoma</i>	<ul style="list-style-type: none"> <li>• Shows areas of ameloblastoma with keratinisation, tumour islands with papilliferous appearance along with cystic areas resembling odontogenic keratocysts.</li> </ul>
<i>iii. Hybrid Ameloblastoma</i>	<ul style="list-style-type: none"> <li>• Extremely unusual</li> <li>• Desmoplastic variant with areas of classical follicular/plexiform variant</li> <li>• Tumour cells with granular transformation along with areas of follicular and plexiform ameloblastoma while some show basaloid changes</li> </ul>
<i>iv. Hemangiomatous Ameloblastoma</i>	<ul style="list-style-type: none"> <li>• Less common</li> <li>• Connective tissue stoma with many blood filled spaces or large endothelial lined capillaries</li> </ul>

v. <i>Pituitary Ameloblastoma</i>	<ul style="list-style-type: none"> <li>• Neoplasm involving central nervous system</li> <li>• Common: childhood and adolescence</li> <li>• Origin: unobiterated portions of fetal craniopharyngeal duct, derived from Rathke's pouch and epithelial remnants of this duct are common on adults</li> </ul>
vi. <i>Peripheral (Extraosseous) Ameloblastoma</i>	<ul style="list-style-type: none"> <li>• Uncommon - 1% to 10% of all ameloblastomas.</li> <li>• arises from rests of dental lamina beneath the oral mucosa or from the basal epithelial cells of the surface epithelium</li> <li>• Histopathologically same features as the intraosseous form of the tumour.</li> </ul>
vii. <i>Metastatic ameloblastoma</i>	<ul style="list-style-type: none"> <li>• Well-differentiated benign histology similar to the solid/multicystic type at the primary site, but additional foci of the benign histology are identified in location(s) remote from the primary and considered to be a metastasis.</li> </ul>
viii. <i>Ameloblastic carcinoma</i>	<ul style="list-style-type: none"> <li>• An ameloblastoma that has cytologic features of malignancy in the primary tumour, in a recurrence, or in any metastatic deposit</li> <li>• Shows the histopathologic features of ameloblastoma, both in the primary tumour and in the metastatic deposits</li> <li>• Aggressive lesions, with ill-defined margins and cortical destruction</li> </ul>

## VI. Differential diagnosis

- Odontogenic keratocyst
- Giant cell granulomas
- Odontogenic myxoma
- Ossifying fibroma

## VII. Treatment

- Most common treatment is surgical resection
- Smaller lesions: removal by intraoral approach

- Larger lesions: May require resection of the jaw
- Maxillary lesions are treated more aggressively as they tend to invade adjacent vital structures
- Inoperable tumors: Radiation therapy

## CALCIFYING EPITHELIUM ODONTOGENIC TUMOUR

- Also called as Pindborg's tumour
- It is seen in 1% of all odontogenic tumour
- It is a locally aggressive tumour, consists of polyhedral cells as sheets and strands in fibrous stroma with no inflammatory component.
- Consists of spherical calcifications and amyloid stained hyaline deposits

### I. Origin: Rest of dental lamina, reduced enamel epithelium

## II. Clinical features

- Age: 40 years

Central (intraosseous)	Peripheral (extraosseous)
Site: 2/3rd of lesions in mandible	Site: anterior gingiva

## III. Radiographic features:

- Commonly seen in premolar and molar area of mandible
- 52% associated with unerupted or impacted tooth
- Well defined cyst borders (few cases will have irregular and ill defined boundary)
- Internal structure with numerous unilocular or multilocular radiopaque foci
- Expansion of the jaw with cortical borders
- May displace a developing tooth or prevent eruption

## IV. Differential diagnosis

- Dentigerous cysts
- Ameloblastomas
- Nodular odontogenic tumour
- Ameloblastic fibro-odontoma

- Calcifying odontogenic cyst

## V. Treatment:

- Local resection
- More conservative than ameloblastoma

## ODONTOEMA

- Most common type of odontogenic tumour
- Characterized radiographically and histologically by the production of mature enamel, dentin, cementum and pulp tissue

<b>I. Clinical features</b>	<ul style="list-style-type: none"> <li>• Seen in 10 - 20 years of age</li> <li>• Maxilla is commonly affected than mandible</li> <li>• Slow growing, hard and painless mass</li> </ul>
<b>II. Types</b>	<ul style="list-style-type: none"> <li>• Complex</li> <li>• Compound</li> </ul>
<b>III. Location</b>	<ul style="list-style-type: none"> <li>• Compound odontoma is seen in anterior maxilla in association with crown of an unerupted canine</li> <li>• Complex odontoma are found in mandibular 1st and 2nd molar areas</li> </ul>
<b>IV. Radiographic features</b>	<ul style="list-style-type: none"> <li>• Well defined cortical borders which are either smooth or irregular</li> <li>• <u>Soft tissue capsule is present immediately inside and adjacent to the border</u></li> <li>• Radiopaque tooth like structures or denticles are present (compound),</li> <li>• Irregular mass of calcified tissue (complex)</li> </ul>
<b>V. Treatment</b>	<ul style="list-style-type: none"> <li>• Removal by simple excision.</li> <li>• Recurrence is not seen</li> </ul>
	<ul style="list-style-type: none"> <li>• Associated with abnormalities such as impaction, malpositioning, diastema, aplasia, nonvital adjacent teeth</li> </ul>

## AMELOBLASTIC FIBROMA

- Synonyms: Soft odontoma, soft mixed odontoma, mixed odontogenic tumour, fibroadamantoblastoma, granular cell ameloblastofibroma
- It is a benign and mixed odontogenic tumour

- Characterized by neoplastic proliferation of mature and early functional ameloblasts

<b>I. Clinical features</b>	<ul style="list-style-type: none"> <li>• Age: 5 - 20 years</li> <li>• Maxilla is commonly affected than mandible</li> </ul>
<b>II. Location</b>	<ul style="list-style-type: none"> <li>• Premolar and molar area of mandible</li> </ul>
<b>III. Radiologic features</b>	<ul style="list-style-type: none"> <li>• Well defined cortical border</li> <li>• Unilocular radiolucent</li> <li>• Larger lesions shows expansion of cortical plate</li> <li>• May inhibits normal eruption of teeth</li> </ul>
<b>IV. Differential diagnosis</b>	<ul style="list-style-type: none"> <li>• Ameloblastoma</li> <li>• Giant cell granuloma</li> <li>• Odontogenic myxoma</li> </ul>
<b>V. Treatment</b>	<ul style="list-style-type: none"> <li>• Conservative surgical approach: enucleation followed by curettage of surrounding bone</li> <li>• Rate of recurrence is low</li> </ul>

### AMELOBLASTIC FIBRO ODONTOMA

- It is a mixed tumour with all the characters of an ameloblastic fibroma but in a scattered manner of enamel and dentine

<b>I. Clinical features</b>	<ul style="list-style-type: none"> <li>• Similar to odontoma</li> <li>• Associated with missing tooth or tooth which has failed to erupt</li> </ul>
<b>II. Radiographic features</b>	<ul style="list-style-type: none"> <li>• Location: posterior aspect of mandible, with the epicentre occlusal to the developing tooth</li> <li>• Well defined border, sometimes corticated</li> <li>• Mixed internal structure which is radiolucent</li> <li>• Small lesions: enlarged follicles with one or two discrete radiopacity</li> <li>• Large lesions: extensive calcified structure</li> </ul>
<b>III. Differential diagnosis</b>	<ul style="list-style-type: none"> <li>• Complex odontoma</li> </ul>
<b>IV. Treatment</b>	<ul style="list-style-type: none"> <li>• Conservative approach: enucleation</li> </ul>

## ADENOMATOID ODONTOGENIC TUMOUR

- Synonyms: Adenoameloblastoma and ameloblastic adenomatoid tumour
- It is an uncommon, nonaggressive, asymptomatic, painless slow growing tumour

<b>I. Clinical features</b>	<ul style="list-style-type: none"> <li>• Affects younger patients with age group between 10 - 19 years</li> <li>• Females are commonly affected</li> <li>• Site: Anterior part of the maxillary jaw is commonly affected</li> <li>• Two type: Central and peripheral tumours, central is divided into follicular and extra follicular type</li> </ul>
<b>II. Radiographic features</b>	<ul style="list-style-type: none"> <li>• Seen commonly in incisor, canine and premolar region</li> <li>• Well defined cortical or sclerotic borders with radiopacities</li> <li>• Resorption of roots is rare</li> <li>• Causes expansion of jaw bone</li> </ul>
<b>III. Differential diagnosis</b>	<ul style="list-style-type: none"> <li>• Follicular cyst</li> <li>• Calcifying epithelial odontogenic tumour</li> </ul>
<b>IV. Treatment</b>	<ul style="list-style-type: none"> <li>• Conservative surgical excision as the tumour is not locally invasive and well encapsulated</li> </ul>

## ODONTOGENIC MYXOMA

- Synonyms: Myxoma, myxofibroma and fibromyxoma
- It is an uncommon odontogenic tumour (3 - 6%), arise from odontogenic ectomesenchyme and resemble dental papilla at mesenchymal portion

<b>I. Clinical features</b>	<ul style="list-style-type: none"> <li>• Age: 10- 30 years</li> <li>• Females are commonly affected</li> <li>• Slow growing, may or may not cause episodes of pain</li> <li>• Causes swelling and if untreated may grow into a large lesion</li> </ul>
<b>II. Radiographic features</b>	<ul style="list-style-type: none"> <li>• Mostly affects premolar and molar areas of mandible.</li> <li>• Consists of a well defined cortical border in mandible, whereas as it is poorly defined border in</li> </ul>

	<p>maxilla</p> <ul style="list-style-type: none"> <li>Internal pattern is mixed radiolucent and radiopaque with residual bone trapped inside the tumour which remodels into curved or septal manner</li> </ul>
<b>III. Differential diagnosis</b>	<ul style="list-style-type: none"> <li>Ameloblastomas</li> <li>Central giant cell granuloma</li> <li>Central hemangioma</li> </ul>
<b>IV. Treatment</b>	<ul style="list-style-type: none"> <li>Surgical resection of tumour along with the surrounding bone as it infiltrates the marrow spaces of adjacent bone</li> </ul>

### BENIGN CEMENTOBLASTOMA

- Synonyms: Cementoblastoma, true cementoma
- It is a solitary, slow growing, mesenchymal neoplasm composed mainly of cementum

<b>I. Clinical features</b>	<ul style="list-style-type: none"> <li>Affects all age groups ranges from 12 - 65 years</li> <li>Females are mostly affected</li> <li>Slow growing lesion eventually displaces teeth (if vital tooth, causes pain)</li> <li>Pain varies from patient to patient and can be relieved by NSAIDS</li> </ul>
<b>II. Radiographic features</b>	<ul style="list-style-type: none"> <li>Location: Affects mandible mostly at premolar or 1st molar region</li> <li>Well defined cortical border with a well defined radiolucent band just inside the cortical border</li> <li>Consists of mixed radiolucent and radiopaque lesions with a <u>wheel spoke pattern</u></li> <li>Density of cemental mass creates an indistinct outline of enveloped root</li> <li>Large lesions may cause expansion of mandible with intact outer cortex</li> </ul>
<b>III. Differential diagnosis</b>	<ul style="list-style-type: none"> <li>Cemental dysplasia</li> </ul>
<b>IV. Treatment</b>	<ul style="list-style-type: none"> <li>Self limiting and rarely recurs</li> <li>Simple excision and enucleation along with</li> </ul>

	extraction of associated tooth structure
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*Please Give Your Feedback on this Answer*

## Congenital and developmental defects of teeth (6M)

### CONTENTS/SYNOPSIS

- Introduction
- Stages of development of tooth
- Defects in tooth development
  - Microdontia
  - Macrodontia
  - Gemination
  - Fusion
  - Concrescence
  - Taurodontism
  - Dilaceration
  - Dens in Dente (dens invaginatus)
  - Dens evaginatus
  - Disturbances in number of tooth
  - Supernumerary teeth
  - Amelogenesis imperfecta
- Reference

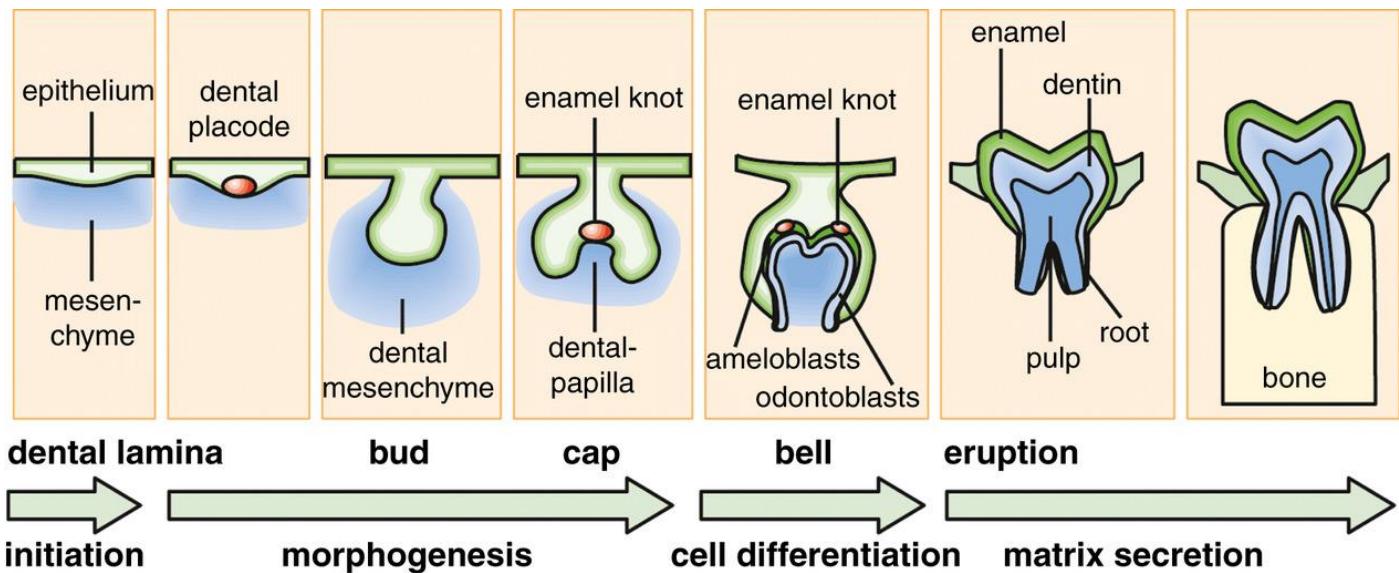
## INTRODUCTION

- Development of tooth is a complex process
- It is a process occurs due to the interaction between epithelium and connective tissue
- Epithelial lining the developing oral cavity is called the oral ectoderm
- It is composed of stratified squamous epithelium & connective tissue underlying is ectomesenchymal in nature which are derived from neural crest cells
- Odontogenesis starts at 3rd week of intra uterine life and begins at the anterior region and proceeds posteriorly

## STAGES OF TOOTH DEVELOPMENT

- Tooth development is a complex process and the various tissues of the tooth and its supporting components derived from tooth germ
- The tooth germ includes all the formative tissues of the tooth
- It has three important components like:
  - **Enamel organ:** Ectodermal part that give rise to enamel
  - **Dental papilla:** Ectomesenchymal portion which forms dentin and pulp
  - **Dental follicle:** Ectomesenchymal part where it develops into cementum, periodontal ligament & part of alveolar socket
- As the tooth developments it goes through various morphological stages with physiological alterations
- Based on the shape of the enamel organ the developmental stages of tooth can be divided

<i>Morphological stages</i>	<i>Physiological phases</i>
<ul style="list-style-type: none"><li>• Bud stage</li><li>• Cap stage</li><li>• Bell stage<ul style="list-style-type: none"><li>➢ Early bell stage</li><li>➢ Advanced bell stage</li></ul></li></ul>	<ul style="list-style-type: none"><li>• Initiation</li><li>• Proliferation</li><li>• Morphodifferentiation</li><li>• Histodifferentiation</li><li>• Apposition</li></ul>



## DEFECTS IN TOOTH DEVELOPMENT

### I. Microdontia

- Presence of unusually small teeth.
- True generalized microdontia- Teeth are smaller than normal.  
Example: pituitary dwarfism, Down syndrome
- Relative generalized microdontia- normal sized teeth widely spaced in jaws that are larger than normal
- Isolated microdontia or microdontia of single tooth- Maxillary Lateral Incisor (peg shaped crown), 3rd molars

### II. Macrodontia

- Teeth are larger than the normal
- True generalized macrodontia- teeth are bigger than normal.  
Example: pituitary gigantism, pineal hyperplasia with hyperinsulinism
- Relative generalized macrodontia- normal or slightly larger than normal teeth in small jaws
- Isolated macrodontia or macrodontia of single tooth- seen in hemi facial hypertrophy

### III. Gemination

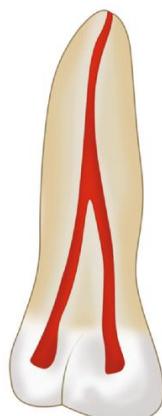
- Single tooth germ attempts to divide resulting in the formation of two completely or incompletely separated crowns that share a common root & root canal

#### IV. Fusion

- Union of 2 separate tooth buds resulting in the formation of a joined tooth with confluence of dentin, but separate canals
- Also, can occur between normal and supernumerary teeth

#### V. Concrecence

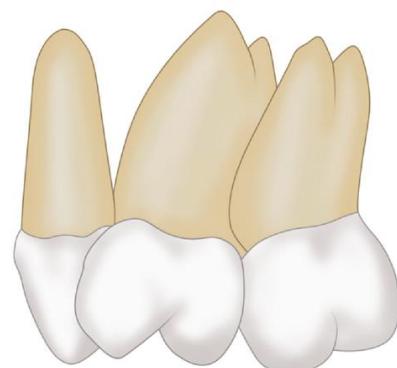
- Roots of two or more teeth united by cementum
- Space is restricted during development
- Could be due to trauma locally, excessive occlusal forces, local infection after development
- Commonly seen in maxillary molars, 3rd molar and supernumerary teeth



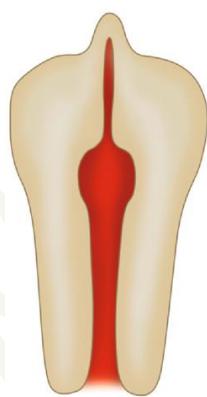
Gemination



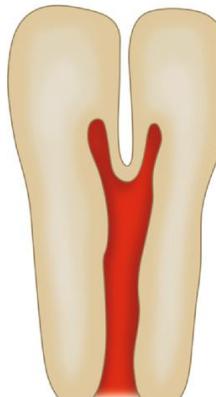
Fusion



Concrecence



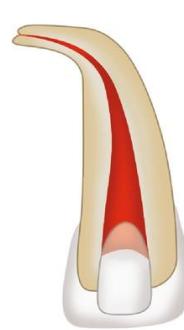
Dens evaginatus



Dens invaginatus



Taurodontism



Dilacerated root

#### VI. Taurodontism

- Pulp chamber is enlarged longitudinally
- Increased distance between CEJ to the bifurcation

- Consists of normal crown size and length but with shortened roots
- Cannot be seen clinically
- Mostly in molars

## **VII. Dilaceration**

- It is a sharp bend or curve in the crown or root
- Commonly seen in maxillary premolars

## **VIII. Dens in Dente (dens invaginatus)**

- Infolding of the outer enamel surface is called dens in dente
- Infold is at pits
- Leads to caries and pulpal infections easily

## **IX. Dens evaginatus**

- It is also called as out folding of enamel organs
- Appears as a tubercle on the outer surface with enamel, dentin and pulp horn extended into evagination
- Commonly seen in premolar and molar
- Causes pulp infection

## **X. Disturbances in number of tooth**

- Anodontia → Total lack of tooth development.
- Hypodontia → Lack of development of one or more teeth.
- Oligodontia → Lack of development of six or more teeth.
- Hyperdontia → Development of increased number of teeth & the additional teeth are called Supernumerary teeth.

## **XI. Supernumerary teeth**

- Extra teeth in the dentition → Resembles the teeth of the group to which it belongs
- Cause → Splitting of the permanent tooth bud or due to hyperactivity of dental lamina
- Conditions associated with increased prevalence of supernumerary teeth → cleft lip & palate, cleidocranial dysplasia & Gardner syndrome

## **XII. Amelogenesis imperfecta**

- Incomplete or defective formation of organic enamel matrix of teeth.

- Synonyms: Hereditary enamel dysplasia/ Hereditary brown enamel/ Hereditary brown opalescent teeth
- Amelogenesis imperfecta is a group of conditions caused by defects in the genes encoding enamel matrix proteins.
- Inheritance can be autosomal dominant, recessive or X-linked.
- Genetic mutations have been associated with Amelogenesis Imperfecta

Gene	Chromosomal location	Protein encoded	Inheritance	Phenotype
AMELX	Xp22.2	Amelogenin	X-linked recessive	Diffuse smooth Hypoplastic, Hypomaturation
ENAM	4q13.3	Enamelin	Autosomal dominant, Autosomal recessive	Hypoplasia (localized & generalised, pitting to diffuse)
MMP-20	11q22.2	Enamelysin	Autosomal recessive	Hypomaturation
KLK4	19q13.4	Enamel matrix serine protease (now called Kallikrein-4)	Autosomal recessive	Hypomaturation
DLX3	-	-	Autosomal dominant	Hypoplastic Hypomaturation with Taurodontism

### Types of Amelogenesis Imperfecta

- Type I / Hypoplastic type (most common form)
- Type II / Hypomaturation type
- Type III / Hypocalcified type
- Type IV/ Hypomaturation-hypoplastic type

Type I	
i. Defect	<ul style="list-style-type: none"> <li>• Inadequate deposition of enamel matrix</li> </ul>
ii. Enamel thickness & color	<ul style="list-style-type: none"> <li>• Thinner than normal enamel, well mineralized &amp; does not chip</li> </ul>

iii. Radiographic features	<ul style="list-style-type: none"> <li>• Radiodensity of enamel is greater than that of dentin</li> </ul>
iv. Inheritance	<ul style="list-style-type: none"> <li>• Autosomal dominant, autosomal recessive or X-linked recessive</li> </ul>
<b>Type II</b>	
i. Defect	<ul style="list-style-type: none"> <li>• Quantitatively normal amounts of enamel is present, but the maturation of enamel's crystal structure is defective</li> </ul>
ii. Enamel thickness & color	<ul style="list-style-type: none"> <li>• Enamel appears chalky, soft, discoloured &amp; poorly mineralized</li> <li>• Dental explorer under pressure will pit the enamel surface. Fracturing of the enamel is common.</li> </ul>
iii. Radiographic features	<ul style="list-style-type: none"> <li>• Radiodensity of enamel is similar to that of dentin</li> </ul>
iv. Inheritance	<ul style="list-style-type: none"> <li>• Autosomal dominant, autosomal recessive or X-linked recessive</li> </ul>
<b>Type III</b>	
i. Defect	<ul style="list-style-type: none"> <li>• Defect in calcification of normal enamel matrix</li> </ul>
ii. Enamel thickness & color	<ul style="list-style-type: none"> <li>• Developing &amp; erupting teeth are normal in shape, with normal enamel thickness.</li> <li>• Soon after eruption, the brown enamel undergoes severe chipping, leaving a roughened, brown dentinal surface with some enamel remaining, especially at the gingival margin.</li> </ul>
iii. Radiographic features	<ul style="list-style-type: none"> <li>• Radiodensity of enamel is almost same as that of normal dentin</li> </ul>
iv. Inheritance	<ul style="list-style-type: none"> <li>• Autosomal dominant or recessive</li> </ul>
<b>Type IV</b>	
i. Defect	<ul style="list-style-type: none"> <li>• Mixed type I &amp; II</li> </ul>
ii. Enamel thickness & color	<ul style="list-style-type: none"> <li>• <i>Subtype A</i> → predominantly hypomature + taurodontism → enamel appears yellow-white to yellow-brown, buccal pitting</li> <li>• <i>Subtype B</i> → predominantly hypoplastic + taurodontism → thin, mottled enamel</li> </ul>
iii. Radiographic features	<ul style="list-style-type: none"> <li>• Radiodensity of enamel is similar to that of dentin</li> </ul>

iv. *Inheritance*

- Autosomal dominant

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*Please Give Your Feedback on this Answer*

## Types and Oro dental manifestation of ectodermal dysplasia (6M)

### CONTENTS/SYNOPSIS

- Introduction
- Classification
  - According to Freire - Maia
  - According to the national foundation of ectodermal dysplasia (NFED)
- Pathophysiology
- Clinical features
  - Hair
  - Nail
  - Sweat glands
  - Skin
  - Orofacial features
  - Others
- Investigations
- Management
- Challenges in prosthodontic management
- Conclusion
- References

## INTRODUCTION

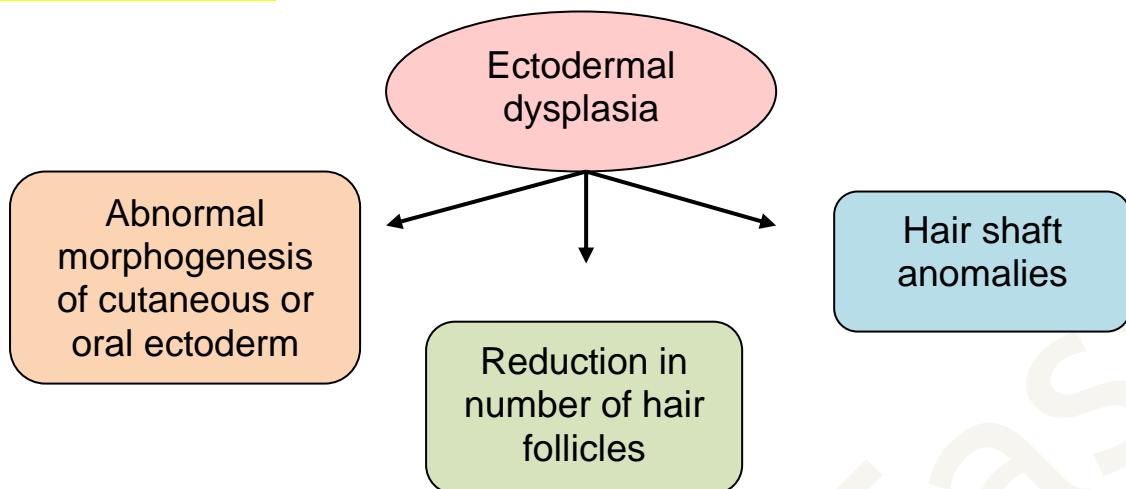
- Ectodermal dysplasia is a hereditary disorder characterized by abnormal development of tissues and structures which are of ectodermal origin

## CLASSIFICATION

- According to Freire - Maia, it is a syndrome exhibiting atleast two of the following features
  - Trichodysplasia (abnormal hair)
  - Abnormal dentition
  - Onchodysplasia (abnormal nails)
  - Dyshidrosis (abnormal sweat glands)
- According to the national foundation of ectodermal dysplasia (NFED), it is a genetic disorder with a minimum of 2 or more abnormalities of ectodermal structures.
- These structures are skin, hair, teeth, nails, nerve cells, sweat glands, parts of the eye and ear and other parts
- The NFED lists 20 common type of disorders
- The most commonly reported ectodermal dysplasia syndromes are inherited as an X linked recessive trait and are of two types
  - X linked hypohidrotic dysplasia (Christ - Siemens - Touraine syndrome)
  - Hidrotic form/ Clouston syndrome

	Hidrotic	Hypohidrotic
Mode of inheritance	Most often autosomal dominant	Most often autosomal recessive
Scalp hair	Soft, downy, and color is darker	Fine in texture, fair, and short
Teeth	Anodontia to hypodontia	Anodontia to hypodontia
Lips	No abnormality	Protruding
Sweat glands	Active	Reduced to absent
Nasal bridge	No flattening	Underdeveloped
Nails	Dystrophic	No abnormality
Eyebrows	Frequently absent	Absent
Eyelashes/pubic/ axillary hairs	Scanty/absent	Variably affected

## PATOPHYSIOLOGY



## CLINICAL FEATURES

- Incidence: 1: 100000 births
- Males are commonly affected, whereas females inherit it as carriers

<b>I. Hair</b>	<ul style="list-style-type: none"> <li>• Thin, sparse and light hair colour over scalp and body</li> <li>• May be coarse, excessively brittle, curly</li> </ul>
<b>II. Nail</b>	<ul style="list-style-type: none"> <li>• Thick finger nails and toe nails, abnormally shaped, discolored, ridged, brittle and slow growing</li> <li>• Nails may be absent in few cases</li> <li>• Cuticles are prone to infection</li> </ul>
<b>III. Sweat glands</b>	<ul style="list-style-type: none"> <li>• Exocrine sweat glands may be absent or sparse with abnormal functioning</li> <li>• Improper body temperature regulation</li> <li>• High fever and seizures may be experienced in children</li> </ul>
<b>IV. Skin</b>	<ul style="list-style-type: none"> <li>• Lightly pigmented skin</li> <li>• Thick skin over the palms and soles making them prone to cracking, bleeding and infections</li> <li>• Eczematous type reactions</li> <li>• Prone to rashes and infection</li> </ul>
<b>V. Orofacial features</b>	<ul style="list-style-type: none"> <li>• <u>Hypodontia or Anodontia</u></li> <li>• <u>Peg shaped</u> or conical teeth</li> <li>• Decreased lower facial height</li> <li>• Protruded and everted lips</li> <li>• Frontal bossing</li> </ul>

- Depressed nasal bridge

## VI. Other signs and symptoms

- Abnormal development of ear leading to hearing problems
- Cleft palate / lip
- Missing fingers or toes
- Respiratory infections due to lack of protective secretions of mouth and nose
- Chronic nasal infections
- Poor or no breast development
- Dry eyes, cataract formation and visual defects

## INVESTIGATIONS

- Radiographs to rule out dental abnormalities
- Skin biopsy to check for absence or hypoplasia of sweat glands
- Genetic testing

## MANAGEMENT

- Early dental evaluation and management
- Body temperature regulation using cooling water baths and sprays
- Lubrication to eyes to prevent damage to the eyes
- Saline irrigation to the nasal mucosa

## CHALLENGES DURING PROSTHODONTIC MANAGEMENT:

- All the prosthodontic steps are challenging starting from impression making till the usage of dentures because of the following problems

- Fragile mucosa
- Hyper salivation
- Poor residual alveolar ridges
- Maxilla is underdeveloped
- Right side of the tongue is paralyzed
- Neuromuscular control is poor
- Mandibular movements are uncontrolled

**Modifications:**

- Impressions are made by using irreversible hydrocolloids instead of impression compound as the mucosa is fragile
- Enhanced retention and stability by modified tooth preparations
- Final impressions are made of zinc oxide eugenol paste
- Jaw relation: vertical dimension of occlusion is slightly reduced to limit vertical forces on underdeveloped alveolar ridge
- In cases with collapse of maxillary arch, cross arch stabilization is planned
- Occlusion given is bilateral balanced occlusion to reduce lateral forces

**CONCLUSION**

- Ectodermal dysplasia is a hereditarily acquired disorder, hence with known family histories patients can be explained about genetic counseling
- In several cases, it is possible to diagnose ectodermal dysplasia at very early ages with thorough check ups and knowledge on the syndromes

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**Please Give Your Feedback on this Answer**

## Nerve block anesthesia (10M)

### CONTENTS/SYNOPSIS

- Introduction
- Indications
- Contraindications
- Anesthesia
  - Topical anesthesia
  - Local anesthesia used in dentistry
- Nerve blocks
  - Local infiltrations
    - Supra periosteal injection
    - Intraligamentary/ PDL injections
    - Intraosseous injection
    - Intraseptal injection
    - Intrapulpal injections
  - Maxillary injection techniques
    - Superior alveolar nerve block
    - Middle superior alveolar nerve block
    - Anterior superior alveolar nerve
    - Nasopalatine nerve block
    - Greater palatine nerve block
    - Maxillary nerve block
  - Mandibular injections technique
    - Inferior alveolar nerve block
    - Incisive nerve block
    - Mandibular nerve block
    - Mental nerve block
    - Buccal nerve block
    - Lingual nerve block
- Conclusion
- References

## INTRODUCTION

- Pain control in dentistry is one of the greatest challenges.
- Pain causes stress leading to a release of catecholamines followed by cardiovascular problems in severe cases.
- An oral nerve block is a simple and effective way to manage orofacial pain.
- Nerve block or Regional anesthesia is a form of anesthesia in which only a part of the body is anesthetized.
- In this block anesthetic is directly injected adjacent to the nerve supplying the surgical field. The injection of this nerve numbing substance is called a nerve block

## INDICATIONS

- Dentoalveolar abscess
- Toothache
- Pulpitis
- Root impaction
- Repair of orofacial lacerations
- Post extraction pain
- Dry socket pain
- Dentoalveolar fractures or trauma
- Maxillary and mandibular fractures

## CONTRINDICATIONS

- Hypersensitivity or allergy to local anesthetic agents
- Uncooperative patients (Patients with anxiety, medically compromised patients etc)
- Injection through infected tissue area
- Patients with cardiac diseases (congenital abnormalities, endocarditis)
- Bleeding disorders
- Pre existing neurologic disorders and damages

## ANESTHESIA

### I. Topical anesthesia:

- Used to reduce the discomfort or pain during needle insertion
- Commonly used topical anesthetics are
  - Benzocaine 2%
  - Lidocaine 5%

### II. Local anesthesia used in dentistry

- Only five local anesthetic agents are currently available in cartridge form for dentistry, namely:

#### Local anesthetics available in dental cartridges

Drug	Preparation
Lidocaine 2%	1:50,000 epinephrine 1:100,000 epinephrine
Mepivacaine 3%	Plain (no vasoconstrictor)
Mepivacaine 2%	1:20,000 levonordefrin
Prilocaine 4%	Plain 1:200,000 epinephrine
Articaine 4%	1:100,000 epinephrine 1:200,000 epinephrine
Bupivacaine 0.5%	1:200,000 epinephrine

- Local anesthetics are supplied in single-dose glass cartridges containing either 1.7 or 1.8 ml.
- Cartridges of a plain local anesthetic solution contain the hydrochloride salt of the local anesthetic and distilled water.
- Cartridges containing a vasoconstrictor also contain epinephrine or levonordefrin, sodium metabisulfite, and citric acid.
- These latter acts to stabilize the vasoconstrictor and prevent oxidative breakdown.

### 1. Lidocaine

- Lidocaine is the most commonly used dental local anesthetic and has become the gold standard against which all other dental local anesthetics are compared.
  - Lidocaine 2% combined with a vasoconstrictor in a 1:100,000 concentration provides reliable and profound pulpal anesthesia for approximately 60 minutes with a duration of soft tissue anesthesia ranging from 3 to 5 hours.
  - Lidocaine is also supplied as a 2% solution with 1: 50,000 epinephrine.
- Although this concentration may be useful to provide surgical hemostasis by local infiltration, its routine use for primary operative or surgical anesthesia should be avoided because of the possibility of an acute epinephrine reaction, which may often manifest as hypertension or tachycardia in susceptible patients.

### 2. Mepivacaine

- Mepivacaine is very similar to lidocaine in its efficacy, onset, and duration.
  - It is supplied in dental cartridges as a 2% solution with 1:20,000 levonordefrin and as a 3% plain solution.
- Mepivacaine 3% plain solution is a popular alternative for patients in whom epinephrine may be contraindicated.

### 3. Prilocaine

- Prilocaine is somewhat less potent than lidocaine and so is supplied in a higher concentration.
  - It is available as a plain 4% solution, or as a 4% solution with 1:200,000 epinephrine.
- Prilocaine has been implicated in a higher incidence of paresthesia associated with nerve block injections compared with lidocaine.
- Its potential to induce methemoglobinemia also may limit its use.

#### 4. Articaine

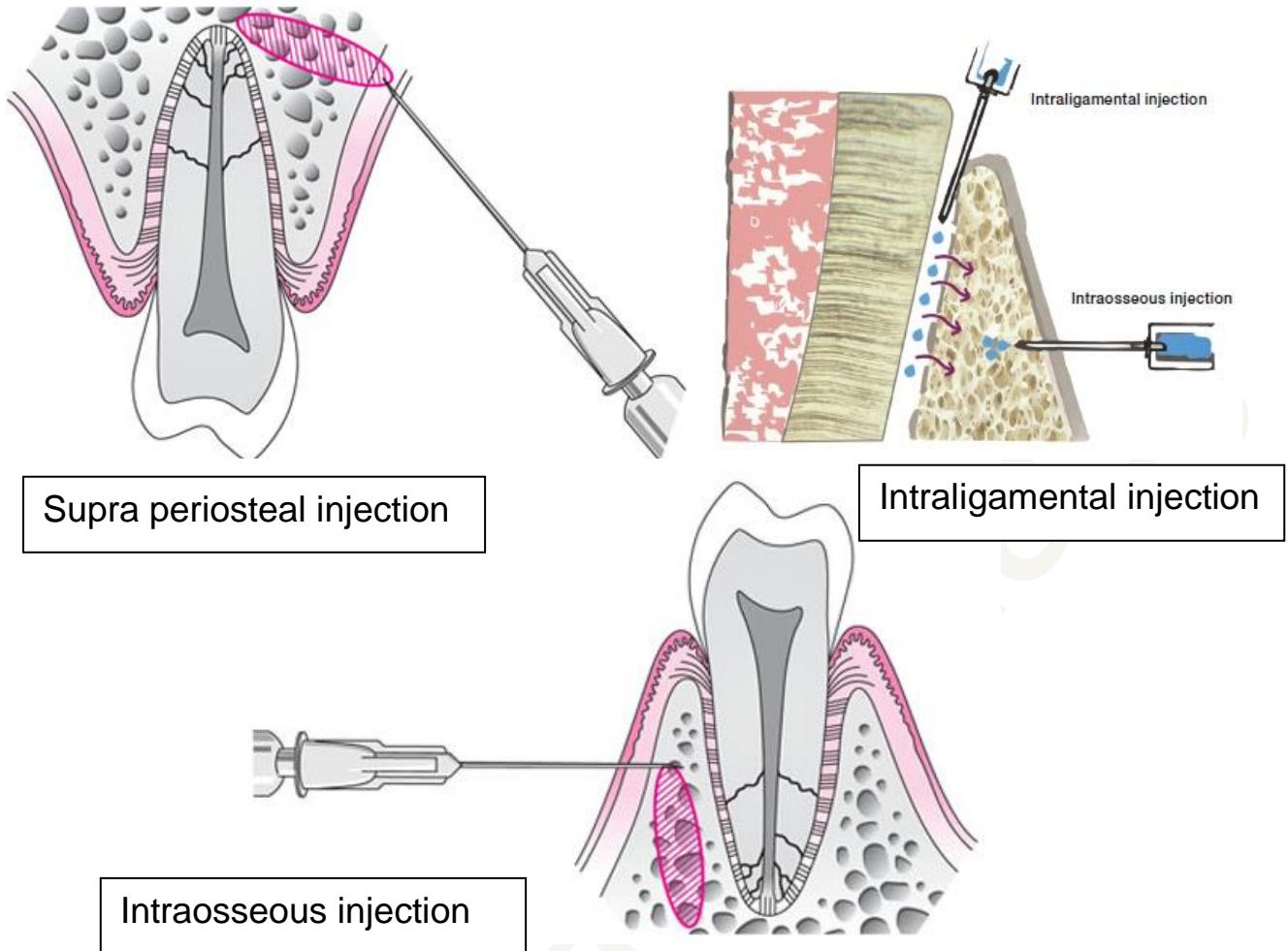
- Articaine is the newest local anaesthetic available in dental cartridges
- The lower concentration of epinephrine is useful when the total amount of vasoconstrictor should be reduced
  - It is available in dental cartridges as a 4% solution containing either epinephrine in 1:100,000 or 1:200,000 concentrations
- A major advantage of articaine is that its half-life is significantly reduced because of hydrolysis of its ester side-chain by nonspecific plasma esterases.
- This reduces its toxic potential
- Its 4% concentration has been implicated as a causative factor in the development of paresthesia after nerve block injections.
- Articaine seems to be more effective for infiltration techniques in the maxilla and mandible than other local anesthetics

#### 5. Bupivacaine

- Bupivacaine is similar chemically to mepivacaine, but is much more lipid soluble and thus more potent
- It is much more cardiotoxic with a clinically significant slower onset time
- Its high lipid solubility renders it unsuitable for maxillary infiltration injection because its diffusion is retarded by sequestration in mucosal tissues
  - Bupivacaine is available in dental cartridges as a 0.5% solution with 1:200,000 epinephrine
- Bupivacaine is primarily used in dentistry to produce long-acting soft tissue anesthesia lasting 8 hours or more after oral surgical procedures
- Combined with appropriate postoperative analgesics and anti-inflammatory drugs, bupivacaine plays an important role in reducing pain in the postoperative period

## NERVE BLOCKS

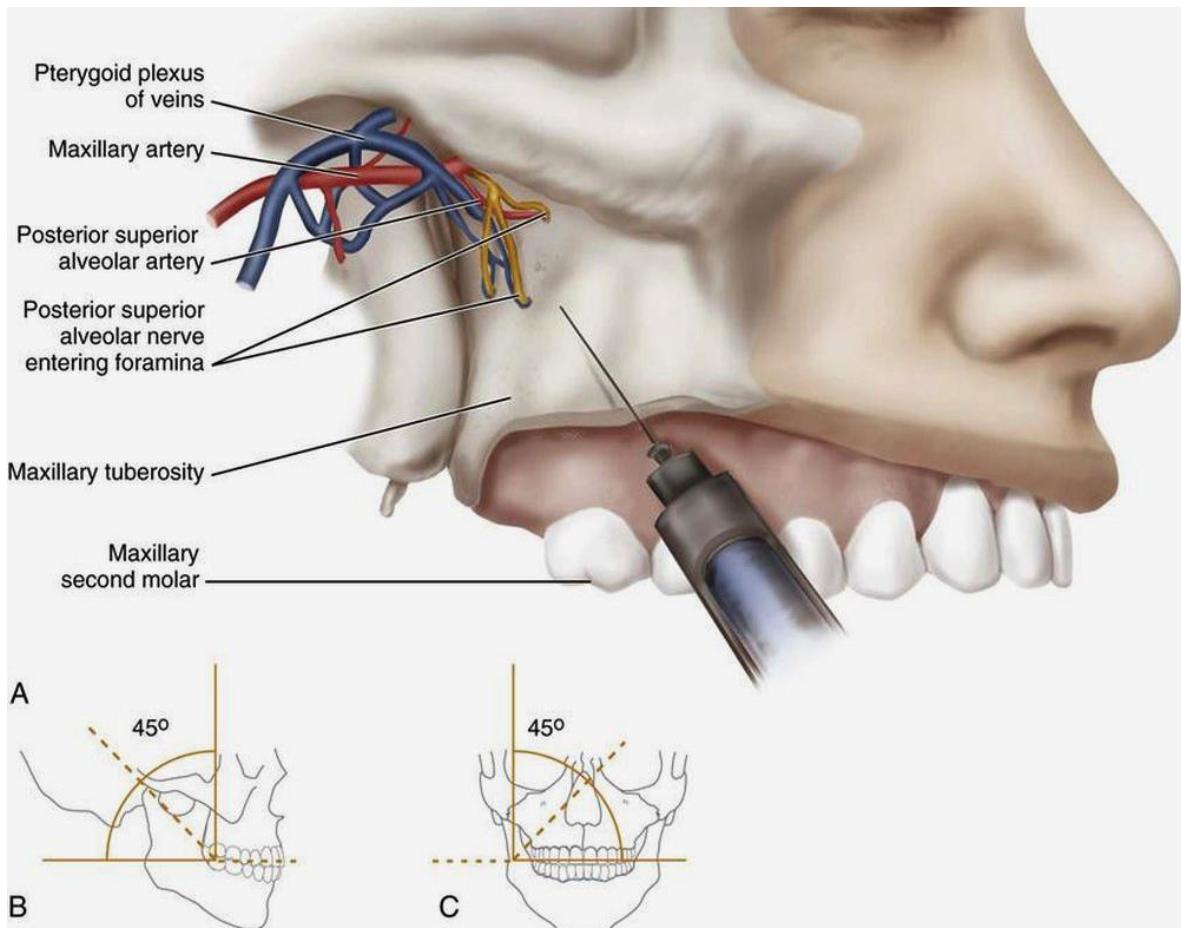
<b>Local infiltrations</b>	
<b>1. Supra periosteal injection</b>	<ul style="list-style-type: none"> <li>• It is a pulpal and soft tissue anesthesia</li> <li>• Used for maxillary anterior teeth</li> <li>• A 25 or 27 gauge needle is inserted at towards the bone at the height of the mucobuccal fold near the apex of the tooth which has to be treated</li> </ul>
<b>2. Intraligamentary/ PDL injections</b>	<ul style="list-style-type: none"> <li>• A 0.2ml of anesthetic solution is deposited for about 20 seconds into the gingival sulcus of either maxillary or mandibular tooth to be treated</li> <li>• Can be uncomfortable, if the rate of injection is rapid</li> </ul>
<b>3. Intraosseous injection</b>	<ul style="list-style-type: none"> <li>• Local anesthesia is injected into the cancellous bone located adjacent to the tooth to be treated.</li> <li>• Can be used as a supplemental technique with nerve blocks</li> </ul>
<b>4. Intraseptal injection</b>	<ul style="list-style-type: none"> <li>• Used for soft tissue, osseous anesthesia and to control bleeding</li> <li>• A 0.2 ml of anesthetic solution is injected slowly into the papilla to be anesthetized at an angle of 90°</li> </ul>
<b>5. Intrapulpal injections</b>	<ul style="list-style-type: none"> <li>• A volume of 0.2 - 0.3ml anesthetic is injected into the pulpal chamber directly</li> <li>• Uncomfortable, but works effectively</li> </ul>



## Maxillary injection techniques

### 1. Posterior superior alveolar nerve block

- **Areas to be anesthetized:** maxillary molars except the mesiobuccal aspect of 1st molar
- A 25 or 27 gauge needle is inserted at the height of the mucobuccal vestibule distal to the second molar at a  $45^0$  angle in an upward, inward and backward direction
- **Landmarks:** Mucobuccal fold, zygomatic process, maxillary tuberosity
- **Complications:** Hematoma due to maxillary artery perforations



## 2. Middle superior alveolar nerve block

- Used for maxillary first molar (mesiobuccal aspect), first and second premolars, buccal bone, periodontal ligament, periosteum, soft tissue lateral to this area.
- Area of insertion:** A 27 gauge needle with 1 ml of anesthetic solution is inserted at the height of the mucobuccal fold above the second premolar

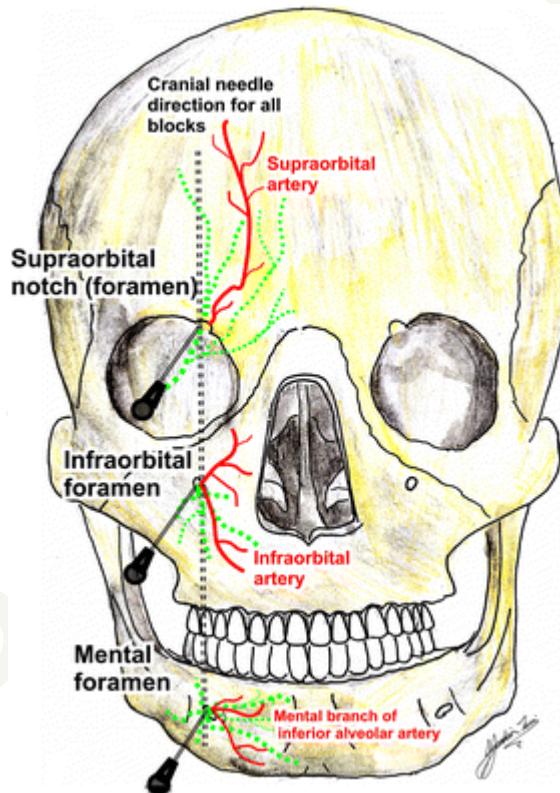
## 3. Anterior superior alveolar nerve

- Also called as infraorbital nerve block
- Areas:** Periodontal ligament, alveolar bone, periosteum, buccal soft tissue and teeth from canine to the incisor
- Area of insertion:** A 25 gauge long needle is penetrated towards bone at the height of mucobuccal fold directly over the first premolar

There are two approaches for infraorbital nerve block

- **Bicuspid approach:** Needle is inserted into the mucobuccal fold using maxillary cuspid as the guide and needle should pass beneath and lateral to the external maxillary artery and facial vein
- **Central incisor approach:** Needle is inserted into the mucobuccal fold using central incisor as guide and should pass beneath labii superioris muscle

- **Target area:** Infraorbital foramen
- **Landmarks:** Mucobuccal fold, infraorbital notch, infraorbital foramen
- **Complications:** Hematoma across lower eyelid around infraorbital foramen



#### 4. Nasopalatine nerve block

- Also called as incisive and sphenopalatine nerve block
- **Areas:** Anesthetize the tissues of palatal aspect of the premaxilla

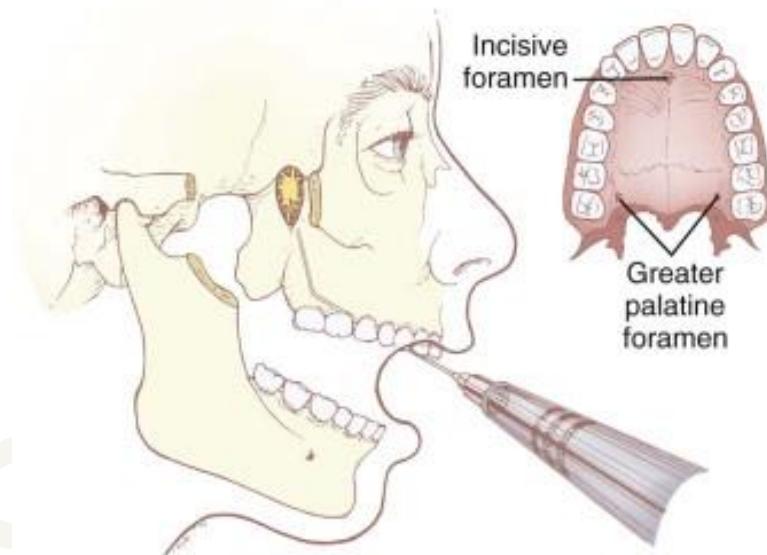
- **Approaches:**

Single penetration

- A 25 or 27 gauge short or ultra short needle is inserted into the palatal mucosa just lateral to the incisive papilla at a  $45^{\circ}$  angle with the orientation of bevel towards the tissue

Multiple penetration

- A 25 or 27 gauge needle with short or ultra short needle is used at 3 points of insertion
  - Labial frenum between maxillary central incisors
  - Interdental papilla between maxillary central incisors
  - Palatal soft tissue lateral to the incisive papilla



### 5. Greater palatine nerve block

- **Areas anesthetized:** Posterior area of the hard palate and overlying soft tissues till first premolar anteriorly and midline medially
- A 27 gauge short needle is inserted into the soft tissues slightly anterior to the greater palatine foramen from the opposite side of the mouth at a right angle with the bevel oriented towards palatal soft tissue
- **Target areas:** greater palatine nerve
- **Landmarks:** Greater palatine foramen, junction of the maxillary alveolar process and palatine bone
- **Complications:** Hematoma (rare), ischemia and necrosis of soft tissues

## 6. Maxillary nerve block

- Very effective method to achieve anesthesia of a hemi maxilla
- Indications:**
  - Used in extensive surgical, periodontal and restorative procedures which require anesthesia of entire maxilla
  - In conditions with excessive inflammation or infection
  - For the diagnosis and therapeutic procedures for neuralgias
- Approach:** High tuberosity approach
- A 25 gauge long needle is inserted at the height of mucobuccal fold above the distal aspect of the maxillary second molar into the foramen to 30 mm
- Target area:** Maxillary nerve
- Landmarks:** Mucobuccal fold at the distal side of maxillary second molar, maxillary tuberosity, zygomatic process of maxilla
- Complications:** Hematoma, technique sensitive

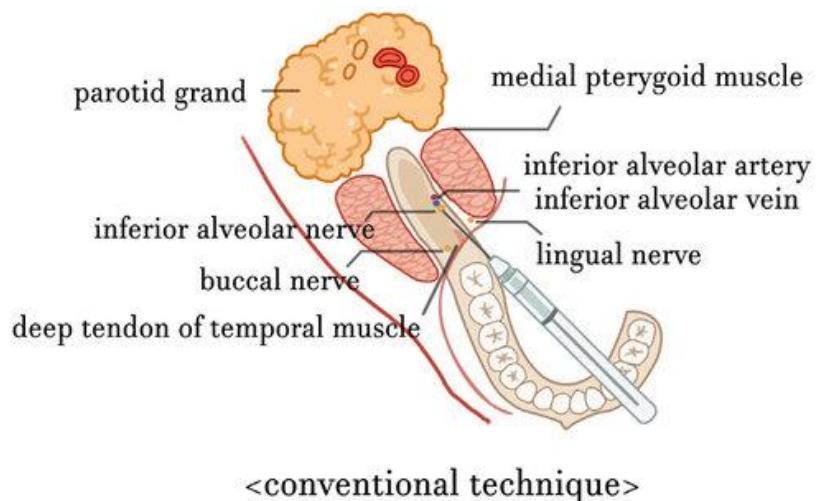
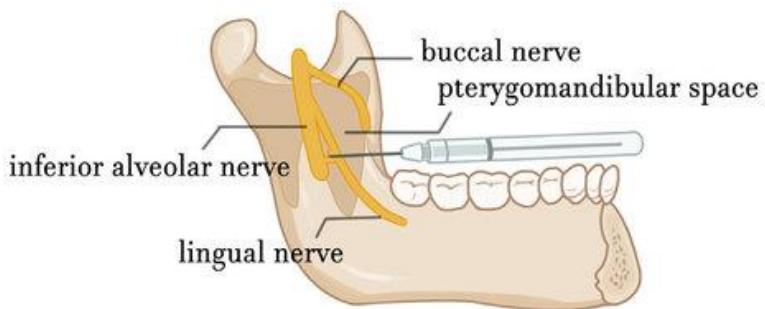
Maxillary techniques	Recommended volumes of anesthetic
• Posterior superior alveolar nerve block	• 0.9 - 1.8 ml
• Middle superior alveolar nerve block	• 0.9 - 1.2 ml
• Anterior superior alveolar nerve block	• 0.9 - 1.2 ml
• Greater palatine nerve block	• 0.45 - 0.6 ml
• Nasopalatine nerve block	• 0.45 ml
• Maxillary nerve block	• 1.8 ml

## Mandibular injections technique

### 1. Inferior alveolar nerve block

- Also called as mandibular nerve block
- It is the 2nd most frequently used method after infiltration
- Nerves anesthetized:** Inferior alveolar nerve, incisive, mental and lingual nerves
- A 25 gauge long needle is used to insert at the mucous membrane above the occlusal plane from the opposing premolar as guide
- Target area:** inferior alveolar nerve
- Landmarks:** Coronoid notch, pterygomandibular raphe, occlusal plane of mandibular teeth
- Signs & symptoms:** Tingling and numbness of the lower lip (anesthesia of mental nerve) and tongue (anesthesia of lingual nerve)

- **Complications:** Hematoma, trismus, transient facial paralysis



## 2. Incisive nerve block

- A 27 gauge short needle is inserted into the mucobuccal fold of the mandibular premolars at or just anterior to the mental foramen
- **Target area:** mental foramen through which mental nerve and incisive nerves exits
- **Complications:** hematoma, paresthesia of lip and chin

## 3. Mandibular nerve block

Gow - Gates mandibular nerve block (Open mouth)	Vazirani - Akinosi Nerve block (Closed mouth)
<ul style="list-style-type: none"> <li>• First published in 1973</li> </ul> <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• Higher success rate</li> <li>• Slower incidence of positive aspiration</li> <li>• No complications of accessory nerve innervations</li> </ul> <p><b>Nerves anesthetized:</b></p>	<ul style="list-style-type: none"> <li>• Dr sunder J Vazirani and Dr Joseph akinosi introduced this approach in 1977</li> <li>• Also called tuberosity technique</li> <li>• It is an intraoral approach to provide anesthesia and motor blockade to cases with severe unilateral trismus</li> </ul>

- Inferior alveolar nerve, lingual auriculotemporal, buccal and mylohyoid nerve.
- A 25 or 27 gauge needle is inserted at the mucous membrane on the mesial side of the mandibular ramus on a line drawn from inter tragic notch to the corner of the mouth distal to the second maxillary molar to a depth of 25 - 30mm

#### Target areas:

- Lateral side of the condylar neck just below the insertion of lateral pterygoid muscle

#### Landmarks

- Extraoral: Lower border of the tragus, corners of the mouth
- Intraoral: Height of the injection established by the placement of the needle tip just below the mesolingual cusp of the maxillary second molar,
- Soft tissue penetration distal to the maxillary second molar

#### Nerves anesthetized:

- Inferior alveolar, lingual, buccal and mylohyoid nerves
- A 25 gauge long needle is inserted parallel to the maxillary occlusal plane at the height of maxillary vestibule buccally

#### Areas of insertion:

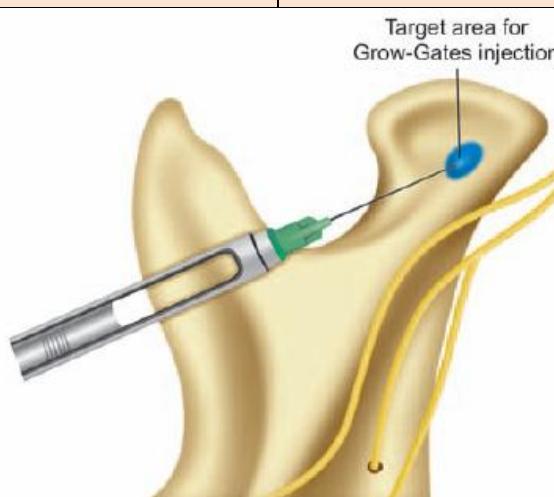
- Soft tissue in the lingual border of the mandibular ramus directly adjacent to the maxillary tuberosity at the height of the mucogingival injection adjacent to maxillary third molar

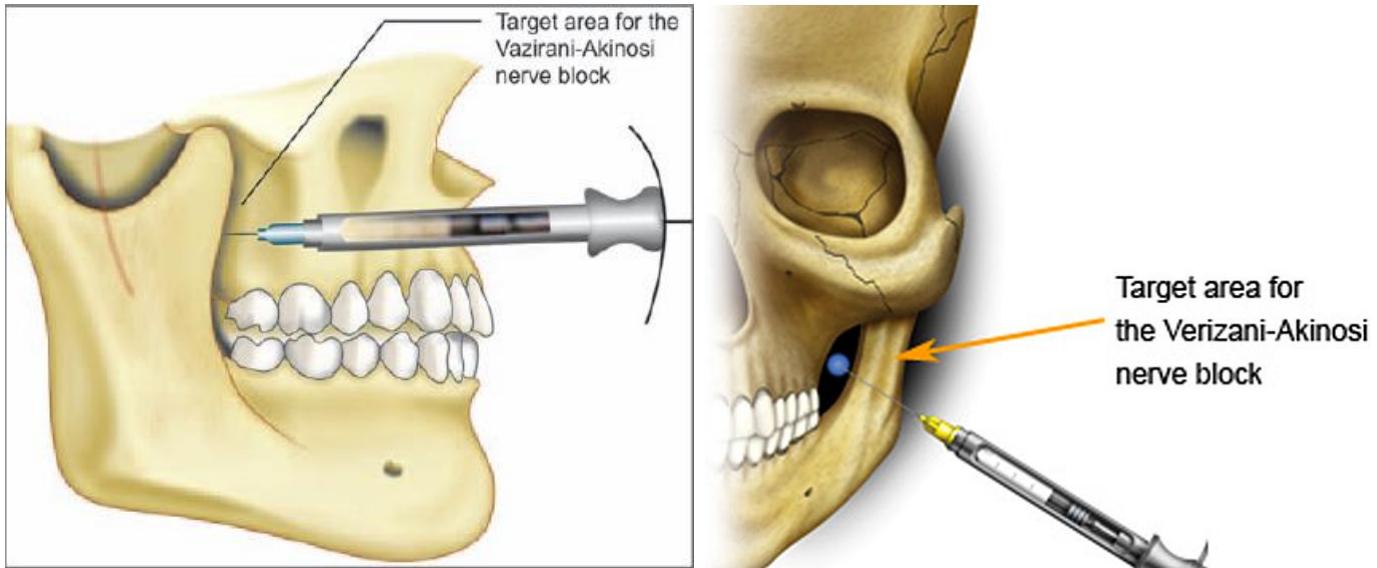
#### Target areas:

- Soft tissue of the medial border of the ramus till the mandibular foramen
- The Vazironi - Akinosi technique is carried out blindly as there are no bony end points

#### Complications:

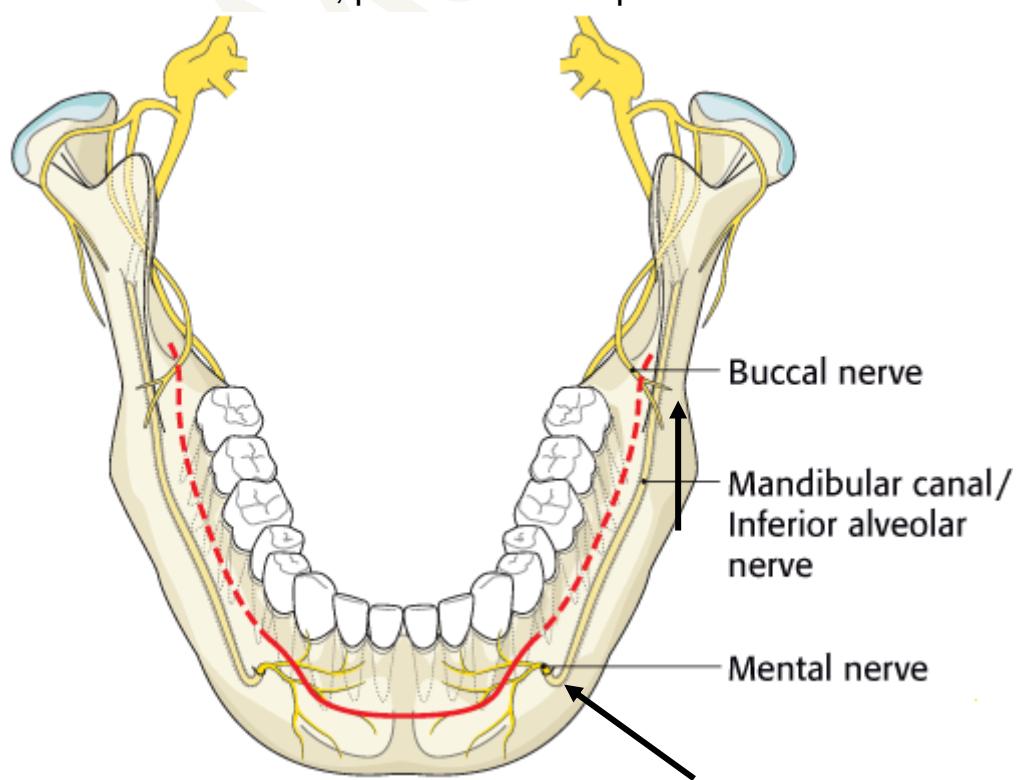
- Hematoma, trismus, facial nerve paralysis





#### 4. Mental nerve block

- Used when in need of bilateral anesthesia for the procedures involving premolars and anterior teeth (soft tissue biopsies, suturing of soft tissue)
- A 25 or 27 gauge short needle is inserted at the mucobuccal fold, just anterior to the mental foramen or in between two apices of premolars
- The difference between mental and incisive nerve block is that the incisive nerve block requires pressure to direct to inject anesthetic solution into mental foramen
- Complications:** Hematoma, paresthesia of lip or chin



## 5. Buccal nerve block

- Also called as long buccal nerve block and buccinator nerve block
- Areas anesthetized: buccal soft tissue lateral to the mandibular molars
- A 25 gauge long needle is injected into the distobuccal vestibule of second and third molar just medial to the coronoid notch until bone is contacted.
- Usually follows inferior alveolar nerve block
- Indications:**
  - Scaling and curettage
  - Rubber dam placement
  - Subgingival caries removal
  - Subgingival tooth preparation
  - Gingival retraction cord placement, matrix bands
- Complications:** Hematoma

## 6. Lingual nerve block

- Will anesthetize the lingual gingiva, floor of the mouth and tongue
- Anesthetized directly during inferior alveolar nerve block at 10mm of injection

Mandibular techniques	Recommended volumes of anesthetic
• Inferior alveolar nerve block	• 1.5 ml
• Buccal nerve block	• 0.3 ml
• Mental nerve block	• 0.6 ml
• Incisive nerve block	• 0.6 - 0.9 ml
• Gow - Gates nerve block	• 1.8 - 3 ml
• Vazirani - Akinosi	• 1.5 - 1.8 ml

## CONCLUSION

- Dental practitioner's must be well aware of the usage of local anesthesia, their usages and applications.
- The required armamentarium must be chosen according to the patient's needs to deliver a painless injections for a desirable level and duration to reduce patients fear and stress and aid in compliance with dental treatment

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*Please Give Your Feedback on this Answer*

**Enumerate the viral infections affecting the oral cavity. Write in detail the pathogenic clinical features and oral manifestations of herpes simplex virus (10M)**

### CONTENTS/SYNOPSIS

- Introduction
- Viral infections affecting the oral cavity
  - Herpes Simplex Infection (HSV)
    - Herpetic gingivostomatitis
    - Herpes labialis
    - Recurrent Herpes Simplex infection
  - Varicella-zoster virus infections
    - Chicken pox infection
    - Herpes zoster infections
  - Epstein-Barr virus infection(EBV)
  - Cytomegalovirus infection(CMV )
  - Human Herpes virus infection
    - Human Herpesvirus-6 (HHV-6)
    - Human Herpesvirus-7(HHV-7)
    - Human Herpesvirus-8(HHV-8)
- References

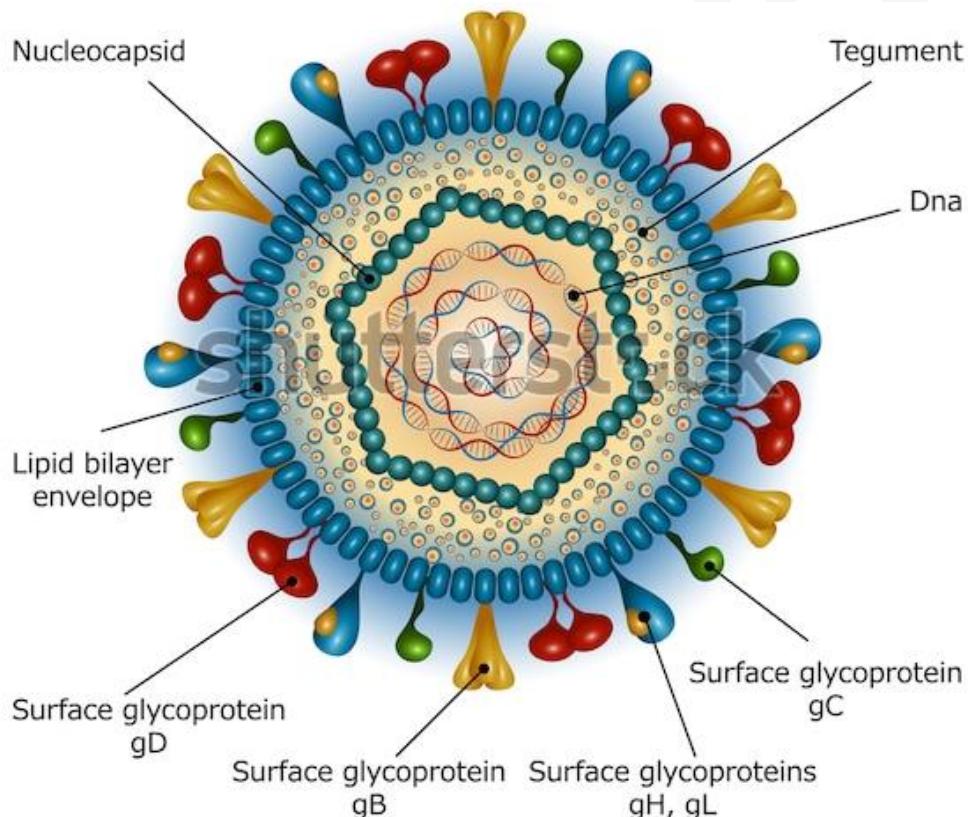
## INTRODUCTION

- Viral diseases may either occur due to cellular destruction or consequence of immune reaction following viral proteins.
- Viral infections typically present with abrupt onset and association of solitary or multiple blister or ulcerations.

## VIRAL INFECTIONS AFFECTING THE ORAL CAVITY

### I. Herpes Simplex Infection (HSV)

- Virions of herpes virus vary in size from 120 to 250 nm and consist of a double-stranded linear DNA molecule surrounded by an icosahedral capsid, a proteinaceous tegument and a lipid-containing envelope with embedded viral glycoproteins

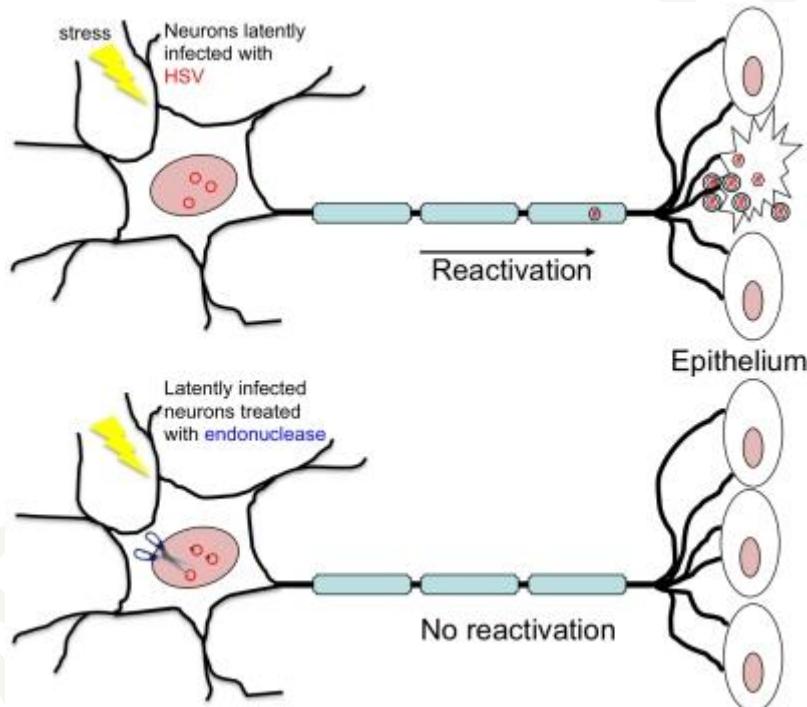


- HSV belongs to herpesviridae group and is a significant pathogenic virus that is known to cause mucocutaneous conditions in the oral cavity and genital region.
- Two major types of herpes viruses are present

- HSV-1 is known to have a significant association with pharyngeal infection, meningoencephalitis, and dermatitis above the waistline.
- The incidence of primary HSV-1 infections usually occurs at an early age

- HSV-2 is associated with genital and anal region infection

- HSV replicates at the portal of entry, often at oral or genital mucosal tissue, leading to infection of sensory nerve endings.
- Following to portal into sensory nerve endings, HSV is then transported to regional ganglia and establishes latency



### 1. Herpetic gingivostomatitis

- Causative virus : Herpes simplex virus-1
- Initial stages: Discrete, spherical, grey vesicles,
- After 24 hours, Vesicles rupture painful small ulcers
- Red, elevated, halo-like margins Depressed greyish white central portion
- Diffuse, shiny, erythematous, with oedema gingival bleeding

### 2. Herpes labialis

- "Cold sore" small fluid filled vesicles and surface

	<p>scale formation , Involving the of the lips and face</p> <ul style="list-style-type: none"> <li>• Around 15 to 30% of the community are affected by episodes of secondary herpes simplex lesions such as herpes labialis.</li> </ul>
<p><b>3. Recurrent Herpes Simplex infection</b></p>	<ul style="list-style-type: none"> <li>• Recurrent herpes simplex infection occurs with reactivation of HSV to trigeminal nerve ganglion</li> <li>• <u>Incubation period:</u> 3-9 days</li> <li>• Reactivation virus may be a resultant of numerous conditions such as age, exposure to sunlight or cold, trauma, physical or emotional stress, fatigue, pregnancy, immunosuppressive state, fever, respiratory illness, menstruation, systemic illness, or malignancy and lead recurrent herpes simplex infection.</li> </ul>

## II. Varicella-zoster virus infections

- Varicella-zoster virus (VZV) belongs to herpes viridae group, is a significant pathogenic virus that is known to cause mucocutaneous conditions in oropharyngeal mucosa and skin.
- Pathogenesis: causes both primary and recurrent infections and remains latent in neurons present in sensory ganglia.
- The incubation period is approximately 2 weeks.
- It is responsible for two major clinical infections: the primary type is chickenpox and the recurrent type is shingles (herpes zoster).

### 1. Chicken pox infection

- Chickenpox usually begins with prodromal symptoms such as headache, pharyngitis, rhinitis, and anorexia.
  - Followed by maculopapular rash that are intensely pruritic or vesicular eruptions of the skin and low-grade fever.
    - The eruptions are noted on the trunk and spread to involve the face and extremities.
      - Chickenpox spread from nasopharyngeal secretions or by coming in direct contact with skin lesions of the infected patients.

- Oral lesions are characterized by small blister-like manifestations that involve various areas of oral mucosa.
- Oral lesions resemble vesicles of primary HSV, but these lesions are not particularly an important symptomatic, diagnostic, or management problem.
- Complications:**

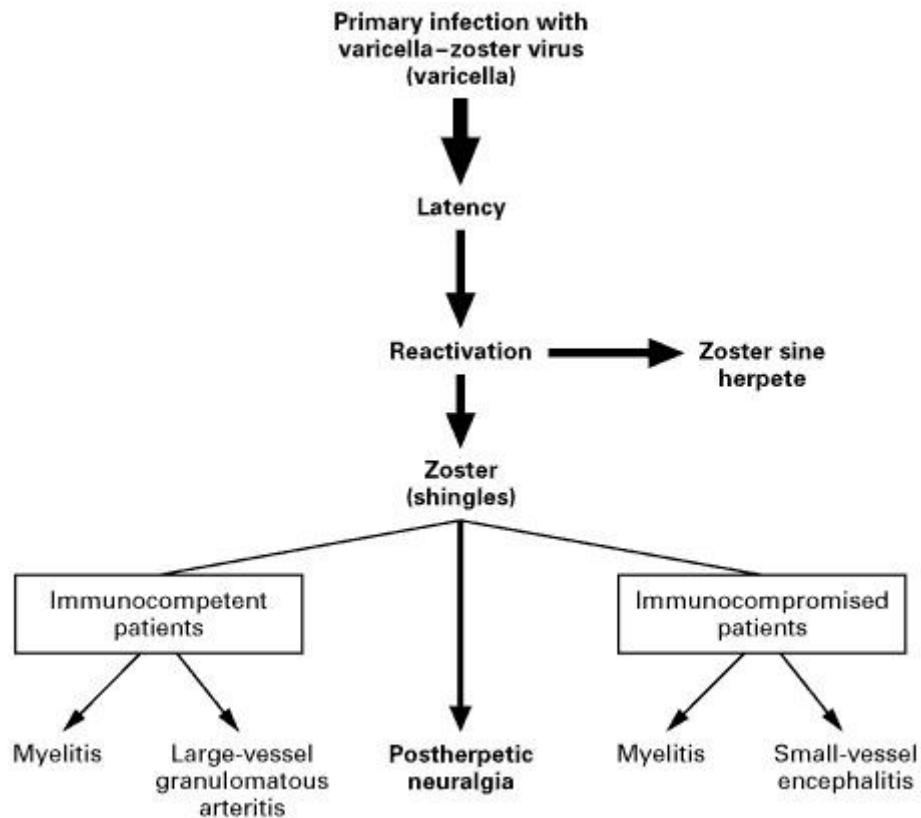
- Encephalitis
- Pneumonitis
- Reye's syndrome
- Guillain-Barre syndrome

## 2. Herpes zoster infections

<i>i. Pathogenesis</i>	<ul style="list-style-type: none"> <li>Following the primary infection of Varicella-zoster, virus becomes reactivated from the latency at dorsal root of cranial nerve ganglia.</li> <li>The nerves most commonly affected are C-3, T-5, L-1, and L-2.</li> <li>Ophthalmic symptoms are observed when infection involve the trigeminal ganglion (ophthalmic division)</li> </ul>
<i>ii. Clinical features</i>	<ul style="list-style-type: none"> <li>Acute infection, extremely painful associated with vesicular eruptions of the skin or mucous membranes in areas supplied by the affected sensory nerves.</li> <li>Ramsay Hunt syndrome is typically characterized by unilateral vesicles of oral mucosa and external ear, unilateral facial paralysis that appear 3–5 days later an inflamed base along the involved nerve.</li> <li>Unilateral vesicles are observed when geniculate ganglion of the facial nerve is involved.</li> </ul>

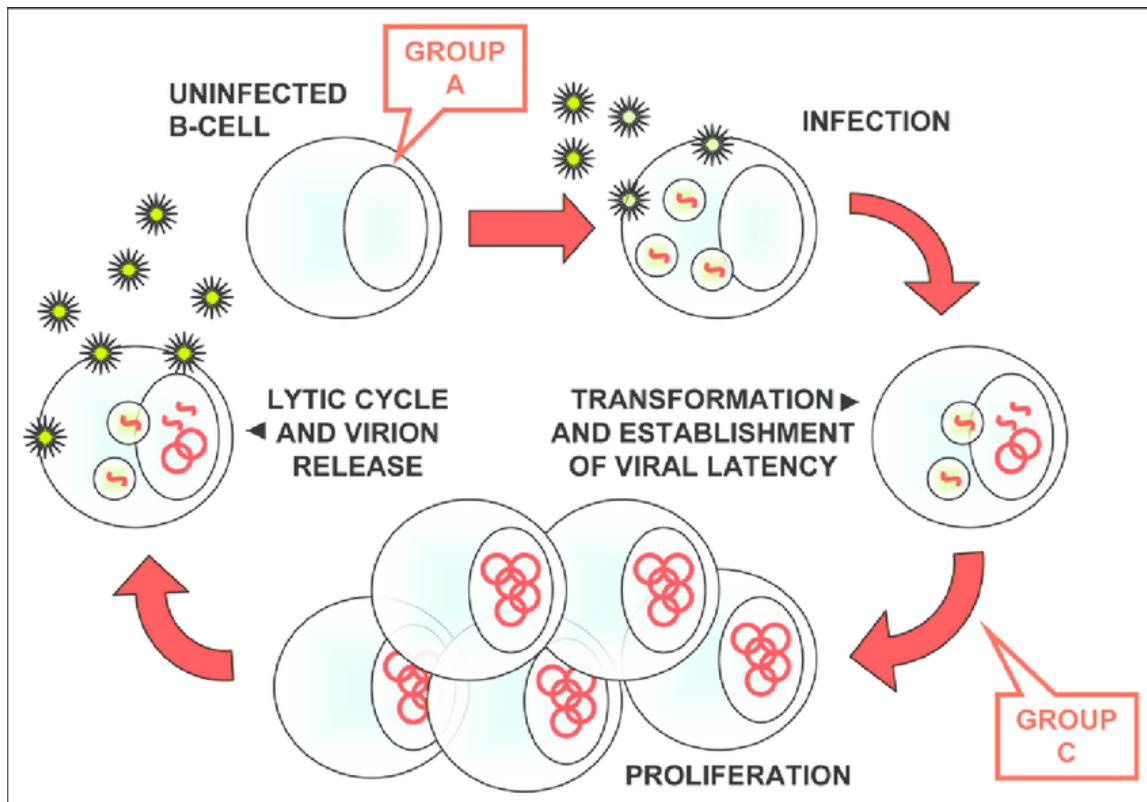
- Diagnosis** is usually based on typical clinical signs and symptoms, dramatic distribution of unilateral involvement associated with this disease with extreme pain, helping to distinguish it from HSV recurrence.
- Varicella zoster may also cause pain along the course of nerve with no lesions on oral mucosa or external ear; the latter is referred as zoster sine herpete or zoster sine eruption.
- In immunocompetent patients, herpes zoster may cause large local lesions or disseminated infection.

- Post herpetic neuralgia is a potential consequence of herpes zoster resulting from scarring of the involved nerve during the infection.



### III. Epstein-Barr virus infection (EBV)

- Epstein-Barr virus (EBV) belongs to the herpes viridae group, is a significant pathogenic virus that is known to infect B cells in the oropharyngeal epithelium.



<b>1. Pathogenesis</b>	<ul style="list-style-type: none"> <li>The <u>transmission</u> of EBV infection occurs following the <u>contact with oral secretions, saliva on fingers, toys or other objects</u>.</li> <li>EBV replicates in epithelial cells of the oropharynx and viruses are usually shed in the saliva.</li> <li>Incubation period is 8 weeks.</li> <li><u>Causes infectious mononucleosis</u>.</li> <li>Associated with several lymphoproliferative disorders, lymphomas (African Burkitt's lymphoma), and nasopharyngeal carcinoma. Other reported associated conditions are oral hairy leukoplakia, gastric carcinomas, hepatocellular carcinomas, salivary lymphoepithelial carcinomas, oral squamous cell carcinoma.</li> </ul>
<b>2. Clinical features</b>	<ul style="list-style-type: none"> <li>EBV infections of infants and children are asymptomatic, whereas the infections of adolescents and adults result in infectious mononucleosis.</li> <li><u>The classical triad includes fever, lymphadenopathy, and pharyngitis</u>.</li> <li>Other symptoms are fever, lymphadenopathy,</li> </ul>

- |  |  |
|--|--|
|  | <p>pharyngitis, hepatosplenomegaly, oral ulcerations, rhinitis, or cough.</p> <ul style="list-style-type: none"> <li>• Hepatomegaly, rhinitis, and cough are less frequently observed in children less than 4 years of age.</li> </ul> |
|--|--|

## IV. Cytomegalovirus infection(CMV)

### 1. Pathogenesis

- Transmission occurs through contaminated blood and body fluid secretions such as saliva, genital secretions, and breast milk.
- CMV can reside latently in salivary gland cells, endothelium, macrophages, and lymphocytes.
- Neonates may develop CMV which is also responsible for microcephaly, chorioretinitis, nerve deafness, hepatitis, hepatosplenomegaly, and thrombocytopenia.
- CMV chorioretinitis is significantly associated with AIDS and tends to progress rapidly.
- Other complications of primary CMV include myocarditis, pneumonitis, gastrointestinal disease, and aseptic meningitis.

### 2. Clinical features

- Infection often remains asymptomatic in healthy children and adults.
- Primary CMV infection results from either blood transfusion or sexual contact.

- Clinical symptoms include fever, myalgia, cervical lymphadenopathy, and mild hepatitis.
  - The classical features of CMV include hepatosplenomegaly, thrombocytopenia, extramedullary cutaneous erythropoiesis, and petechial hemorrhages.

- Severe mental and motor retardation are observed in encephalitic conditions. In immunocompetent patients.
- Unexplained persistent fever and acute sialadenitis.
- Case reports have been published that there is a relationship between xerostomia and the presence of CMV in saliva of HIV-infected individuals

## V. Human Herpes virus infection

### 1. Human Herpesvirus-6 (HHV-6)

- HHV-6 infection is a common childhood exanthematous disease.
- HHV-6 encephalitis usually occurs in severe immunosuppressive states.

<i>i. Pathology</i>	<ul style="list-style-type: none"> <li>• HHV-6 is significantly associated with CD4 T lymphocytes.</li> <li>• CD 45 is an essential component of the membrane receptor for HHV-6.</li> <li>• HHV-6 becomes latent in cells of the monocyte-macrophage lineage.</li> <li>• CD46 is an HHV-6 receptor that is expressed mostly in macrophages and cells lining blood vessels, and less often in the cells of neuronal origin.</li> <li>• Reactivation of latent HHV-6 is significantly associated with drug-induced hypersensitivity, possibly due to a sudden decrease in serum IgG levels.</li> <li>• HHV-6 principally targets mature CD4 T lymphocytes and has an ability to dysregulate cellular cytokine production, modulate natural killer cell function, and modify the expression of key cell surface receptors.</li> <li>• Two variants of HHV-6 have been identified: HHV-6A and HHV-6B.</li> </ul>
<i>ii. Clinical features</i>	<ul style="list-style-type: none"> <li>• The virus is transmitted through the respiratory route, virus particles have been isolated from saliva.</li> <li>• Primary infection with HHV-6 is usually asymptomatic.</li> </ul>

### 2. Human Herpesvirus-7(HHV-7)

- HHV-7 infection is ubiquitous and is acquired in childhood.
- The genomic material of HHV-7 and both variants of HHV-6 are closely related.
- HHV-7 infection in children has been linked with seizures and encephalitis.
- Transmission is similar to HHV 6

#### *Clinical features*

- Primary infection with HHV-7 is often asymptomatic.
- It presents as a single rose-colored, scaling and herald patch.

- Symptoms in oral tissue : punctuated hemorrhages, ulcers, bullae, or erythematous plaques.
- Disseminated HHV-7 infection in immunocompromised patients may lead to multiorgan infection that includes encephalitis, pneumonitis, and hepatitis.

### 3. Human Herpesvirus-8 (HHV-8)

- HHV-8 (HHV-8) or Kaposi's sarcoma-associated virus is the most recently identified HHV type.
- It is significantly associated with malignant conditions in AIDS patients.
- HHV-8 infection is strongly associated with malignant diseases, which is Kaposi's sarcoma that involves oropharyngeal and gastrointestinal mucosal membranes.
- Lesions may be solitary, multifocal, or multicentric red-purple macules, plaques, or nodules of varying size.
- Posterior hard palate, gingivae, and dorsum of tongue are most common sites of oral tissue involvement in Kaposi's sarcoma.

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Please Give Your Feedback on this Answer

**Describe the pathophysiology of pain. Explain the role of opiate system in modulation of pain (10M) (7M)**

## CONTENTS/SYNOPSIS

- Introduction
- Types of pain
- Nociceptors
  - A- $\delta$  fibers
  - A- $\beta$  fibers
  - C fibers
- Pain pathway
  - Sensory neurons involved in pain pathway
    - First order neurons
    - Second order neurons
    - Third order neurons
  - Pathway of pain transmission
  - Afferent (sensory) neuron of dental pulp (pseudounipolar)
  - Process of pain pathway
    - Transduction
    - Transmission
    - Modulation
    - Perception
  - Perception of pain
- Propagation of impulse
  - Sodium-potassium pump
- Mechanism of pain transmission
  - Specificity theory
  - Pattern theory
  - Gate control theory
- Methods to control pain
- Opioids in pain modulation
  - Classification of opioid analgesics
  - Mechanism of action of opioid analgesics
  - Pharmacologically useful actions of opioids
- References

## INTRODUCTION

- Pain is an ill-defined, unpleasant sensation, usually evoked by an external or internal noxious stimulus.
- Pain is a warning signal and is primarily protective in nature, but causes discomfort and suffering; may even be unbearable.

## TYPES OF PAIN

### I. Acute pain

- At the site of local tissue injury, the activation of nociceptive transducers contributes to this form of pain.
- The local injury environment may further alter the characteristics of nociceptors, central connections, and the autonomic nervous system.

### II. Chronic pain

- Persistent pain is related to conditions (e.g., diabetes mellitus, arthritis, and tumour growth) which potentiates chronic tissue inflammation or alteration of the properties of peripheral nerves (neuropathic).
- External factors such as stress, emotions, and the environment may produce a summative effect with the damaged tissue to enhance the intensity of the pain.

### III. Somatic pain

- This form of pain may be acute or chronic and is pain activated by the nociceptors in the cutaneous or deep tissues.
- It is described as more throbbing or aching and is less localized

### IV. Visceral pain

- This pain arises mainly from the viscera and deep somatic structures (e.g., pain from the gastrointestinal tract).
- Visceral pain is not distinctly localized is carried by the C fibres from the deep structures to the spinal cord.

### V. Neuropathic

- Occurs due to damage to nerve fibers, leading alterations in their conduction or neurotransmitter properties.

## VI. Allodynia

- Pain due to a stimulus that does not normally provoke pain.
- Pain resulting from a typically harmless stimulus is referred to as allodynia.
- It is thought to potentially arise from
  - Sensitization of the skin, leading to a decreased threshold of silent nociceptors
  - Damage to peripheral neurons inducing structural changes leading touch-sensitive fibers to reroute and form synapses in areas of the spinal cord that normally receive pain input.

## VII. Hyperalgesia

- Occurs when noxious stimuli generate an exaggerated pain response.

## VIII. Referred pain

- Visceral pain often radiates/referred to other areas.
- Irritation of visceral organ produces pain that is not felt at the site but in somatic structure that may be in some distance away. (referred pain)
- When pain is referred, it is usually to a structure developed from same embryonic segment/ dermatome in which pain originates.
- The basis of referred pain may be convergence of somatic and visceral pain fibres on the same second order neuron in the dorsal root that project to the thalamus and then to somatosensory cortex (convergence projection theory).

## NOCICEPTORS

- They are sensory receptors that are activated by noxious insults to peripheral tissues
- The receptive endings to peripheral pain fibres are free nerve endings
- These nerve endings are largely distributed in the

### I. Distribution of nociceptors

- Skin
- Dental pulp
- Periodontium
- Meninges
- Pain and temperature sensations arises from receptors located on unmyelinated dendrites of sensory neurons
- These receptors are located in deep tissues.

## II. Classification of nociceptors

1. **Mechanical nocireceptor** respond to strong pressure
2. **Chemically sensitive** nocireceptor responds to chemicals such as histamine, high acidity, environmental stimulus.
3. **Thermal nocireceptor** responds to temperature above 45 C/ severe cold and 20C
4. **Polymodal nocireceptor** responds to combinations of above stimuli
  - Sensory nerves to the teeth are branches of the Maxillary & Mandibular divisions of the Trigeminal nerve
  - Nerves of the pulp
    - Myelinated – A  $\delta$  & A  $\beta$  - sharp pain
    - Myelinated Efferent – B
    - Non-Myelinated -C fibers - dull pain
  - Impulse from nocireceptor are transmitted through

### I. A- $\delta$ fibers

- Form 90% of A fibers
- 2-5 $\mu$ m in diameter
- Carry pain (nociceptive) sensations at speed ranging from 2 – 30 m/sec
- Produce sharp, pricking & unpleasant but bearable pain
- Relatively low threshold of stimulation
- Activation of AS fibres release glutamate is responsible for first pain/fast pain.
- AS fibres has the ability to localize the size and Intensity of noxious stimulus

### II. A- $\beta$ fibers

- More sensitive to stimulation than A- $\delta$  fibers
- Carry touch, pressure & proprioceptive impulses at a speed of 70 m/sec

### III. C fibers

- Carry pain sensations at a slower speed
- 0.3-1.2 $\mu$ m in diameter
- 0.5 – 1.0 m/sec because of their lack of myelin & smaller diameter
- They are 3-4 times the No. of A fibers
- Continuous, constant, or throbbing pain is a result of sustained smaller C fiber activity
- Pain is dull, intense, diffuse, unpleasant feeling associated with noxious stimulus

- Have a higher threshold of excitability
- Stimulation is associated with tissue damage & inflammatory process
- Activation of C fibres release glutamate and substance P responsible for delayed second pain/ slow pain
- A variety of receptors on the endings of nociceptive sensory nerves respond to noxious mechanical thermal or chemical stimuli

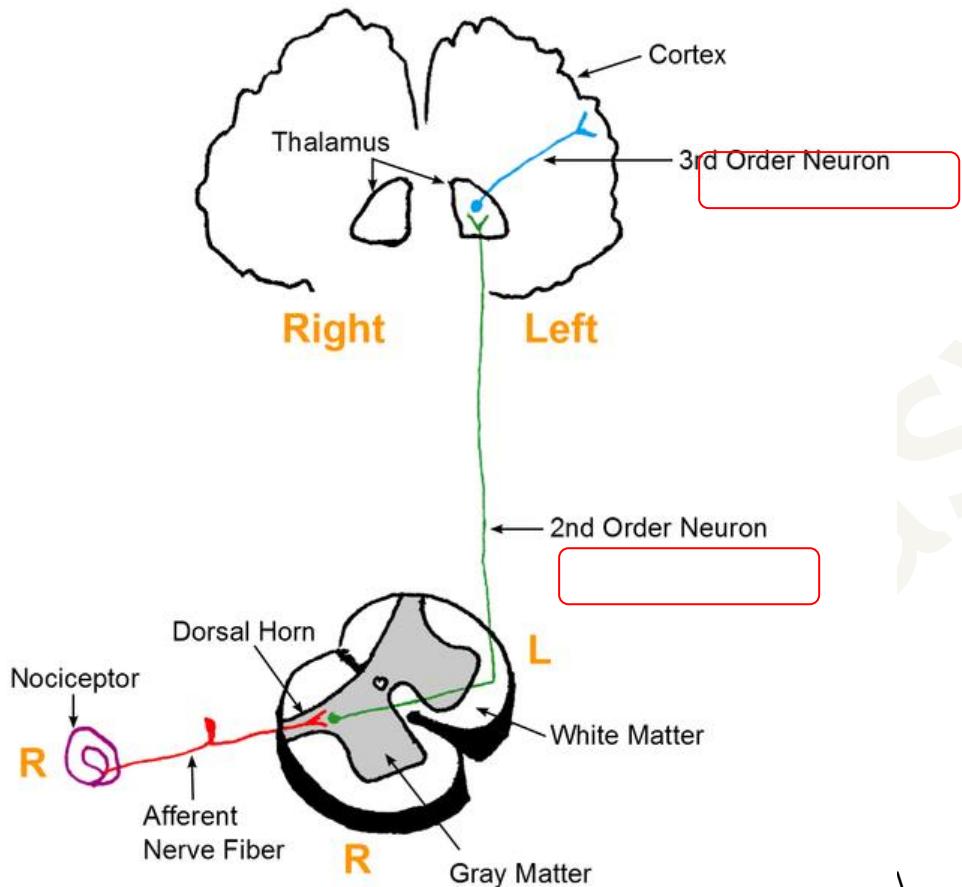
## PAIN PATHWAY

The region of central nervous system involved in transmission of pain is-

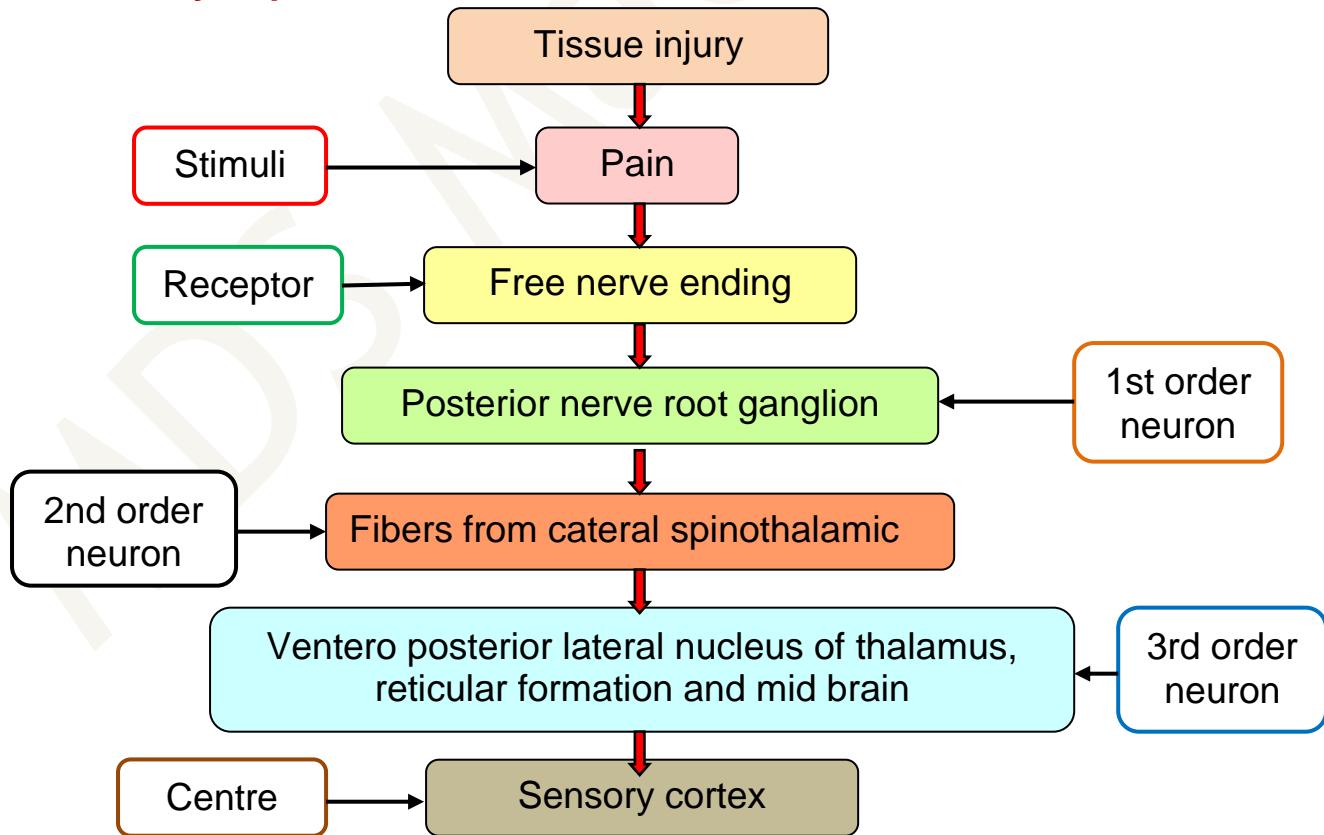
- Spinal cord (supraspinal)
- Brain stem (midbrain, medulla, pons)
- Cortical regions (cerebral cortex)

### I. **Sensory neurons involved in pain pathway are:**

<b>1. First order neurons</b>	<ul style="list-style-type: none"><li>• Each sensory receptor is attached to first order primary afferent neuron that carries impulses to CNS</li></ul>
<b>2. Second order neurons</b>	<ul style="list-style-type: none"><li>• The primary afferent neuron carries impulse into the CNS and synapses with the second order neurons</li><li>• Second order neuron is otherwise called as transmission neuron.</li><li>• Synapse of primary afferent and second order neuron access in dorsal horn of spinal cord</li></ul>
<b>3. Third order neurons</b>	<ul style="list-style-type: none"><li>• Cell bodies of third order neurons of nocireceptors-relaying pathway are housed in venteroposterior lateral, venteroposterior anterior and intralaminar thalamic nuclei</li><li>• Third order neuron fibres from the thalamus relay thermal sensory information to the somatosensory cortex</li></ul>



## II. Pathway of pain transmission



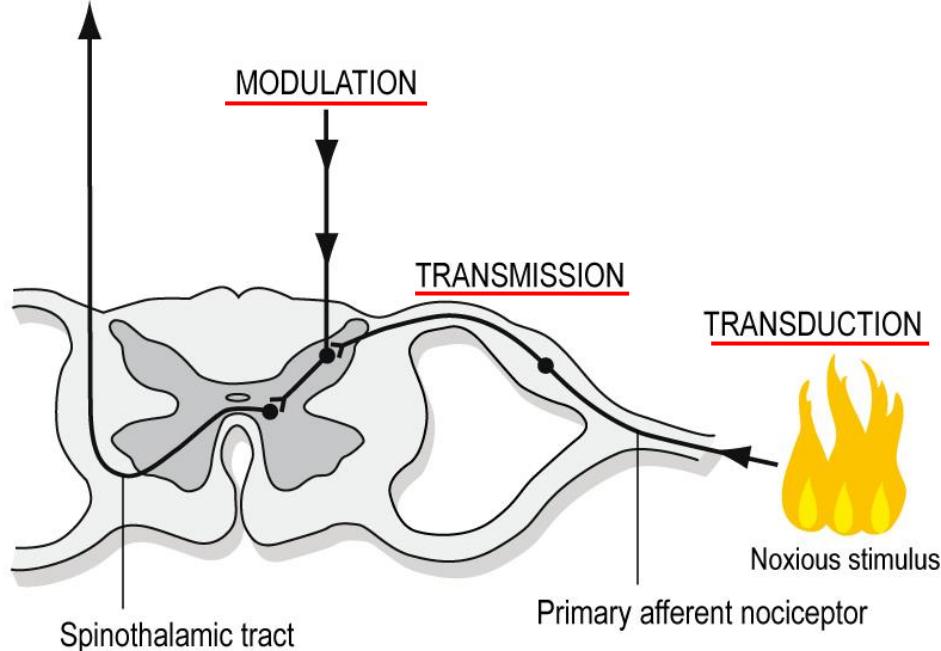
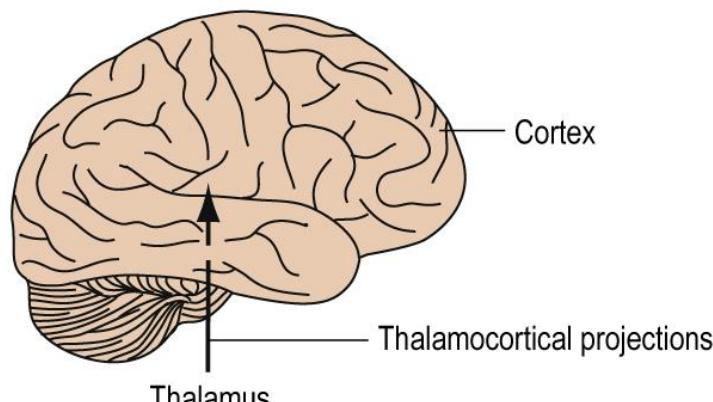
### III. Afferent (sensory) neuron of dental pulp (pseudounipolar) with two processes:

- Dendrite: originates in the pulp
- Its terminals are receptors at the pulp periphery
- Cell body is located in semilunar ganglion of the trigeminal nerve
- Axon: proceeds to the CNS where it terminates in an island of gray matter (spinal nucleus of trigeminal nerve)
- A second order neuron crosses to the other side & carries impulse to the thalamus, synapsing with the third order neuron which terminates in the post central gyrus of the cerebral cortex

### IV. Process of pain pathway

- There are four process of pain pathways

#### PERCEPTION



<b>1. Transduction</b>	<ul style="list-style-type: none"> <li>Pain is detected by nociceptors (A delta and C fibers)</li> <li>Noxious stimuli translated into electrical activity at free nerve endings of sensory neurons found in all tissues and organs except brain           <ul style="list-style-type: none"> <li>➤ Unimodal: respond to only one type of stimulus</li> <li>➤ Polymodal: respond to more than one type of stimuli</li> </ul> </li> <li>Damage to tissue releases chemicals to stimulate nociceptors</li> <li>Eg. Bradykinin, histamine, acetylcholine, serotonin, prostaglandins etc</li> </ul>
<b>2. Transmission</b>	<ul style="list-style-type: none"> <li>Propagation of impulses along spinothalamic pathway</li> </ul>
<b>3. Modulation</b>	<ul style="list-style-type: none"> <li>Transmission is modified</li> </ul>
<b>4. Perception</b>	<ul style="list-style-type: none"> <li>Affective/ motivational aspect</li> </ul>

- Transduction, transmission and modulation interact to create subjective emotional experience in pain
- All these four processes have a potential target for analgesic therapy

## V. Perception of pain

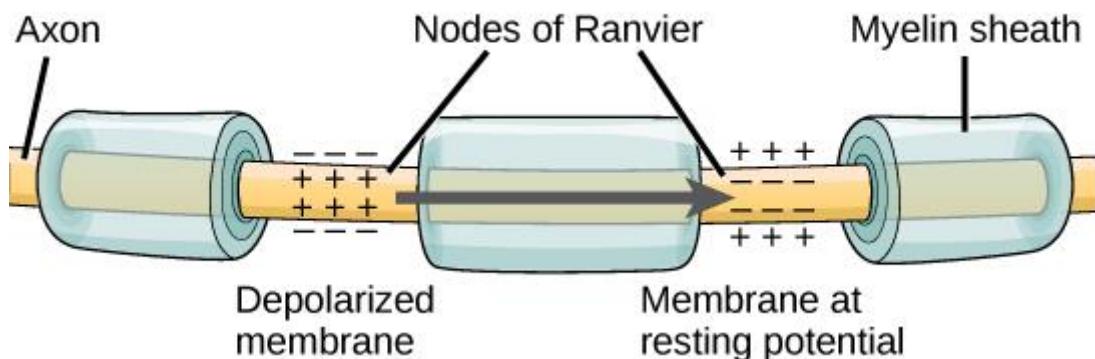
- Pain perception is dependent upon
- Cellular damage
- Stimulation of the receptor
- Ascending neural pathways
- Arousal of sensory cortex
- Consciously aware of pain stimulation

## PROPAGATION OF IMPULSE

### Sodium-potassium Pump

- When nerve fibre is at rest (resting potential), positively charged sodium ions ( $Na^+$ ) are concentrated in the extracellular tissue fluid
- Positively charged potassium ions ( $K^+$ ) are concentrated in the cytoplasm of the nerve
- Nerve fibre membrane is polarised due to this unequal concentration of ions
- Depolarization of membrane is required for propagation of impulse

- Stimulation increases the permeability of membrane to  $\text{Na}^+$ , permitting their movement into axon resulting in momentary depolarization
- $\text{K}^+$  migrate outwards as impulse moves away
- Sodium pump expels  $\text{Na}^+$  into the extracellular fluid while potassium pump returns  $\text{K}^+$  to the intracellular fluid
- Resting potential is restored locally
- This cycle repeats itself down the length of the nerve.



- When the electrical impulse arrives at the synaptic terminal, neurotransmitter molecules are released (acetylcholine, nor epinephrine) that diffuse to generate (or inhibit) an electrical impulse in the receptors of dendrites or other neurons

## MECHANISM OF PAIN TRANSMISSION

- International Association for the Study of Pain (IASP)- “an unpleasant sensory & emotional experience associated with actual or potential tissue damage, or described in terms of such damage.”
  - Specificity theory: proposed by Descartes in 1644; advanced by Von Frey in 1894
  - Pattern theory: proposed by Schilder
  - Gate Control theory: introduced by Melzack & Wall in 1964

### I. Specificity theory

- States that different sensory fibers mediate different sensory modalities
- Receptors for pain are specific & are unmyelinated nerve endings
- When stimulated, they transmit impulses along specific pathways

## II. Pattern theory

- Pain is generated by non-specific receptors
- All nerve fiber endings are alike & pattern for pain is produced by more intense stimulation than for other sensations
- Summation of pain impulses produce a pattern that the brain receives & recognizes

## III. Gate control theory

- A gating mechanism is located in a specific area of gray matter in the spinal cord called the substantia gelatinosa
- Receives painful impulses from peripheral nerves & permits their passage to the brain by opening the gate, or prevents their passage by closing the gate
- Whether the gate opens or closes depends on:
  - Speed of impulse
  - Interaction between noxious pain stimuli transmitted along the smaller diameter fibers
  - Those stimuli of touch & pressure that are transmitted along the larger diameter fibers
- Descending central control from intrinsic brain mechanisms modulates the gating mechanism

## METHODS TO CONTROL PAIN

- Local anesthesia
- Pre medications
- Inhalation sedation
- Hypnosis
- Electronic dental anesthesia

## OPIOIDS IN PAIN MODULATION

### I. Classification of Opioid analgesics

#### 1. Natural opium alkaloids

- Morphine, codeine

#### 2. Semi synthetic opiates

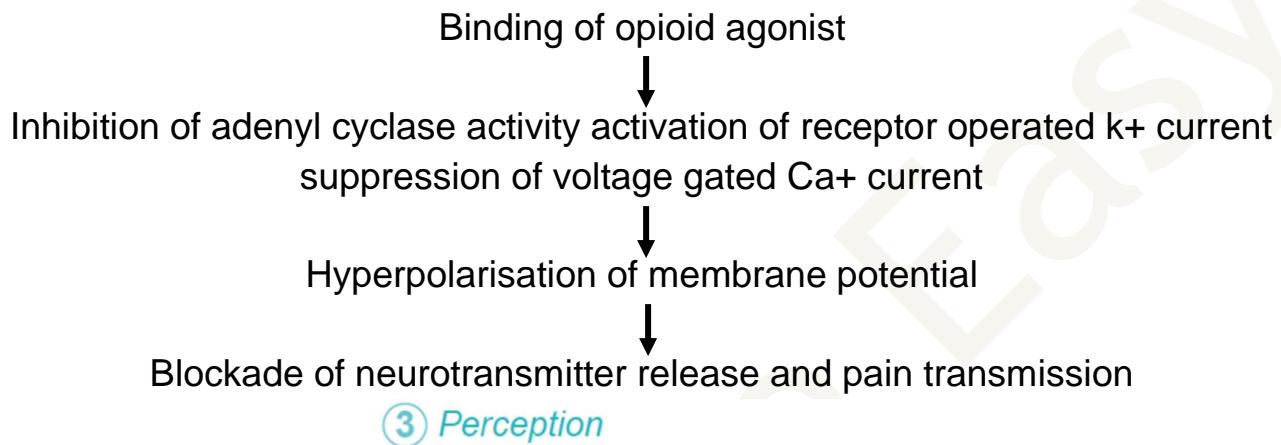
- Diacetylmorphine (heroin), pholcodeine

#### 3. Synthetic opioids

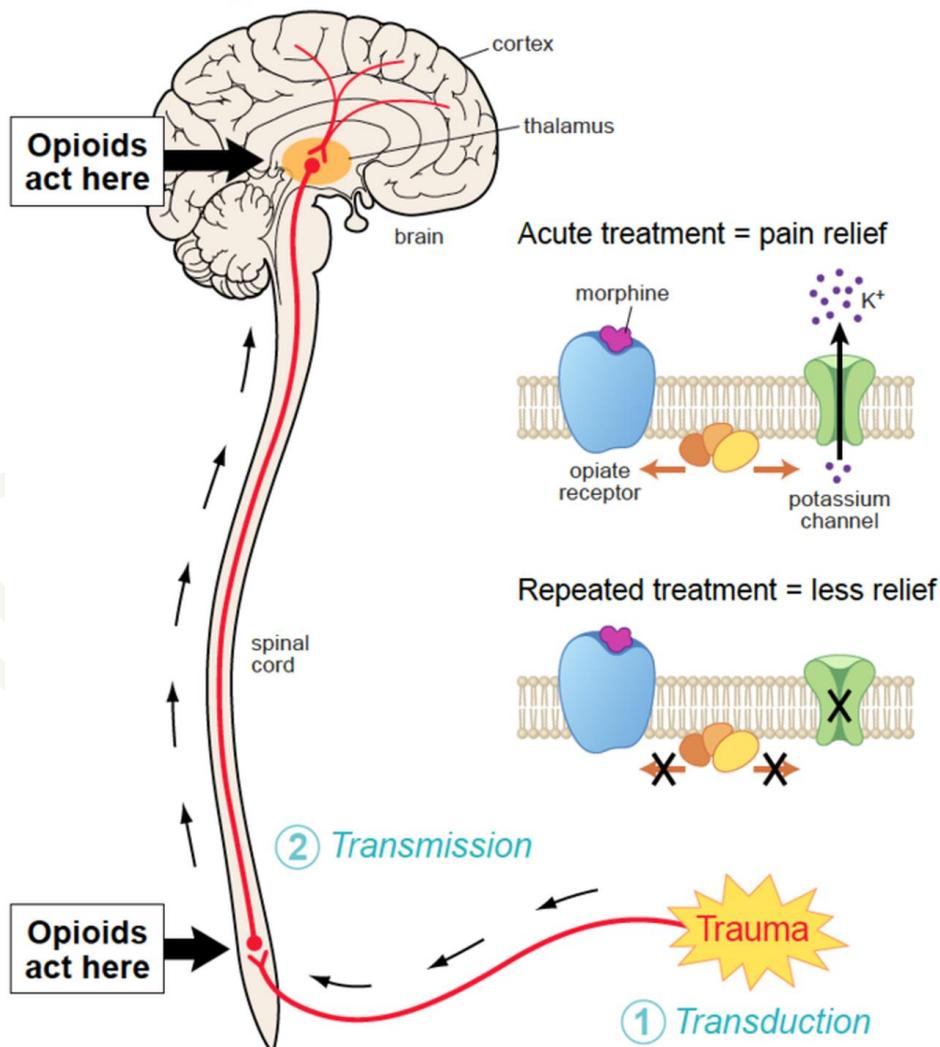
- Pethidine (meperidine), fentanyl, methadone, dextropropoxyphene, tramadol

## II. Mechanism of action of opioid analgesics

- Opioid analgesics relieve inflammatory pain by reducing activity in sensitized nociceptive primary afferent fibres and affecting immune cell activity.
- In the spinal cord, opioids produce presynaptic inhibition of nociceptive afferents (by inhibition of calcium entry) and postsynaptic inhibition of nociceptive dorsal horn cells (via a G protein-coupled K<sup>+</sup> conductance increase).



### ③ Perception



### III. Pharmacologically useful actions of opioids

<b>1. Analgesia</b>	<ul style="list-style-type: none"> <li>• Strong analgesic</li> <li>• Nociceptive pain arising from peripheral pain receptors is better relieved than neurotic pain</li> <li>• Reactions associated with intense pain like apprehension, fear, autonomic effects ... are also depressed</li> </ul>
<b>2. Mood and subjective changes</b>	<ul style="list-style-type: none"> <li>• Calming effect</li> <li>• Loss of apprehension, feeling of detachment, lack of initiative, mental clouding and inability to concentrate</li> </ul>

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*Please Give Your Feedback on this Answer*

## Precancerous conditions and their effects on prosthodontic treatment. (6M)

### CONTENTS/SYNOPSIS

- Introduction
- Etiopathogenesis
- Detection
- Classification
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  - Definition
  - Classification
    - Sharps staging of leukoplakia
  - Clinical Features
  - Histopathological features
  - Differential diagnosis
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- Actinic cheilitis
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  - Clinical Features
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  - Management
- Other conditions
  - Some inherited cancer syndromes
  - Immunodeficiency
- References

## INTRODUCTION

- In a World Health Organization Workshop, held in 2005, the terminology, definitions and classifications of oral lesions with a predisposition to malignant transformation have been discussed and recommended to use the term “potentially malignant disorders” to eliminate terminological confusion
- The most common oral precancerous lesions are oral leukoplakia, oral submucous fibrosis (OSMF), and oral erythroplakia.
- Actinic cheilitis, some miscellaneous inherited diseases such as xeroderma pigmentosum and Fanconi’s anemia, and immunodeficiency are another potentially malignant disorders for oral carcinoma as well as these three diseases

## ETIOPATHOGENESIS

- Not well-known
- Increase in:
  - Salivary thiobarbituric acid reacting substance
  - advanced glycation end products
  - Expression of CK8 & CK18
  - Expression of Podoplanin & ABCG2
  - Prevalence of p53 mutations

- Risk factors
  - Tobacco chewing,
  - Tobacco smoking,
  - Alcohol
  - Human papilloma virus (HPV)

## DETECTION

- Early detection of premalignant lesions and oral cancer is very important.
- Available modalities:
  - Oral cavity examination and history
  - Supravital staining
  - Oral cytology
  - Optical technologies
    - Spectroscopy,
    - Fluorescence spectroscopy,

- Elastic scattering (reflectance) spectroscopy,
- Raman spectroscopy,
- Fluorescence imaging,
- Optical coherence tomography,
- Narrow-band imaging,
- Multimodal optical imaging

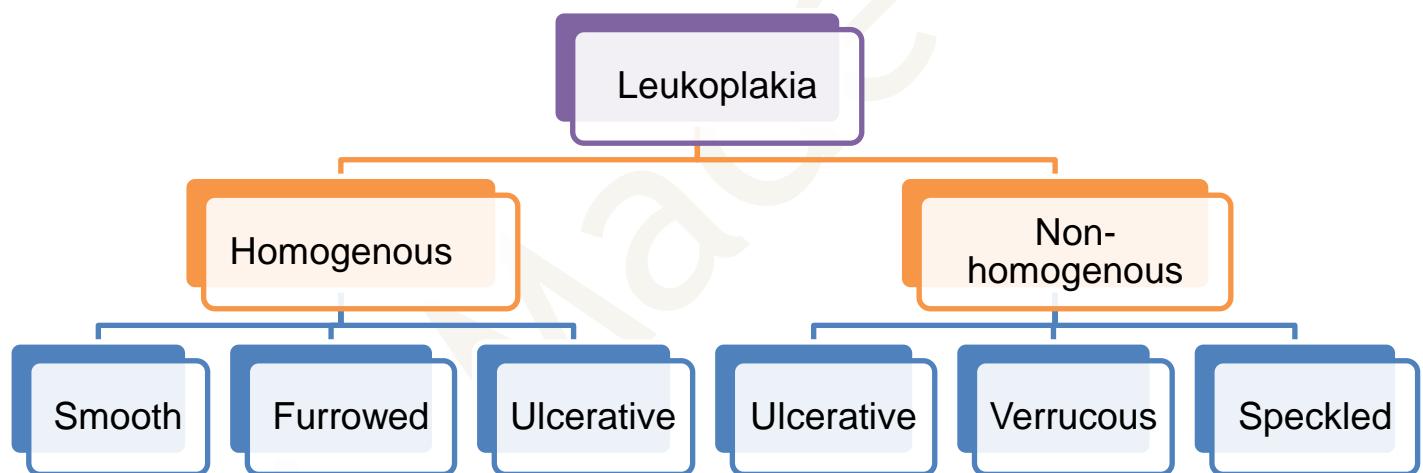
## ORAL LEUKOPLAKIA

### I. Definition

- A white patch or plaque in the oral cavity which cannot be scrapped off or stripped off easily & more over, which cannot be characterized clinically or pathologically as any other disease

### II. Classification

#### 1. Based on Clinical appearance



#### 2. Based on Extent (Axell & Pindborg et al 1983)

- Local
- Diffuse

#### 3. Based on Risk of Malignant Transformation

##### High risk sites

- Floor of the mouth
- Lateral/ ventral surface of tongue
- Soft palate

##### Low risk sites

- Dorsum of tongue
- Hard palate

#### 4. Basis: Histology (Axell & Pindborg et al 1983)

- Dysplastic
- Non dysplastic

##### *Sharp's staging of leukoplakia*

- Stage I : Earliest lesion-non palpable, faintly translucent, white discolouration
- Stage II : Localized or diffuse, slightly elevated plaque of irregular outline. It is opaque white & may have a fine granular texture
- Stage III : Thickened white lesion showing induration and fissuring

### III. Clinical Features

- Clinically, leukoplakia may affect any part of the oral and oropharyngeal cavity
- Age: affects all ages, more common in 4<sup>th</sup> to 6<sup>th</sup> decade

<b><i>Homogenous lesions</i></b>	<b><i>Non- homogenous lesions</i></b>
<ul style="list-style-type: none"> <li>• Uniformly flat, thin</li> <li>• Uniformly white in colour</li> <li>• Shallow cracks of the surface keratin</li> </ul>	<ul style="list-style-type: none"> <li>• Have been defined as a white and red lesion (<i>erythroleukoplakia</i>)</li> <li>• May be either irregularly flat (speckled) or nodular</li> </ul>

- Solitary or multiple white patches
- Varies from a non-palpable faintly translucent white area to a thick fissured, papillomatous or indurated lesion
- 70% in buccal mucosa, commissural areas, followed by lower lip, floor of the mouth, palate & gingiva
- Symptoms:
  - Feeling of increased thickness of mucosa
  - Ulcerated or nodular type → burning sensation

### IV. Histopathological features

- Epithelial hyperplasia
- Surface hyperkeratosis
- Lesions show benign hyperkeratosis with/without acanthosis

- Dysplastic changes typically begin in basal & parabasal zones of epithelium

## V. Differential diagnosis

- Aspirin burn
- Chemical injury
- Oral pseudo membranous and hyperplastic candidiasis
- Frictional keratosis
- Leukoedema
- Linea alba
- Lupus erythematosus
- Smoker's palate
- White sponge nevus
- Oral lichen planus (OLP)
- Lichenoid reaction

## VI. Risk factors of malignant transformation

- Female gender
- Long duration of leukoplakia
- Leukoplakia in non-smokers
- Location on the tongue and/or floor of the mouth
- Size  $> 200 \text{ mm}^2$
- Non-homogenous type
- Presence of epithelial dysplasia

## VII. Investigations

- Oral leukoplakia should be confirmed by mucosal biopsy.
- But before biopsy, some staining methods may be used as a diagnostic aid → methylene blue

## VIII. Management

<b>1. Conservative management</b>	<ul style="list-style-type: none"><li>• Elimination of etiological factor</li><li>• Habit cessation- Restraining from smoking or chewing tobacco</li><li>• Removal of sharp broken down teeth</li><li>• Correction &amp; replacement of overhanging or faulty metal restorations with a metal bridge</li></ul>
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<b>2. Chemoprevention</b>	<ul style="list-style-type: none"> <li>• Isoretinooin / 13- cis- retinoic acid</li> <li>• Beta carotene -30mg TID</li> <li>• Topical Bleomycin – 0.5-1% solution/ 2wks</li> <li>• 5-Fluorouracil &amp; Cisplatin</li> </ul>
<b>3. Surgical management</b>	<ul style="list-style-type: none"> <li>• Entire lesion excised if it is &gt;1cm in size,</li> <li>• Following modalities used: <ul style="list-style-type: none"> <li>➢ Scalpel – surgical stripping</li> <li>➢ Cryosurgery – with liquid nitrogen</li> <li>➢ Electrocautery</li> <li>➢ Laser ablation</li> </ul> </li> <li>• Recurrence after surgery : 10% and 35%</li> </ul>

## ORAL ERYTHROPLAKIA

<b>I. Definition</b>	<ul style="list-style-type: none"> <li>• Any lesion of the oral mucosa that presents as a bright red velvety patch or plaque, which cannot be characterized clinically or pathologically as any other recognizable condition.</li> </ul>
<b>II. Etiopathogenesis</b>	<ul style="list-style-type: none"> <li>• Not known exactly .</li> <li>• Chewing tobacco and alcohol → ?</li> </ul>
<b>III. Clinical Features</b>	<ul style="list-style-type: none"> <li>• Prevalence : 0.02% and 0.83%.</li> <li>• Age: middle aged and the elderly.</li> <li>• Male &gt; Female</li> <li>• Usually solitary lesion</li> <li>• <u>Most commonly affected areas → soft palate, the floor of the mouth, and the buccal mucosa</u></li> <li>• Size: typically &lt;1.5 cm in diameter, but can range from 1cm – 4 cm</li> <li>• Flat or even depressed erythematous change of the mucosa without a patch lesion.</li> <li>• Maybe granular or nodular</li> <li>• Well-defined: May have an irregular, red granular surface interspersed with white or yellow foci</li> <li>• Soft on palpation</li> <li>• Both red and white changes in the same lesion</li> </ul>

	refer to as <u>erythroleukoplakia</u>
<b>IV. Clinical variants</b>	<ul style="list-style-type: none"> <li>• Homogenous erythroplakia</li> <li>• Erythroplakia interspersed with patches of leukoplakia</li> <li>• Granular or Speckled erythroplakia</li> </ul>
<b>V. Differential Diagnosis</b>	<ul style="list-style-type: none"> <li>• Oral candidiasis</li> <li>• Oral histoplasmosis</li> <li>• Oral tuberculosis</li> <li>• Atrophic OLP</li> <li>• Lupus erythematosus</li> <li>• Pemphigus and pemphigoids</li> <li>• Haemangioma</li> <li>• Mucositis</li> <li>• Drug reaction</li> <li>• Median rhomboid glossitis</li> </ul>
<b>VI. Management</b>	<ul style="list-style-type: none"> <li>• Surgery → either by cold knife or by laser, is the recommended therapy.</li> <li>• Surgical excision may be used in lesions with severe epithelial dysplasia or carcinoma <i>in situ</i></li> <li>• Malignant transformation rates is very high (vary from 14% to 50%) → Early intervention advised</li> </ul>



White patches: Leukoplakia, Red patches: Erythroplakia

## ORAL LICHEN PLANUS

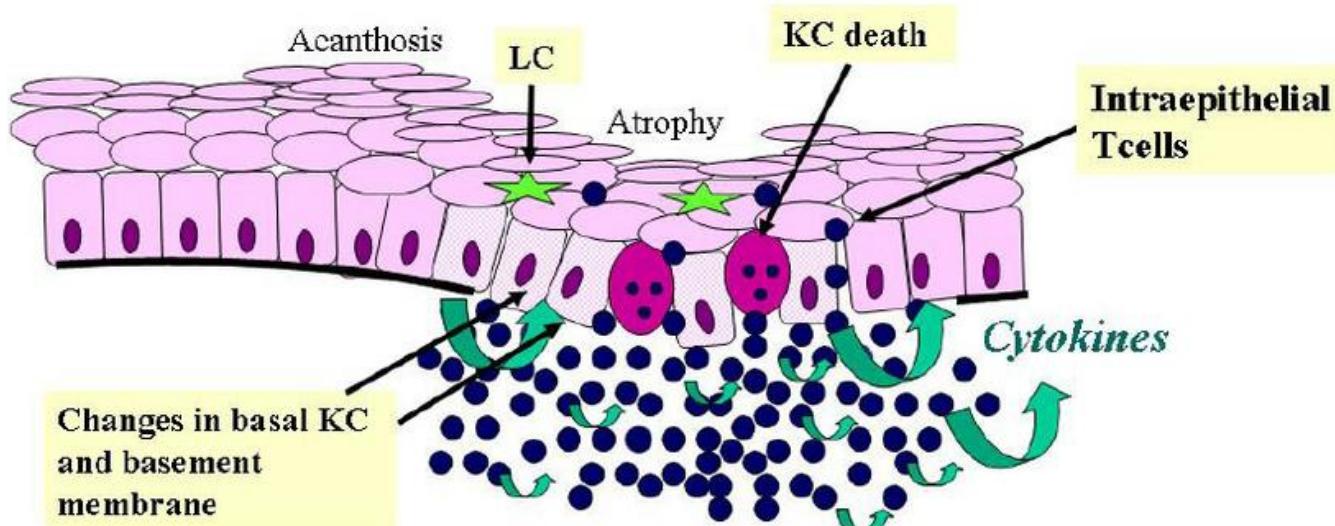
### I. Definition

- A common chronic immunologic inflammatory mucocutaneous disorder that varies in appearance from keratotic (reticular or plaque like) to erythematous and ulcerative, affecting the stratified squamous epithelium
- may affect skin, oral mucosa, genital mucosa, scalp, and nails

### II. Etiopathogenesis

- Both antigen-specific & non-specific mechanisms may be involved in pathogenesis of OLP

<b>Antigen-specific mechanisms</b>	<b>Non-specific mechanisms</b>
<ul style="list-style-type: none"> <li>• Antigen presentation by basal keratinocytes</li> <li>• Antigen-specific keratinocyte killing by CD8 + cytotoxic T-cells</li> </ul> <p>• These mechanisms may combine to cause</p> <ul style="list-style-type: none"> <li>➢ T-cell accumulation in superficial lamina propria</li> <li>➢ Basement membrane disruption</li> <li>➢ Intra-epithelial T-cell migration</li> <li>➢ Keratinocyte apoptosis</li> </ul>	<ul style="list-style-type: none"> <li>• Mast cell degranulation and matrix metalloproteinase (MMP) activation</li> </ul>



KC: Keratinocyte  
LC: Langerhans cell

### III. Clinical features

- Prevalence of OLP varies from 0.5% to 3%
- It mainly occurs among female
- Age of onset : 3<sup>rd</sup> to 6<sup>th</sup> decade
- Approx 1.2% - 5.3% lesions undergo malignant changes
- Lesions usually symmetrical
- Frequently affects buccal mucosa, tongue, gingiva, lip and palate
- Extra-oral mucosal involvements: anogenital area, conjunctivae, oesophagus/larynx

- ***On skin***

- ***On skin***
- Flat-topped purple polygonal & pruritic papular rash

- ***Oral Cavity***

- ***Oral Cavity***
- Asymptomatic Reticular → Wickham's striae
- discrete erythematous border
- Plaque-like → Resemble leukoplakia

- ***Types***

- Atrophic: Diffuse red patch, peripheral radiating white striae
- Erosive: Irregular erosion covered with a pseudo membrane
- Bullous: Small bullae / vesicles that may rupture easily

### IV. Histopathology

- 3 classic microscopic features of OLP
  - Overlying hyperkeratinisation
  - A band like layer of chronic inflammatory cells within underlying connective tissue
  - Liquefaction degeneration of basal cell zone (Civatte bodies)

### V. Investigations

- Oral biopsy
- Direct Immunofluorescence

### VI. Management

- Reticular type: is asymptomatic & treatment often unnecessary
- Erosive type presents significant management problems
- All patients should optimize oral hygiene

- Corticosteroids, is the treatment of choice

- - Eg: Fluocinonide or Clobetasol gel for 2 weeks, with 3months follow-up

- In symptomatic patients

- - With apparent contact dental factor:

- - Patch test with replacement of amalgam

- - In those with no apparent contact factor:

- - Topical or intralesional steroid - first line treatment.

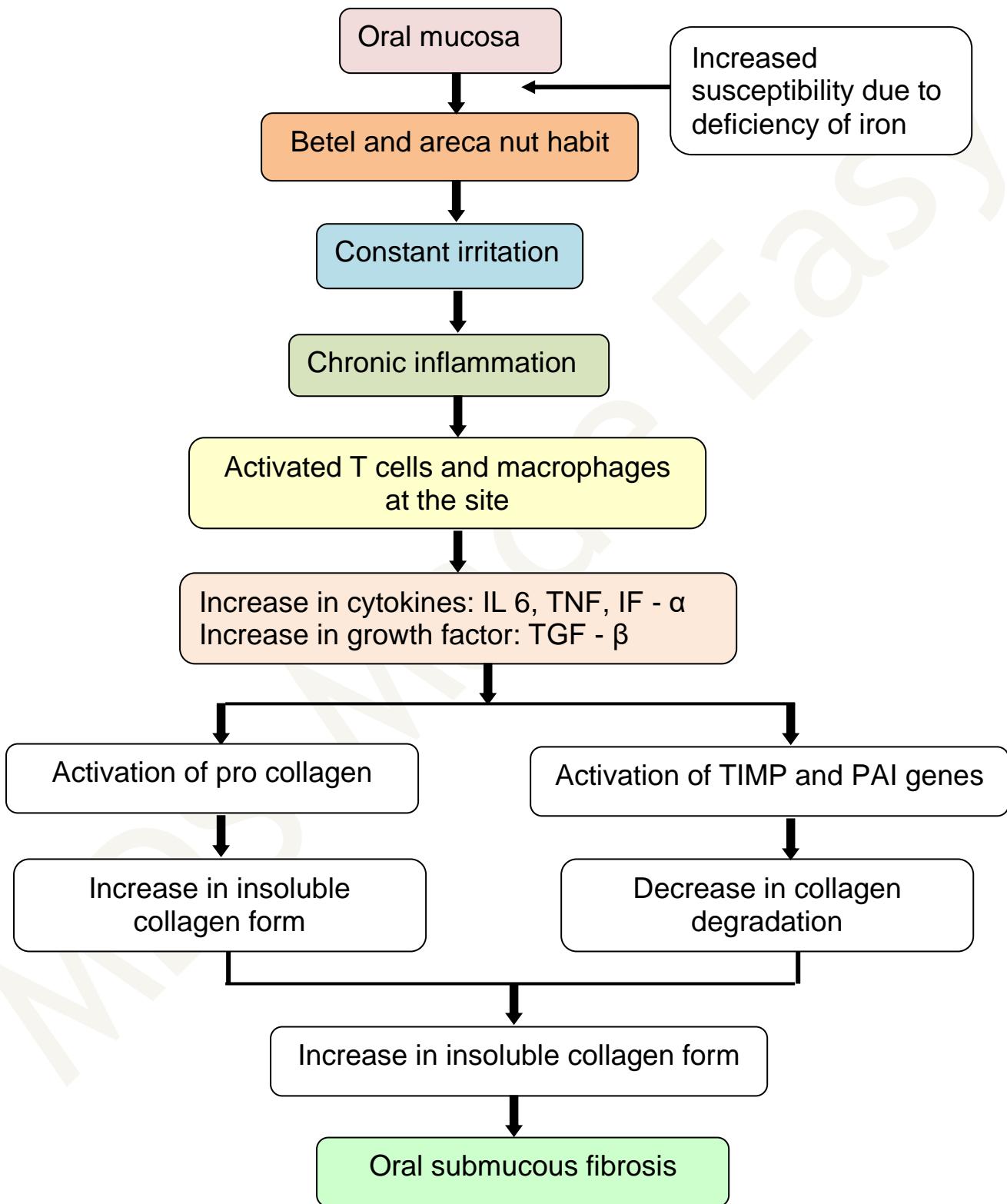
- - A short course of systemic steroid for more rapid control

## ORAL SUBMUCOUS FIBROSIS

- It is an insidious chronic disease affecting any part of the oral cavity and sometimes the pharynx.
- Although occasionally preceded by or associated with vesicle formation, it is always associated with juxta-epithelial inflammatory reaction followed by a fibro-elastic changes of the lamina propria with epithelial atrophy leading to stiffness of the oral mucosa and causing trismus and inability to eat.

## I. Etiopathogenesis

- Its etiology is not well-known and thought to be multifactorial
- Surgical treatments may be used to improve mouth opening and movements.



## II. Clinical features

- Common site: buccal mucosa, retromolar area, uvula, palate, etc
- Initially, pain and a burning sensation upon consumption of hot & spicy foods
- Vesicle & ulcers
- Excessive or reduced salivation & defective gustation
- Hearing loss
- Depapillation & atrophy of tongue and uvula
- Depigmented & loss of stippling over gingiva
- Nasal tone in the voice
- Difficulty in deglutition Impaired mouth movements (eg, eating, whistling, blowing, sucking)
- Age predilection : second and third decade

### Mortality/morbidity

- High rate of morbidity → progressive inability to open mouth, resulting in difficulty eating & consequent nutritional deficiencies
- Significant mortality rate - can transform into oral cancer (SCC)

### Clinical stages

i. Stage 1	<ul style="list-style-type: none"> <li>• Stomatitis includes erythematous mucosa, vesicles, mucosal ulcers, melanotic mucosal pigmentation &amp; mucosal petechiae</li> </ul>
ii. Stage 2	<ul style="list-style-type: none"> <li>• Fibrosis occurs in ruptured vesicles &amp; ulcers when they heal, hallmark of this stage</li> </ul>
iii. Stage 3	<ul style="list-style-type: none"> <li>• Sequela of OSMF</li> <li>• Speech and hearing deficits may occur because of involvement of the tongue and the eustachian tubes</li> </ul>

### Clinical and Functional staging (Ranganathan et al):

i. Group I	<ul style="list-style-type: none"> <li>• Only Symptoms,</li> <li>• Normal mouth opening</li> </ul>
ii. Group II	<ul style="list-style-type: none"> <li>• Mouth opening &gt; 20mm</li> </ul>
iii. Group III	<ul style="list-style-type: none"> <li>• Mouth opening &lt; 20mm</li> </ul>
iv. Group IV	<ul style="list-style-type: none"> <li>• Limited mouth opening</li> <li>• precancerous &amp; cancerous changes throughout mucosa</li> </ul>

### III. Histopathology

- Hyperkeratinized, atrophic epithelium with flattening & shortening of rete pegs
- Nuclear pleomorphism & severe inter-cellular edema
- Finely fibrillar collagen & increased fibroblastic activity in early stage showing dilated & congested blood vessels with areas of haemorrhage
- Advanced stage shows “homogenization” and “hyalinization” of collagen fibers (important feature)
- Degeneration of muscle fibers and chronic inflammatory cell infiltration in the connective tissue

### IV. Management

<b>1. Behavioural therapy</b>	<ul style="list-style-type: none"> <li>• Patient counselling</li> <li>• Cessation of habit</li> </ul>
<b>2. Medical therapy</b>	<ul style="list-style-type: none"> <li>• Hyaluronidase: topically, shown to improve symptoms more quickly than steroids alone</li> <li>• Mild cases: intralesional inj. Dexamethasone 4 mg to reduce symptoms</li> <li>• Steroids, interferon gamma, placental extracts, immunized milk, pentoxifylline, buFlomedil hydrochloride, nylidrin, isoxsuprine, <math>\beta</math>-carotene, lycopene, vitamins, micronutrients, collagenase, hyaluronidase, chymotrypsin, and aloevera have been used with varying success rates</li> </ul>
<b>3. Physical therapy</b>	<ul style="list-style-type: none"> <li>• Physical exercise regimen</li> <li>• Splints or other mouth opening devices</li> <li>• Microwave diathermy</li> </ul>
<b>4. Surgical therapy</b>	<ul style="list-style-type: none"> <li>• Splitting / excision of fibrous bands: scalpel or laser</li> </ul>

- Recent study: intralesional inj. of gamma interferon 3 times a week, improves mouth opening significantly

## ACTINIC CHEILITIS

- Actinic cheilitis is a potentially malignant disease of the lip caused by exposure to solar radiation
- Commonly seen the surface area of the lower lip

<b>I. Etiology</b>	<ul style="list-style-type: none"> <li>In addition to solar rays, tobacco use, lip irritation, poor oral hygiene, and ill-fitting dentures may play a role in the development of actinic cheilitis.</li> </ul>
<b>II. Clinical Features</b>	<ul style="list-style-type: none"> <li>Males &gt; Females</li> <li>Early stages: erythema and edema</li> <li>Late stages: diffuse scaling, thickened epithelium with small greyish-white plaques, inflammatory areas (erythroleukoplakia), and linear fissures</li> <li>Malignant transformation rate : 1.4% to 36%</li> </ul>
<b>III. Histopathology</b>	<ul style="list-style-type: none"> <li>Hyperplasia, acanthosis or atrophy of the epithelium</li> <li>Thickening of the keratin layer,</li> <li>Mild to severe dysplasia may be present</li> <li>Basophilic degeneration of collagen fibers, known as solar elastosis in connective tissue</li> </ul>
<b>IV. Management</b>	<ul style="list-style-type: none"> <li>5-fluorouracil</li> <li>Scalpel vermillionectomy</li> <li>Chemical peel</li> <li>Electrosurgery, cryosurgery, CO2 laser</li> <li>Imiquimod</li> <li>Photodynamic treatment</li> <li>Diclofenac 0.3% gel for symptomatic relief</li> </ul>

## OTHER CONDITIONS

### I. Some inherited cancer syndromes

- In patients with xeroderma pigmentosum and Fanconi's anemia, incidence of oral cancer has increased

### II. Immunodeficiency

- In patients with prolonged use of immunosuppressive drugs after solid organ transplants, human immunodeficiency virus-patients, and chronic graft versus

host disease after stem cell transplantation are the patients in risk group for oral cancer development

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*Please Give Your Feedback on this Answer*

**Classify analgesic. Discuss in detail about the action of NSAIDs explaining the mechanism of actions. what are the advantages and disadvantages of using CoX2 selective inhibitors (10M)**

**Anti inflammatory and analgesics drugs used in prosthodontics (7M)**

### CONTENTS/SYNOPSIS

- Introduction
- Types
  - NSAIDs
  - Opioid analgesics
- Mechanism of action of NSAIDs
- Mechanism of action of opioid analgesics
- Classification of NSAIDs
  - Non-selective COX inhibitors
    - Salicylates
    - Propionic acid derivatives
    - Anthranilic acid derivatives
    - Aryl acid derivatives
    - Oxicam derivatives
    - Pyrrolo-pyrrole derivatives
    - Indole derivatives
  - Preferential COX-2 inhibitors
  - Selective COX-2 inhibitors
  - Analgesics-antipyretics with poor anti-inflammatory action
- Pharmacologically useful actions of NSAIDS
- Adverse effects of NSAIDS
- Classification of opioid analgesics
  - Natural alkaloids
  - Semi-synthetic opiates
  - Synthetic opioids
- Pharmacologically useful actions of opioids
- Combination drugs
- Co- analgesics
- Considerations in dentistry
  - Effects of NSAIDS on wound healing

- Effects of NSAIDS on bone healing
- References

MDS Made Easy

## INTRODUCTION

- Pain is an ill-defined, unpleasant sensation, usually evoked by an external or internal noxious stimulus
- Pain is a warning signal and is primarily protective in nature, but causes discomfort and suffering; may even be unbearable
- Dental pain is usually acute in nature and is the most important symptom for which patient comes to dentist
- Analgesics are defined as the drug that selectively relieves pain by acting in the CNS or on peripheral pain mechanisms, without significantly altering consciousness

## TYPES

Analgesics can be broadly classified into 2 types-

### I. **Non-steroidal anti-inflammatory drugs (NSAIDs)**

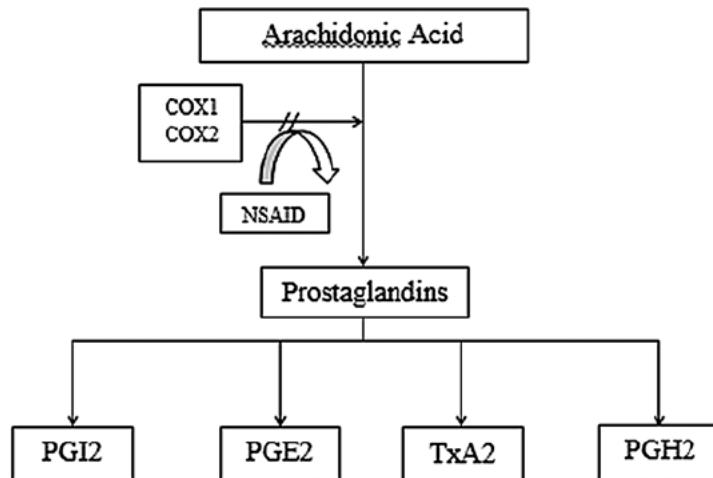
Synonyms: Non-narcotic  
Non opioid  
Aspirin like analgesics

### II. **Opioid analgesics**

Synonyms: Narcotic  
Opioid  
Morphine like analgesics

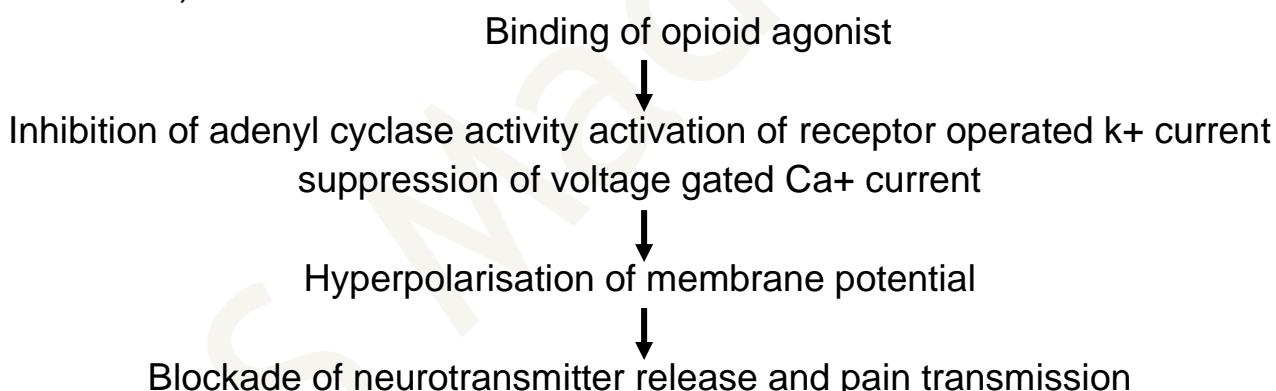
## MECHANISM OF ACTION OF NSAIDs

- NSAIDs act by inhibiting the action of cyclo-oxygenase enzyme preventing the synthesis of prostaglandins, prostacyclins and thromboxane.
- Prostaglandins, Prostacycline (PGI<sub>2</sub>) and Thromboxane A<sub>2</sub>(TXA<sub>2</sub>) are produced from Arachidonic acid by the enzyme cyclo-oxygenase which exists in a constitutive (COX-1) and an inducible (COX-2) isoforms.
- Prostaglandins, prostacyclins and thromboxane are mediators of inflammation and also produce symptoms of pain.
- Most NSAID's inhibit COX-1 and COX-2 non-selectively.
- Some selective COX-2 inhibitors are included as newer NSAIDs.



## MECHANISM OF ACTION OF OPIOID ANALGESICS

- Opioid analgesics relieve inflammatory pain by reducing activity in sensitized nociceptive primary afferent fibres and affecting immune cell activity.
- In the spinal cord, opioids produce presynaptic inhibition of nociceptive afferents (by inhibition of calcium entry) and postsynaptic inhibition of nociceptive dorsal horn cells (via a G protein-coupled K<sup>+</sup> conductance increase).



## CLASSIFICATION OF NSAIDs

### I. Non selective COX inhibitors (conventional NSAID's)

#### 1. Salicylates

Example: Aspirin

- Aspirin is acetylsalicylic acid. It is a derivative of salicylic acid.
- Salicylic acid was found in the bark of the willow tree and was used as an analgesic and anti-pyretic for treating malaria.
- Aspirin is one of the oldest analgesic-anti inflammatory drugs and is still widely used.

## 2. Propionic acid derivatives

Examples: Ibuprofen, Naproxen, Ketoprofen, Flurbiprofen

- Ibuprofen is the first introduced member of this class
- Anti-inflammatory efficacy of this group is lower than aspirin
- They Inhibit PG synthesis
- Naproxen is the most potent propionic acid derivative.

## 3. Anthranilic acid derivatives

Example: Mephenamic acid

- Inhibits COX also antagonizes certain actions of Prostaglandins.
- Exerts peripheral as well as central analgesic action.

## 4. Aryl-acid derivatives

Example: Diclofenac sodium

- Inhibits Prostaglandin synthesis
- Has short lasting anti platelet action
- Adverse effects are mild

## 5. Oxicam derivatives

Examples: Piroxicam, tenoxicam

- Long acting NSAID with potent anti-inflammatory and good analgesic-anti pyretic action.
- Reversible inhibitor of COX
- Metabolized in liver by hydroxylation and glucuronide conjugation

## 6. Pyrrolo-pyrrole derivative

Example: Ketorolac

- Novel analgesic with potent analgesic and modest anti inflammatory activity
- Used in post operative, dental and acute, musculoskeletal pain
- Also used for pain due to bony metastasis

## 7. Indole derivative

Example: Indomethacin

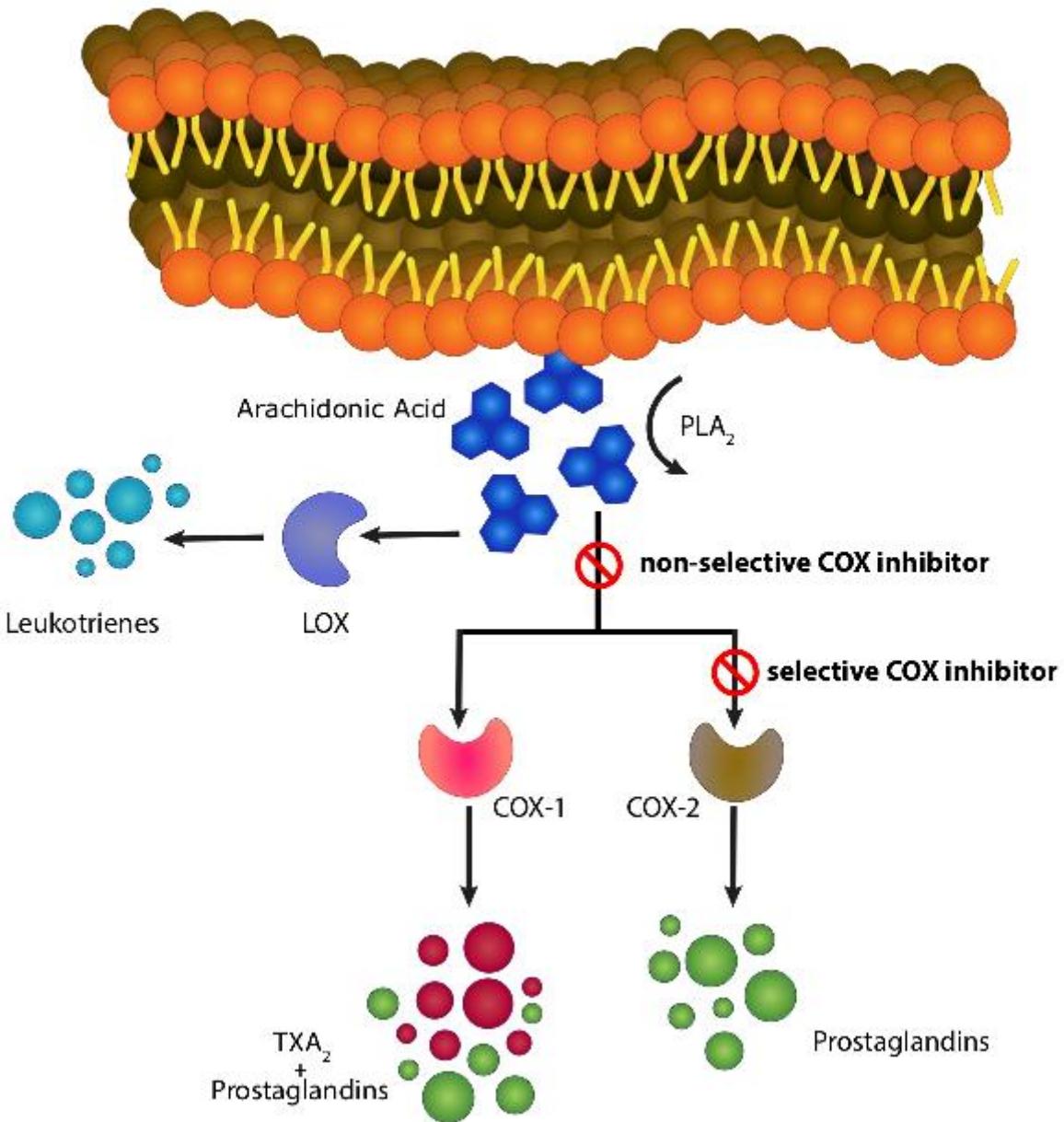
- Potent anti-inflammatory with prompt antipyretic action.
- High incidence of GI and CNS side effects are noted.

<i>i.</i> <i>Uses</i>	<i>ii.</i> <i>Adverse effects</i>	<i>iii.</i> <i>Contraindications</i>
<ul style="list-style-type: none"> <li>• Commonly used for headache and musculoskeletal pain</li> <li>• Best drug as antipyretic</li> <li>• Can be prescribed for all age groups</li> </ul>	<ul style="list-style-type: none"> <li>• It is a safe and well tolerated drug</li> <li>• Rarely nausea</li> <li>• High dosages may cause hepatic necrosis</li> </ul>	<ul style="list-style-type: none"> <li>• Patients who are allergic to aspirin</li> <li>• Peptic ulcers</li> <li>• Pregnant and breast feeding</li> <li>• Under anticoagulant therapy</li> <li>• With bleeding disorders</li> <li>• Chronic liver disease</li> </ul>
<i>iv.</i> <i>Pharmacokinetics</i>		
<ul style="list-style-type: none"> <li>• Well absorbed orally</li> <li>• Metabolism: Liver</li> <li>• Excretion: Kidneys</li> </ul>		

## II. Preferential COX-2 inhibitors

Examples: Nimesulide, Meloxicam, Nabumetone

- Relatively weak inhibitor of Prostaglandin synthesis.
- Used for short-lasting painful inflammatory conditions like
  - sports injuries
  - sinusitis and other ENT disorders
  - dental surgery
  - dysmenorrhea
  - fever and low backache
- Recently instances of fulminant hepatic failure have been reported with Nimesulide. So it has been banned in many parts of the world.



### III. Selective COX-2 inhibitors

Examples: Celecoxib, Rofecoxib, Valdecoxib, Etoricoxib

- Introduced over the past decade hence called as 'Newer NSAIDs'.
- Can be used in larger doses
- More safe, better tolerated than other NSAIDs and is equally efficacious.

i. Uses	ii. Pharmacokinetics
<ul style="list-style-type: none"> <li>• Osteoarthritis</li> <li>• Rheumatoid arthritis</li> <li>• Ankylosis spondylitis</li> <li>• Acute pain managements</li> </ul>	<ul style="list-style-type: none"> <li>• Slow absorption</li> <li>• Metabolism: Liver</li> <li>• Excretion: Kidney</li> </ul>

#### IV. Analgesics-antipyretics with poor anti-inflammatory action

- Para aminophenol derivative: Paracetamol (Acetaminophen)
- Pyrazolone derivatives: Metamizol (Dipyrone), Propiphenazone
- Benzoxazocine derivative: Nefopam

#### PHARMACOLOGICALLY USEFUL ACTIONS OF NSAIDS

- Analgesia
- Antipyretic
- Anti-inflammatory
- Prophylaxis in patients at risk of thromboembolism
- Anti-thrombotic
- Inhibiting platelet aggregation and clumping
- Acute rheumatic fever
- Rheumatoid arthritis
- Osteoarthritis
- Prophylaxis in Post myocardial patients
- Prophylaxis in Post stroke patients

#### ADVERSE EFFECTS

##### Gastro intestinal tract:

- Gastric irritation
- Erosions
- Peptic ulcerations
- Gastric perforations
- Esophagitis

##### Brain:

- Headache
- Mental confusion
- Behavioural disturbances
- Seizure precipitation

**Liver:** Raised transaminases, hepatic failure

##### Brain:

- Headache
- Mental confusion
- Behavioural disturbances

##### Blood:

- Bleeding
- Thrombocytopenia
- Hemolytic anemia
- Agranulocytosis

**Others:** Exacerbation of asthma, nasal polyposis, skin rashes, angioedema, pruritis

## CLASSIFICATION OF OPIOID ANALGESICS

### I. Natural opium alkaloids

- Morphine, codeine

### II. Semi synthetic opiates

- Diacetylmorphine (heroin), pholcodeine

### III. Synthetic opioids

- Pethidine (meperidine), fentanyl, methadone, dextropropoxyphene, tramadol

## PHARMACOLOGICALLY USEFUL ACTIONS OF OPIODS

### I. Analgesia

- Strong analgesic
- Nociceptive pain arising from peripheral pain receptors is better relieved than neurotic pain
- Reactions associated with intense pain like apprehension, fear, autonomic effects ... are also depressed

### II. Mood and subjective changes

- Calming effect
- Loss of apprehension, feeling of detachment, lack of initiative, mental clouding and inability to concentrate

## COMBINATION DRUGS

- More often than not combinations of analgesic, antipyretic and anti-inflammatory drugs are prescribed.
- These combination drugs counter act the side effects of each other while providing synergistic action.
- Some of the commonly used combination analgesics are-
  - Ibuprofen (400mg) + Paracetamol (325mg)

- Diclofenac (50mg) + Paracetamol (325mg)
- Aceclofenac (100mg)+ Paracetamol (325mg)
- Paracetamol (650mg) + Caffeine (50mg)
- Tramadol (37.5 mg) + Paracetamol (325 mg)
- Pentazocin (15mg) + Paracetamol (500mg)
- Codeine (30mg) + Paracetamol (500mg)

### CO – ANALGESICS

- Co-analgesics are the drugs with analgesic potential.
- They are used to supplement the action of conventional analgesics.
- They also limit the side effects of analgesics.
- Also known as adjuvant analgesics.
- Commonly used co-analgesics are:
  - Steroids
  - Anti- arrhythmic
  - Anti- depressants
  - Anti -epileptics
  - Serotonin reuptake inhibitors
  - Muscle relaxants

### CONSIDERATIONS IN DENTISTRY

I. Effects of NSAIDs on wound healing	II. Effects of NSAIDs on bone healing
<ul style="list-style-type: none"><li>• COX 2 inhibitors reduces the scar tissue formation</li><li>• Accelerates re-epithelialization</li><li>• Leads to uneventful wound healing</li></ul>	<ul style="list-style-type: none"><li>• Generally prostaglandins are produced by bone cells to have either formative or resorptive effects on bone remodeling.</li><li>• COX 2 regulates mesenchymal cell differentiation and helps bone healing and repair</li></ul>

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## Blood groupings (6M)

### CONTENTS/SYNOPSIS

- Introduction
- Landsteiner's law
- Blood grouping system
  - MN blood grouping system
  - Classical ABO blood grouping system
    - Biochemical basis of ABO blood group system
    - Population distribution of ABO blood groups
    - Inheritance of ABO blood groups
    - Appearance of antigens & antibodies
  - Rh blood grouping system
- Determination of blood group
- Applied aspects
  - Clinical applications of blood groups
  - Haemolytic disease of newborn
  - Donors & recipients
- References

## INTRODUCTION

- Agglutinogens – Antigens present on cell membrane of RBC
- Agglutinins – antibodies against Agglutinogens present in plasma.
- Agglutination – of RBC is reaction between these 2

## LANDSTEINER'S LAW

- If an Agglutinogens is present on surface of RBC corresponding agglutinins must be absent in plasma.
- If an Agglutinogens is absent on surface of RBC corresponding Agglutinins must be present in plasma.

## BLOOD GROUPING SYSTEM.

- 35 blood group systems are recognized

### Major blood group system

- based on Agglutinogens on cell membrane, present widely & causes severe transfusion reaction
  - ABO
  - Rh system

### Minor blood group system

- based on Agglutinogens but present in few populations & causes mild transfusion reaction.
  - MNS
  - P
  - Familial blood group system – found in few families  
Example: Bombay Lewis, Deigo, Kidd

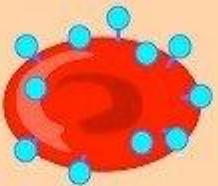
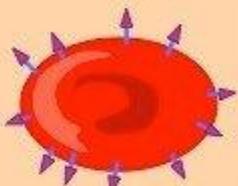
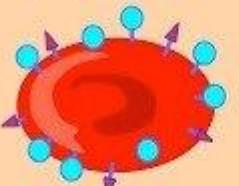
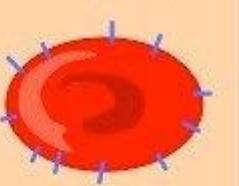
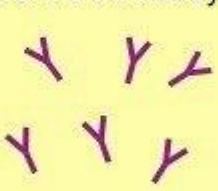
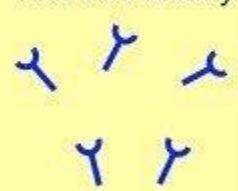
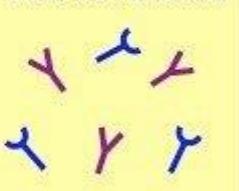
### I. M-N Blood group system

- This system was discovered by Land Steiner and Levine (1927)
- Antigens M and N are encoded by polymorphic genes GYPA and GYPB
- Types:
  - MM blood group
  - NN blood group
  - MN blood group

- Antigens Vs Antibodies
  - M and N antigens are weakly immunogenic for humans
  - Antibodies against M and N antigens are rare
  - Little clinical significance in blood transfusion

## II. Classical ABO Blood grouping system

- A & B Agglutinogens- these are complex oligosaccharides differing in terminal sugar
- Anti-A ( $\alpha$ ) and anti-B ( $\beta$ ) Agglutinins – IgM type & cannot cross placenta.
- Absence of these are determined by Landsteiner's law
- Act best at low temperature so called Cold Antibodies.
- Group Determination:
  - If A antigen is present, blood group will be **A**
  - If B antigen is present, blood group will be **B**
  - If both A and B antigens are present, blood group will be **AB**
  - If neither A nor B antigen is present, blood group will be **O**

	Type A	Type B	Type AB	Type O
Antigen (on RBC)	Antigen A 	Antigen B 	Antigens A + B 	Neither A or B 
Antibody (in plasma)	Anti-B Antibody 	Anti-A Antibody 	Neither Antibody	Both Antibodies 
Blood Donors	Cannot have B or AB blood  Can have A or O blood	Cannot have A or AB blood  Can have B or O blood	Can have any type of blood  Is the universal recipient	Can only have O blood  Is the universal donor

## 1. Biochemical basis of ABO blood group system

- A and B antigens are carbohydrate group bound to lipid
- The specificity of antigen based on terminal sugar of carbohydrate
- The one or two terminal sugar added to 'H' substance determine blood group
- IA allele add N-acetyl galactosamine, IB allele add terminal galactose
- Heterozygote 'IA' 'IB' add both sugar at various sites on RBCs surface
- The recessive allele 'I' does not add either sugar

## 2. Population distribution of ABO blood groups

Blood group	Percentage
A	20 %
B	30 %
AB	08 %
O	32 %

## 3. Inheritance of ABO blood groups

Phenotype	Genotype
A	AA, AO
B	BB, BO
AB	AB
O	OO

## 4. Appearance of antigens & antibodies

- Antigens A & B appears in 6th week of fetal life, at birth 1/5<sup>th</sup> of adult level & rises during puberty & adolescence.
- Antibodies are absent at birth, appear 10 - 15 days after birth, reach maximum at 10 yrs.

## III. Rh blood grouping system

Rh Antigens	Rh Antibodies
<ul style="list-style-type: none"> <li>• The name Rh was derived as these were first discovered in RBC of rhesus monkey.</li> <li>• Discovered by Landsteiner &amp; Weiner in 1940.</li> <li>• 3 types of Rh antigen, C, D&amp; E.</li> </ul>	<ul style="list-style-type: none"> <li>• No natural antibodies like ABO blood groups system</li> <li>• produced when Rh -ve individual is transfused with Rh +ve blood.</li> <li>• IgG type &amp; crosses placenta.</li> <li>• Warm Antibodies.</li> </ul>

Among these D is most common & causes severe transfusion reaction.

- Rh antigens are integral membrane proteins & not found in other tissues.

## DETERMINATION OF BLOOD GROUPS

### I. Principle

- ABO and Rh blood grouping system is based on agglutination reaction.
- Reaction between Antigens present on red blood cells and antibodies present in serum

### II. Procedure

Add one drop of anti-serum to blood



Mix the blood and anti-sera



Observe agglutination

### III. Results

- Agglutination observed when blood is mixed with anti-A reagent then blood group is “A”
- Agglutination observed when blood is mixed with anti-B reagent then blood group is “B”
- Agglutination observed when Anti-A and Anti-B reagents then blood group is AB
- If no Agglutination is observed then blood group is “O”
- If agglutination is observed with Anti Rh-D reagent, → “+ve” Rh factor; if not → “-ve” Rh factor.

## APPLIED ASPECTS

### I. Clinical applications of blood groups

- In blood transfusion.
- In Preventing Haemolytic Disease.
- In Paternity Disputes.
- In Medico legal Cases.
- In knowing Susceptibility to Diseases.

## II. Haemolytic disease of newborn

- Incompatibility of Rh blood groups between fetus & mother.

### 1. Mechanism

- Entrance of Rh +ve fetal RBC into Rh –ve mother's circulation during first pregnancy
- Production of Rh antibodies.
- Rh incompatibility reaction during second pregnancy.

### 2. Manifestations

- Erythroblastosis fetalis
- Anaemia.
- Icterus gravis Neonatorum.
- Jaundice
- Enlarged liver & spleen.
- Kernicterus – excess (<18mg%) bilirubin deposition in brain mainly basal ganglia
- Hydrops fetalis – Grossly oedematous fetus.

### 3. Prevention

- Injecting single dose of Rh antibodies (anti-D) to mother soon after child birth → active antibodies will not be formed by mother.

### 4. Treatment

- Replacement of baby's Rh+ve blood by Rh–ve blood → Exchange Transfusion.

## III. Donors & Recipients

### Universal donor

- Can donate blood to anyone
- Rh Negative.

### Universal recipient

- Can accept blood from anyone
- AB Rh positive

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## Deglutition phases (6M)

### CONTENTS/SYNOPSIS

- Introduction
- Phases of deglutition
  - Oral Phase
  - Pharyngeal Phase
  - Esophageal phase
- Receptive relaxation of stomach
- Nerve supply
  - Enteric Nervous system
  - Autonomic Nervous system
- Sensory aspects of ingestion & chewing
- Applied aspects
  - Dysphagia
  - Pharyngeal diverticulum
  - Gastroesophageal reflux disease (GERD)
- References

## INTRODUCTION

- Deglutition / Swallowing is the process by which food is transferred from the mouth to the esophagus.
- Begins as a voluntary activity
- Involves the tongue, soft palate, pharynx, esophagus, and 22 muscle groups
- Involves 3 phases/ stages

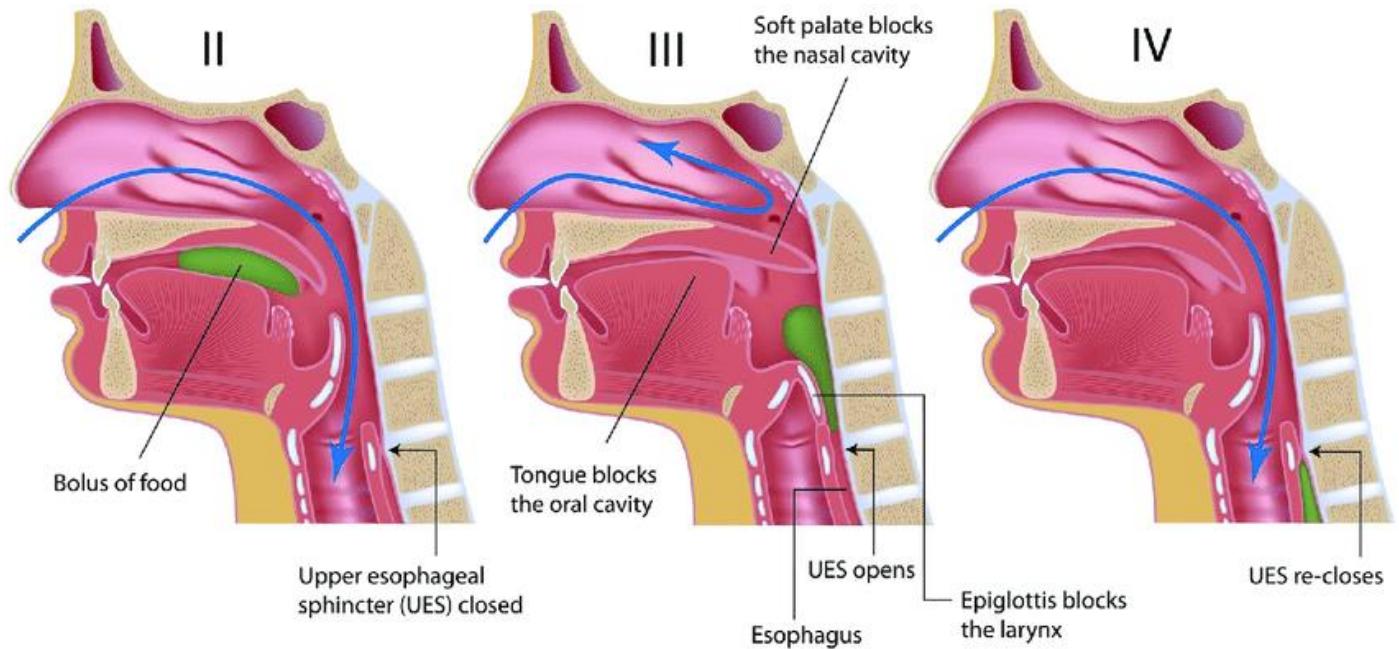
### Preparatory phase

- Oral phase :0.5 second
- Pharyngeal phase : 0.7 second
- Esophageal phase : 3 seconds (liquids) 9 seconds (solids)

## PHASES OF DEGLUTITION

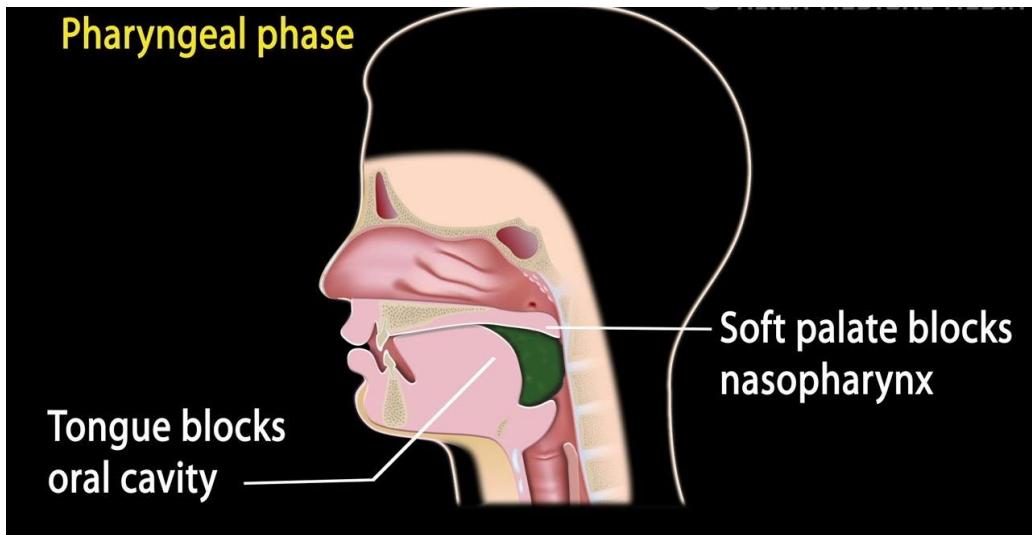
### I. Oral phase/ Buccal phase

- Voluntary in nature.
- Anterior part of the tongue is raised and pressed against the hard palate by the intrinsic muscles of the tongue, especially the superior longitudinal and transverse muscle.
- The movement takes place from anterior to posterior part of the oral cavity and pushes the food bolus into posterior part of the oral cavity.
- Hyoid bone moves upward and forward by the suprathyroid muscles.
- Soft palate closes down on to the back of the tongue to form a bolus.
- Posterior part of the tongue elevates upward and backwards by the Styloglossus and palatoglossal arches approximated palatoglossal, that pushes the bolus through the oropharyngeal isthmus to the oropharynx, and second stage begins



## II. Pharyngeal phase

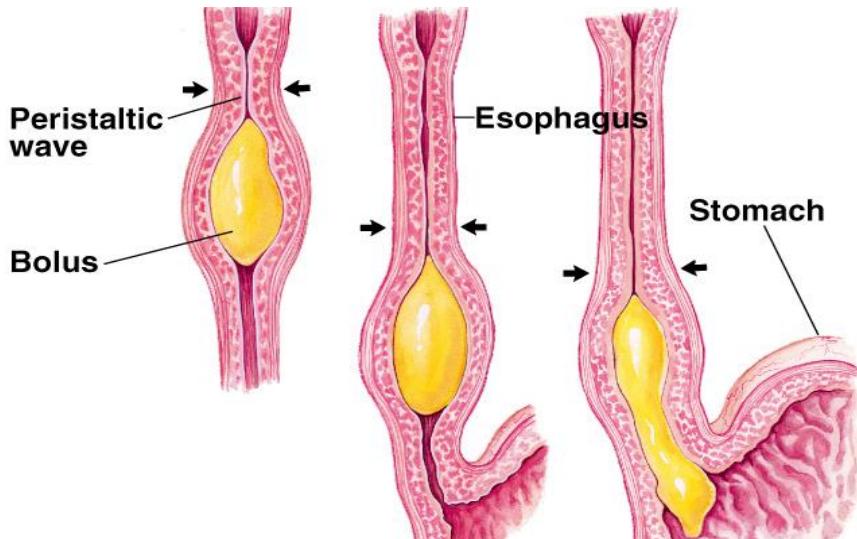
- Involuntary stage
- Soft palate elevates – levator muscles, tightened – tensor muscle approximate to the posterior pharyngeal wall by palatopharyngeal sphincter and upper part of the superior constrictor.
- The pharyngeal isthmus closes tightly to prevent food from ascending into the nasopharynx.
- At the same time → larynx and pharynx are drawn up, behind the hyoid bone, by stylopharyngeus, salpingopharyngeus, thyrohyoid and palatopharyngeus muscle.
- Aryepiglottic folds are approximated and arytenoid cartilage drawn up and forwards by the aryepiglottic, oblique arytenoid and thyro-artenoid muscles.
- Partly by gravity and partly by successive contraction of superior and middle constrictors, bolus slips over the epiglottis, the closed laryngeal inlet and posterior arytenoid surface into the lowest part of the pharynx.
- Passage is facilitated by palatopharyngi which shortens the pharynx by elevating it, on contraction they make the posterior pharyngeal wall into an inclined plane directed postero-inferior and under this the bolus descends.
- The aryepiglottic folds are kept tense and vertical by the backward pull of the posterior crico-arytenoids on the arytenoid cartilages and by muscles within them, assisted by the cuneiform cartilage which act as passive props.



### III. Esophageal Phase

- Wave-like muscular contractions produced by a series of localized reflexes in response to distention of wall by bolus → Peristalsis
- Two types of peristaltic movements:
  - 1° peristalsic waves
  - 2° peristaltic waves
- Circular smooth muscle contract behind, relaxes in front of the bolus.
- Followed by longitudinal contraction (shortening) of smooth muscle.
- Rate of movement: 2 - 4 cm/sec.
- After food passes into stomach, LES constricts.

<b>1° peristalsis waves</b>	<b>2° peristaltic waves</b>
<ul style="list-style-type: none"> <li>• Continuation of a peristaltic wave</li> <li>• Begins in pharynx &amp; spreads into esophagus</li> <li>• Passes in 8-10 sec</li> </ul>	<ul style="list-style-type: none"> <li>• Results from the distention of esophagus</li> <li>• Begins if the 1° wave failed to push the food down</li> </ul>



### **Tertiary contractions**

- Tertiary contractions are non-peristaltic because they occur simultaneously over a long segment of the oesophagus.
- May occur in response to a swallow or oesophageal distension, or they may occur spontaneously.

### **RECEPTIVE RELAXATION OF STOMACH**

- As the waves of peristalsis pass through esophagus to stomach, a wave of relaxation precedes the peristalsis, which transmitted through myenteric inhibitory neurons.
- Function of lower esophageal sphincter (Gastroesophageal sphincter)
  - Above the junction of esophagus with stomach by 3cm.
  - Remains tonic and constricted.
  - Peristaltic swallowing wave passes down esophagus → receptive relaxation of gastro-esophageal sphincter → allow food easily to stomach.
  - Sphincter does not relax satisfactorily → condition called achalasia.

### **NERVE SUPPLY**

#### **I. Enteric Nervous system (ENS)**

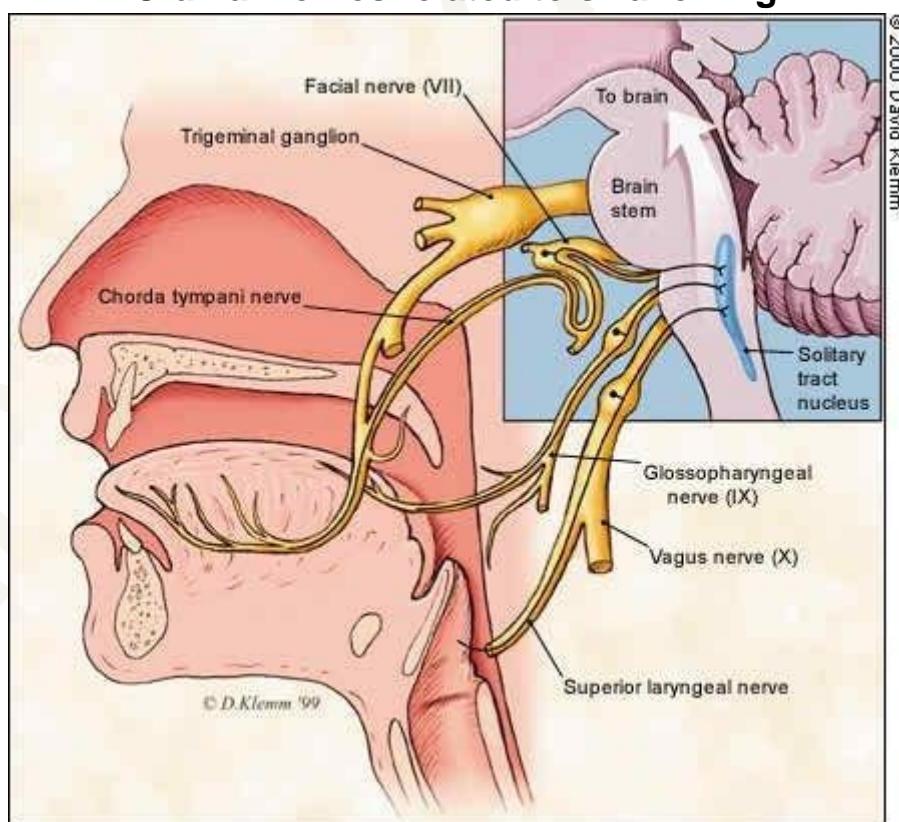
- The neurons of the ENS are arranged into two plexuses: myenteric plexus and submucosal plexus .
- The myenteric plexus or plexus of Auerbach, is located between the longitudinal and circular smooth muscle layers of the muscularis

The submucosal plexus or plexus of Meissner, is found within the submucosa.

- The plexuses of the ENS consist of
  - Motor neurons
  - Interneuron's
  - Sensory neurons

<b>Motor neurons of the myenteric plexus</b>	<b>Motor neurons of the submucosal plexus</b>
<ul style="list-style-type: none"> <li>• Supply the longitudinal and circular smooth muscle layers of the muscularis,</li> <li>• Mostly controls GI tract motility, particularly the frequency and strength of contraction of the muscularis</li> </ul>	<ul style="list-style-type: none"> <li>• Supply the secretory cells of the mucosal epithelium</li> <li>• control the secretions of the organs of the GI tract</li> </ul>

### Cranial nerves related to swallowing



## II. Autonomic nervous system

- The vagus (X) nerves supply parasympathetic fibers to most parts of the GI tract.
- Stimulation of the parasympathetic nerves that innervate the GI tract causes an increase in GI secretion and motility by increasing the activity of ENS neurons.
- Sympathetic nerves that supply the GI tract cause a decrease in GI secretion and motility by inhibiting the neurons of the ENS.
- Emotions such as anger, fear, and anxiety may slow digestion because they stimulate the sympathetic nerves that supply the GI tract.

## SENSORY ASPECTS OF INGESTION AND CHEWING

- Sensory functions of the mandibular nerve are important in sensing how hard the masticatory muscles must contract in order to chew effectively without damaging the teeth and gums.
- This proprioceptive information is carried to the mesencephalic nucleus of the trigeminal nerve and then to other brain stem nuclei.
- The consistency of the food is sensed by branches of the mandibular nerve → when appropriate the bolus is propelled backwards on to the posterior (glossopharyngeal) portion of the tongue and swallowing begins.

## APPLIED ASPECTS

### I. Dysphagia

- Defined as a sensation of “sticking” or obstruction of the passage of food through the mouth, pharynx, or oesophagus.
- Dysphagia caused by a large bolus or luminal narrowing is called mechanical dysphagia.
- Dysphagia due to weakness of peristaltic contractions or to impaired degluttitive inhibition causing non-peristaltic contractions and impaired sphincter relaxation is called motor dysphagia.
- Aphagia signifies complete oesophageal obstruction.
- Odynophagia means painful swallowing.
- Globus pharyngeus is the sensation of a lump lodged in the throat.

### II. Pharyngeal diverticulum or Killian's dehiscence

- Killian's dehiscence is a weak part of pharynx in the posterior wall covered by single sheet of thyropharyngeus muscle,
- Pharyngeal diverticulum formed by out pouching of the dehiscence.
- Attributed to neuromuscular incoordination may be due to fact that different nerve

supply of inferior constrictor

- Propulsive thyropharyngeus: pharyngeal plexus
- Splincteric cricopharyngeus: recurrent laryngeal Nerve

### III. Gastroesophageal reflux disease (GERD)

- If the lower oesophageal sphincter fails to close adequately after food has entered the stomach, the stomach contents can reflux into the inferior portion of the oesophagus.
- Hydrochloric acid from the stomach contents can irritate the oesophageal wall, resulting in a burning sensation that is called heart burn

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*Please Give Your Feedback on this Answer*

**Describe haemostasis. Add a note on local approaches to stop excess bleeding after implant surgical procedures. (20M)**

## CONTENTS/SYNOPSIS

- Introduction
- Types of hemorrhage
  - Primary hemorrhage
  - Reactionary hemorrhage
  - Secondary hemorrhage
- Haemostasis process
  - Vasoconstriction
  - Formation of temporary haemostatic plug formation
    - Platelet adhesion
    - Platelet activation
    - Platelet aggregation
    - Formation of temporary haemostatic plug
    - Inhibition of further plug formation
  - Formation of definitive haemostatic plug formation
    - Coagulation of blood
    - Clotting factors
- Haemostatic agents
  - Properties
  - Classification
    - Active haemostatic agents
      - ✓ Thrombin
      - ✓ Floseal
      - ✓ Sealants
    - Passive haemostatic agents
      - ✓ Collagen based products
      - ✓ Cellulose based products
      - ✓ Gelatin based products
      - ✓ Polysaccharide hemospheres
  - Newer haemostatic agents
- Conclusion
- References

## INTRODUCTION

- Bleeding may occur during or post surgery which if uncontrolled leads to serious life threatening consequences.
- It may compromise the visibility of operating field.
- The source of bleeding can be either hard or soft tissue and is classified into arterial, venous and capillary bleeding.
- In major oral and maxillofacial, periodontal and implant surgical procedures electrocautery and suture ligatures are commonly used to control bleeding.
- Local haemostatic agents are also one source of controlling the bleeding by improving the natural clotting process

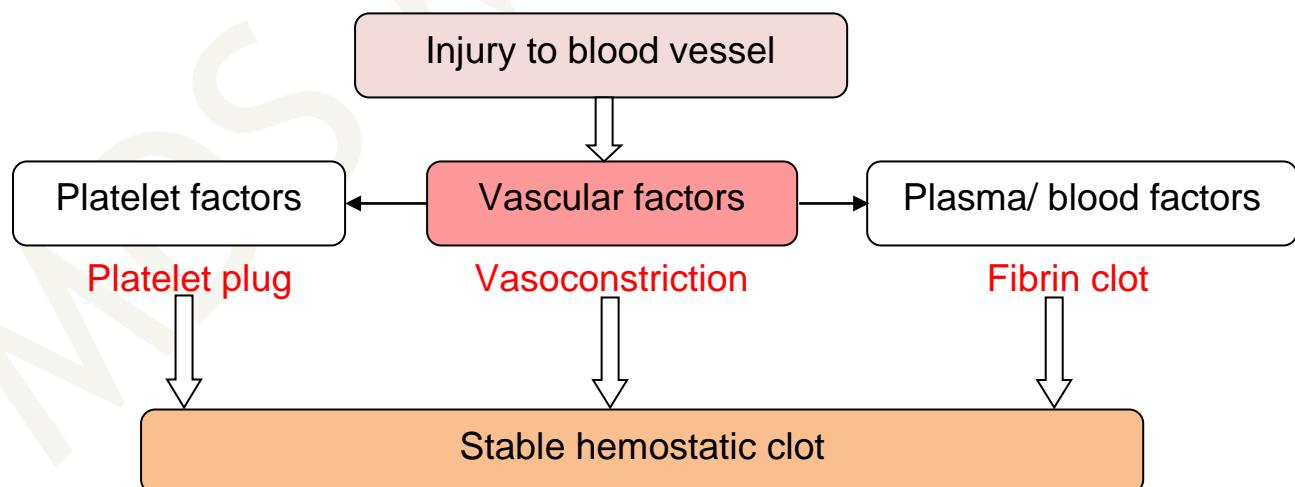
## TYPES OF HEMORRHAGE

The classification of hemorrhage following minor oral surgical procedures are:

I. Primary hemorrhage	II. Reactionary hemorrhage	III. Secondary hemorrhage
<ul style="list-style-type: none"> <li>• Bleeding occurring at the time of surgery</li> </ul>	<ul style="list-style-type: none"> <li>• Bleeding that occurs 2 - 3 hours post surgery</li> </ul>	<ul style="list-style-type: none"> <li>• Bleeding that occurs from the day of surgery till 14 days.</li> </ul>

## HAEMOSTASIS

- Spontaneous arrest or stoppage of bleeding from injured blood vessel by physiological process. There are 3 processes:



### I. Vasoconstriction

- Immediate constriction of damaged blood vessels is caused by vasoconstrictors released by endothelium cells which leads to temporary decrease in flow of blood within the injured vessel

## II. Formation of temporary haemostatic plug formation

### 1. Platelet adhesion

- After injury, platelets contacts with collagen & damaged endothelium
- Swell, becomes irregular & protrudes Pseudopodia
- Contractile proteins contracts & releases granules
- Platelets becomes sticky & adhere to collagen

### 2. Platelet activation

- Platelets secretes ADP & Thromboxane A2 which activates other platelets and cycle continues

### 3. Platelet aggregation

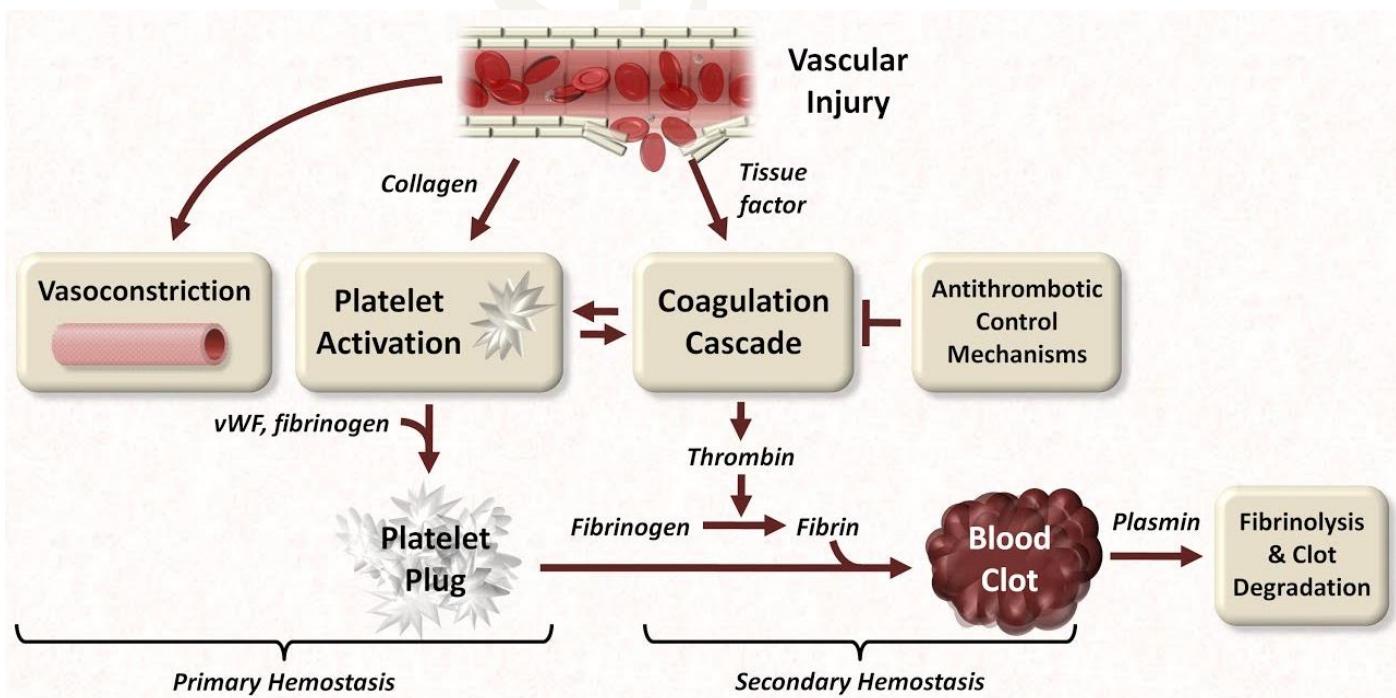
- Activated sticky platelets stick to each other & forms Aggregation
- It is also increased by Platelet Activating Factor (PAF) released by neutrophils, monocyte & platelets cell membrane lipids

### 4. Formation of temporary Haemostatic plug

- Platelet adhesion – Platelet aggregation – Fairly loose plug

### 5. Inhibition of further plug formation

- Prostacycline from membrane phospholipids
- Inhibit Thromboxane formation



### III. Formation of Definitive haemostatic plug formation

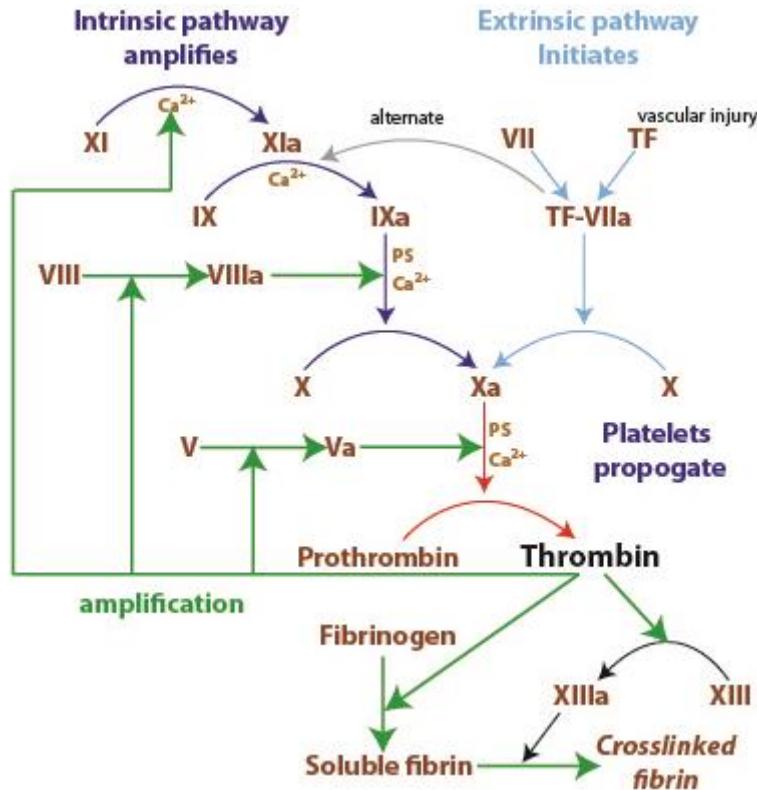
- Temporary plug converted to definitive plug by process of blood coagulation which results in formation of tight unyielding seal

#### 1. Coagulation of blood

- During the platelet plug formation, collagen and tissue factors which are exposed causes a series of reaction.
- Also known as coagulation cascade which ends in the formation of fibrin polymer
- The fibrin protein mesh helps in stabilization of platelet plug to become a blood clot
- Clotting cascade has two pathways

<i>i. Intrinsic pathway</i>	<i>ii. Extrinsic pathway</i>
<ul style="list-style-type: none"><li>Contact activation pathway</li><li>Activates collagen that is exposed at the site of injury and binds with factor XII to initiate this coagulation cascade</li></ul>	<ul style="list-style-type: none"><li>Tissue factor pathway</li><li>Stimulated by tissue factor which is exposed by the tissue injury and factor VII activation</li></ul>

- The two pathways later merges into one common pathway where thrombin converts fibrinogen to fibrin and then final clot formation takes place



## 2. Factors involved in blood coagulation

- Factor 1: Fibrinogen
- Factor 2: Prothrombin
- Factor 3: Thromboplastin
- Factor 4: Calcium
- Factor 5: Labile factor / Proaccelerin
- Factor 6: Unassigned
- Factor 7: Stable factor / Proconvertin
- Factor 8: Anti-haemophilic factor A / Anti-haemophilic globulin
- Factor 9: Christmas factor/ Anti-haemophilic factor B/ Plasma thromboplastin component
- Factor 10: Stuart- Prower factor
- Factor 11: Plasma thromboplastin antecedent / Anti-haemophilic factor C
- Factor 12: Hageman factor/ Glass factor / Contact factor
- Factor 13: Fibrin stabilizing factor / Fibrinase / Laki Lorand factor

## HEMOSTATIC AGENTS

A hemostatic agent is a substance used to promote hemostasis.

### I. Ideal properties of hemostatic agent

- Very effective
- Be able to breakdown its metabolic products
- Biocompatible

- Classification
- Affordable

## II. Classification

- Local hemostatic agents are classified into
  - Passive agents
  - Active agents

Sr.no	Passive hemostatic agents	Active hemostatic agents
1	Collagen-based products Microfibrillar collagen (Avitene) Absorbable collagen hemostat sponge (Helistat) Colla-Cote, Colla-Tape, Colla-Plug.	Thrombin
2	Cellulose-based products Oxidized regenerated cellulose (Surgicel) ActCel and Gelitacel	FloSeal (flowable hemostatic agent)
3	Gelatin-based products Gelfoam	Sealants Fibrin sealant (tisseel)
4	Polysaccharide hemospheres	Albumin derived hemostat (bioglue)

### 1. Passive agents

- Passive agents are commonly used as first line agents
- They form a lattice like physical matrix which adheres to the bleeding site and activates the extrinsic pathway, which provides a platform around which platelets aggregate to form blood clot.
- Used for patients with intact coagulation cascade

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Easily available and inexpensive</li> <li>• No requirement of special storage</li> <li>• Effective in heavy bleeding sites (greater absorption capacity)</li> </ul>	<ul style="list-style-type: none"> <li>• Tendency to expand to a greater volume on contact with bodily fluids, hence recommended to use in smaller quantities.</li> <li>• May compress surrounding vital structures like vessels, nerves.</li> </ul>

#### i. Collagen based products

- Derived from either tendon or bovine dermal collagen
- Non toxic and non pyrogenic
- **Example:** Microfibrillar collagen (Avitene), Absorbable collagen hemostat sponge (Helistat)

*ii. Cellulose based products*

- Derived from plant based cellulose (alpha)
- Available as white, absorbable, knitted fabric
- Can be used for single or multiple sheets with high and lower densities
- Hemostasis is by mechanical pressure
- **Example:** Surgicel, Acticel, Gelitacel

*iii. Gelatin based products*

- Derived from purified pork skin gelatin
- Available in the form of films, gelatin sponges
- Indicated in post operative bleeding (extractions, periodontal surgeries)
- Better than collagen based derivates

*iv. Polysaccharide hemospheres*

- Derived from vegetable starch
- Indicated to control smaller bleeding sites (arterial, venous and capillary)
- Mechanism is by hydrophilic effect
- Do not initiate clotting cascade, instead simulates clot formation

## 2. Active haemostatic agents

- Have biologic activity and participates in the clotting cascade directly
- They are manufactured with a combination of passive agents to provide an active product.
- **Example:** Thrombin, Floseal (flowable hemostatic agent)

### Sealants

- Mechanism of action is by forming a barrier which makes any liquid impenetrable
- Indicated in patients with insufficient fibrinogen to form a blood clot
- Contraindicated in patients with sensitivity to bovine
- Types of sealants are:

- Fibrin sealants,
- PEG polymers,
- Albumin with glutaraldehyde
- Cyanoacrylate sealant

### III. Newer haemostatic agents

- QuikClot (Inorganic hemostat)
- Polysaccharide based hemostats
- Chitosan based products
- Poly-N-acetyl glucosamine-based materials
- Bone hemostats like Bone wax, Ostene (water soluble alkylene oxide copolymers)

### CONCLUSION

- Local hemostatic agents are very helpful in controlling the bleeding areas especially during oral surgical procedures to provide a better operating field and avoid complications due to excessive bleeding.

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*Please Give Your Feedback on this Answer*

**Explain saliva and its role in prosthodontics. (7M) (6M)**

**Discuss physiology of saliva and its effect on retention of complete dentures (20M).**

**Saliva and artificial saliva (7M) (6M)**

**Mechanism of salivary secretion (7M)**

**Functions of saliva (7M)**

### CONTENTS/SYNOPSIS

- Introduction
- Properties of saliva
- Formation of saliva
- Physiology of salivary secretion
  - Initial Formation Stage
  - Modification Stage
- Composition of saliva
- Functions of saliva
  - Defense
  - Digestion
  - Protective function
  - Lubrication function
  - Buffering function
  - Excretory function
- Factors affecting the flow of saliva
  - Hydration
  - Variations in circadian rhythms
  - Smoking
  - Medications
  - Gustatory stimulation
- Clinical consideration
- Prosthodontic considerations
  - Prosthodontic management of xerostomia
  - Prosthodontic management of Sialorrhea
  - Denture base extension

- Consistency and amount of saliva
- Denture retention
- Artificial salivary substitutes
- References

MDS Made Easy

## INTRODUCTION

- Saliva is a complex fluid, produced by the salivary glands.
- Human saliva consist of organic and inorganic components and plays an essential role in mastication, in bolus formation, acts as a lubricant in swallowing, helps in speech production and protecting the mucosal surfaces of the oral cavity from desiccation.
- According to Stedman's Dictionary: Saliva is a clear, tasteless, odourless slightly acidic (pH6.8), viscid fluid, consisting of secretions from the parotid, sublingual and submandibular salivary gland and the mucous glands of the oral cavity.

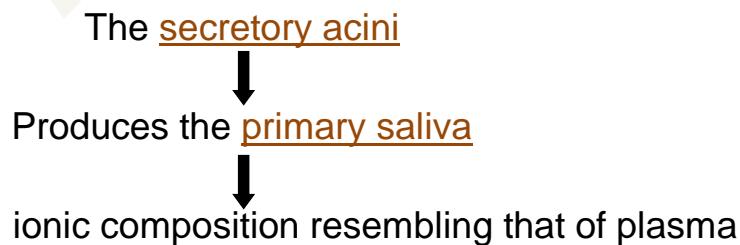
## PROPERTIES OF SALIVA

- **Volume:** Daily secretion ranges between 800 -1500mL
- Contribution by each major salivary gland is:

- Parotid Gland: 25%
- Submandibular Gland: 70%
- Sublingual Gland: 5%

- **pH:** 6.0 - 7.0
- **Specific Gravity:** 1.002 - 1.012
- **Tonicity:** Hypotonic to plasma.
- **Unstimulated salivary flow:** 0.25 - 0.35 ml/ min

## FORMATION OF SALIVA



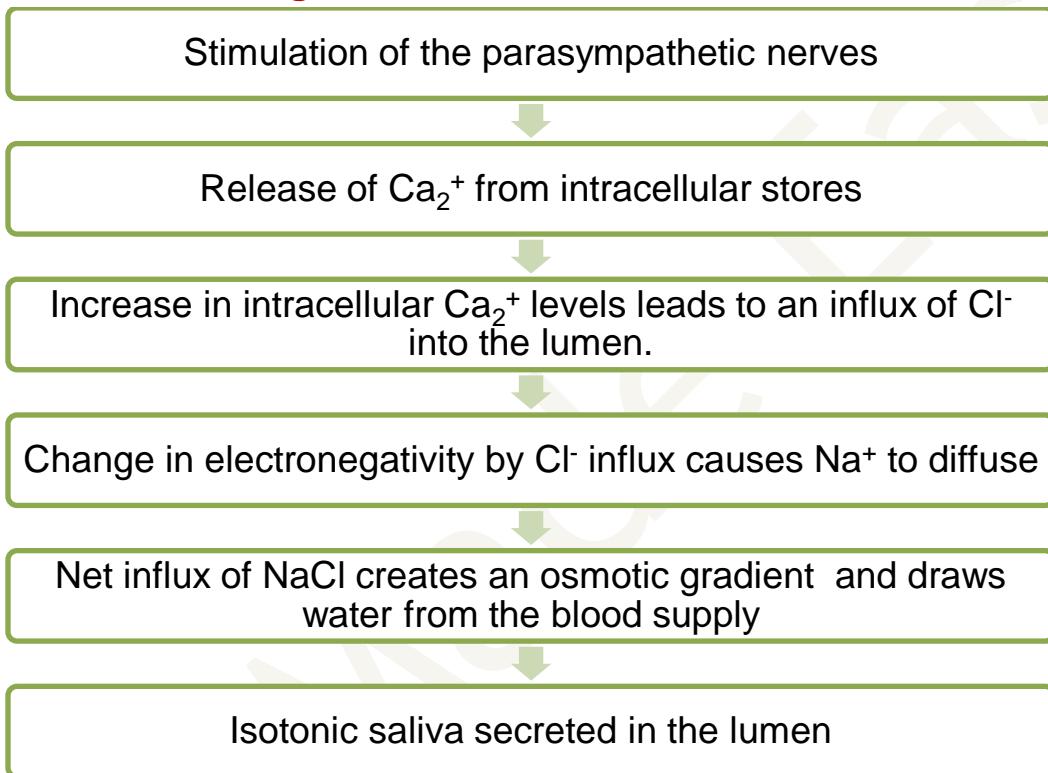
- In the duct system the primary saliva is modified by selective reabsorption of sodium and chloride ions (without water) and secretion of potassium and bicarbonate ions.

## PHYSIOLOGY OF SALIVA SECRETION

Salivary secretion is a two-stage process:

- Initial Formation stage : Involves acini to secrete a primary secretion that contains ptyalin and/ or mucus in a solution of ions similar in plasma.
- Modification stage: When the primary secretion flows through the ducts and the ionic composition of saliva is modified.

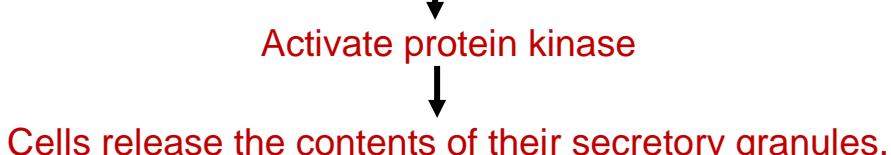
### I. Initial Formation Stage



### II. Modification Stage:

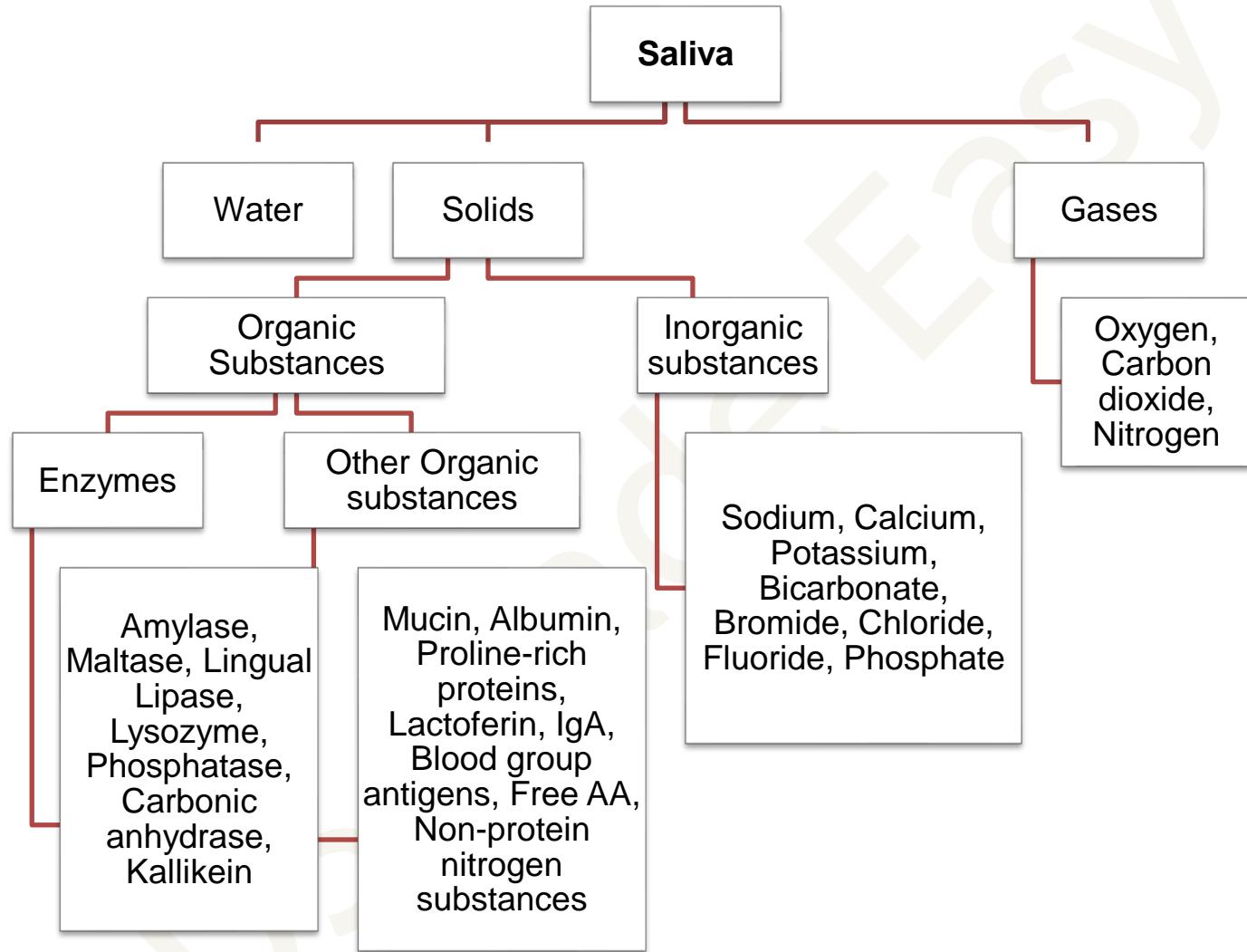
- Composition of primary saliva is modified in the duct system.
- The Intralobular ducts reabsorb  $\text{Na}^+$  and  $\text{Cl}^-$  excluding water, and make the final saliva hypotonic.
- Stimulation of the sympathetic nerve, or  $\beta$ -adrenergic receptors, causes exocytosis but less fluid secretion.

Activation of  $\beta$ -adrenoceptors increases the intracellular cyclic adenosine monophosphate (cAMP) level



- This involves the fusion of the granule membrane with the luminal plasma membrane of the secretory cell followed by rupture of the fused membranes.
- The released contents of granules comprise a wide variety of proteins which are unique to saliva and responsible for its biological functions.

## COMPOSITION OF SALIVA



## Constituents of saliva & their role

Salivary constituent	Properties & Role
<b>Lysozyme</b>	<ul style="list-style-type: none"> <li>• Role in defence, antibacterial</li> </ul>
<b>Amylases</b>	<ul style="list-style-type: none"> <li>• Hydrolyzes alpha (1-4) bonds of starches such as amylose and amylopectin.</li> <li>• Digestive role</li> </ul>
<b>Lactoferrin</b>	<ul style="list-style-type: none"> <li>• Iron binding protein</li> </ul>

	<ul style="list-style-type: none"> <li>“Nutritional” immunity → Antibacterial</li> </ul>
<b>Histatins</b>	<ul style="list-style-type: none"> <li>Potent inhibitors of <i>Candida albicans</i> growth</li> </ul>
<b>Cystatins</b>	<ul style="list-style-type: none"> <li>inhibitors of cystatine-proteases</li> <li>protective against unwanted proteolysis → in periodontal tissues</li> <li>effect on calcium phosphate precipitation</li> </ul>
<b>Lingual lipase</b>	<ul style="list-style-type: none"> <li>Secreted by von ebners glands</li> <li>first phase of fat digestion</li> <li>Important in digestion of milk fat in new-born</li> </ul>
<b>Statherins</b>	<ul style="list-style-type: none"> <li>prevent precipitation or crystallization of supersaturated calcium phosphate in ductal saliva &amp; oral fluid.</li> <li>effective lubricant</li> </ul>
<b>Proline Rich Proteins (PRPs)</b>	<ul style="list-style-type: none"> <li>Inhibitors of calcium phosphate crystal growth</li> </ul>
<b>Mucins</b>	<ul style="list-style-type: none"> <li>Protective coating about hard &amp; soft tissues - primary role in formation of acquired pellicle</li> <li>Increase lubricating qualities</li> <li>Deter bacterial adherence</li> </ul>
<b>Ig A</b>	<ul style="list-style-type: none"> <li>Antibacterial and anti-viral actions</li> </ul>
<b>Sodium</b>	<ul style="list-style-type: none"> <li>Contributes to osmolarity</li> </ul>
<b>Calcium</b>	<ul style="list-style-type: none"> <li>Prevents dissolution of enamel</li> <li>Facilitates enamel mineralization.</li> </ul>
<b>Potassium</b>	<ul style="list-style-type: none"> <li>Contributes to osmolarity of saliva</li> </ul>
<b>Bicarbonate</b>	<ul style="list-style-type: none"> <li>Buffer in saliva</li> </ul>
<b>Chlorine</b>	<ul style="list-style-type: none"> <li>Contributes to osmolarity of saliva</li> </ul>
<b>Fluoride</b>	<ul style="list-style-type: none"> <li>Anti-caries property</li> </ul>

## FUNCTIONS OF SALIVA

### I. Defense:

- Antibacterial
- Antifungal
- Antiviral
- Immunological

- Enzymes lysozyme of saliva kills some bacteria such as *Staphylococcus*, *Streptococcus* & *Brucella*

- Proline rich proteins (poses antimicrobial property) and neutralize toxic substances such as tannins
- Tannins are found in many food substances including fruits

<b>Lactoferrin</b>	<ul style="list-style-type: none"> <li>• Antimicrobial property</li> </ul>
<b>Proline rich proteins and lactoferrin</b>	<ul style="list-style-type: none"> <li>• Provides protection to teeth by stimulating enamel formation</li> </ul>
<b>Ig A</b>	<ul style="list-style-type: none"> <li>• Antibacterial and anti-viral actions</li> </ul>
<b>Mucin</b>	<ul style="list-style-type: none"> <li>• Lubricates mucus membrane of mouth</li> </ul>

## II. Digestion

- Digestive enzymes: ptyalin, lipase
- Formation of bolus
- Taste

<b>1. Salivary amylase</b>	<b>2. Maltose</b>
<ul style="list-style-type: none"> <li>• Carbohydrate: digestive (amylolytic) enzymes</li> <li>• Converts cooked or boiled starch into dextrin and maltose</li> <li>• Cannot act on cellulose</li> <li>• Optimum pH for activation of salivary amylase is 6.</li> </ul>	<ul style="list-style-type: none"> <li>• Present in faeces</li> <li>• Converts maltose into glucose</li> </ul>
<b>3. Lingual Lipase</b>	
<ul style="list-style-type: none"> <li>• Lipid digesting (lipolytic) enzyme.</li> <li>• Secreted from serous glands situated on the posterior aspect of tongue.</li> <li>• Digests milk fats (pre - emulsified fats)</li> <li>• Hydrolyzes triglycerides into fatty acids and glycerol</li> <li>• Food taken into the mouth is moisture and dissolved by saliva</li> <li>• Mucus membrane of mouth is also moistened by saliva which facilitates chewing</li> <li>• By movement of tongue → moistened and masticated → Rolled into bolus</li> <li>• MUCIN- lubricates the bolus and facilitates swallowing</li> </ul>	

### III. Protective function:

- Protective coating for soft tissues
- Protective coating for hard tissues

- Proline rich proteins lactoferrin → protect the teeth by stimulating enamel formation
- Mucin: protects the mouth by lubricating the mucus membrane of mouth.
- Constant secretion of saliva keeps the mouth and teeth rinsed and free-off debris, shed epithelial cells and foreign particles
- Saliva prevents bacterial growth by removing materials, which may serve as culture media for the bacterial growth

### IV. Lubrication function:

- Keeps the oral cavity moist
- Facilitates speech
- Helps in mastication and swallowing

- If mouth becomes dry – articulation and pronunciation become difficult
- Saliva helps in BOLUS formation
- Saliva keeps the food moistened and helps in mastication and swallowing

### V. Buffering function:

1. Regulation of body temperature	2. Regulation of water balance
<ul style="list-style-type: none"> <li>• In humans, sweat glands play a major role in temperature regulation</li> <li>• Saliva does not play any role in this function</li> <li>• In dogs and cattle → excessive dripping of saliva during panting → helps in loss heat and regulation of body temperature</li> </ul>	<ul style="list-style-type: none"> <li>• Decrease body water content causes decrease in salivary secretion</li> <li>• This causes dryness of mouth</li> <li>• Induces thirst</li> <li>• When water is taken → quenches thirst → restores body water content</li> </ul>

## VI. Excretory function:

- Organic and inorganic substances are excreted in saliva
- Excretes substances like mercury, potassium iodide, lead and thiocyanate
- Also excretes some viruses such as those causing RABIES and HUMPS
- Pathological conditions in which saliva shows components, which are not found in saliva under normal condition

- Glucose in diabetes mellitus
- Excess urea in nephritis
- Excess calcium in hyperparathyroidism

- Saliva contains large amounts of potassium and bicarbonate ions & less amounts of sodium and chloride ions when compared to plasma
- Primary secretion contains ptyalin and/or mucin in a solution of ions with concentrations similar to those of extracellular fluid

## FACTORS AFFECTING THE SALIVARY FLOW

<b>I. Hydration</b>	<ul style="list-style-type: none"> <li>On reduction of body water content to 8%, rate of salivary flow diminishes to zero.</li> <li>Severe intake of water may lead to increase in salivary flow</li> </ul>
<b>II. Variations in circadian rhythms</b>	<ul style="list-style-type: none"> <li>Human body attains a higher concentration of proteins at the end of the afternoon, whereas the peak production levels of Na and Cl ions are seen at the early morning hours</li> </ul>
<b>III. Smoking</b>	<ul style="list-style-type: none"> <li>Smoking causes a temporary increase in unstimulated salivary flow</li> </ul>
<b>IV. Body posture</b>	<ul style="list-style-type: none"> <li>Individuals who stand for a longer time present higher salivary flow, whereas individuals who lie down for a longer time show a lowering of salivary flow</li> </ul>
<b>V. Medications</b>	<ul style="list-style-type: none"> <li>Many drugs have a side effect towards salivary flow</li> <li>Example: Anticholinergic drugs like antidepressants, anxiolytics, antipsychotics, antihistamines and</li> </ul>

	antihypertensives
<b>VI. Gustatory stimulation</b>	<ul style="list-style-type: none"> <li>Chewing of any tasteless food stimulates salivation to a lesser degree when compared to tasty stimulations</li> </ul>

## CLINICAL CONSIDERATIONS

### I. Effect of drugs chemicals on salivary secretion

<i>1. Substances increasing salivary secretion</i>	<i>2. Substances decreasing salivary secretion</i>
<ul style="list-style-type: none"> <li>Sympathomimetic drugs like Adrenaline &amp; Ephedrine.</li> <li>Parasympathomimetic drugs like Acetylcholine, Pilocarpine, Physostigmine.</li> <li>Example: Sialorrhea</li> </ul>	<ul style="list-style-type: none"> <li>Sympathetic depressants like Ergotamine &amp; Dibenahine.</li> <li>Parasympathetic depressants like Atropine &amp; Scopolamine.</li> <li>Example: Sjogren's syndrome, Xerostomia, candidiasis</li> </ul>

### II. Chorda tympani syndrome/ Frey syndrome

- Condition characterized by sweating while eating
- During trauma or surgery damage to parasympathetic fibres to salivary glands may be severe.
- During regeneration of these nerve fibres, which run along with chorda tympani branch of facial nerve may deviate and join with nerve fibres supplying sweat glands.
- Hence when food is placed in the mouth, salivary secretion is associated with sweat secretion.

## PROSTHODONTIC CONSIDERATIONS

### I. Prosthodontic management in xerostomia

#### 1. In fixed partial dentures

- In oral conditions with dry environment, fixed non tissue contacting prosthesis are indicated
- Abutments should have full coverage retainers with easily cleanable pontics and connectors are designed
- Supragingival margins are indicated to provide self cleansing

**2. In removable partial dentures**

- Should design RPD to preserve periodontal health
- Gingivally approaching clasps are used
- Tooth supported dentures with minimal tissues coverage is indicated
- Metal denture bases are preferred as they play a vital role in transferring the senses to palate

**3. In complete dentures**

- Usage of soft liners to improve comfort
- Denture adhesives to enhance retention
- Proper hygiene instructions to avoid candida infections
- Fabrication of intraoral salivary reservoirs using artificial substitutes

**II. Prosthodontic management of patients with Sialorrhea****1. In removable partial dentures**

- Administration of antisialogogues 1 to 2 days prior treatment
- Irrigation with mouth astringent and mouth washes while making impressions
- Fast setting impression material should be used
- Absorptive strips are used during procedure to have a better operating field
- Tandem impression technique is used

**2. Cleaning of alginate impression material**

- Improper cleaning of impressions with residue of saliva leads to inaccurate cast
- Saliva in serous consistency should be washed off under cool tap or soft bristle brush with mild detergent
- In conditions with thick ropy saliva it is advised to sprinkle little gypsum product on the surface of impression

**3. In fixed partial dentures**

- It is important to maintain dry field while making an impression or cementing a fixed prosthesis.
- Can be achieved by using
  - Rubber dam

- High volume suction
- Saliva ejector
- Anti sialagogues (Methantheline bromide, propantheline bromide etc)

### III. Denture base extension (in relation to salivary gland duct openings)

- **Stenson's duct:** Very rarely maxillary denture obstructs this duct
- **Wharton's duct:** Overextension of lingual flange may obstruct the opening of wharton's duct, which may cause swelling under the tongue during mastication
- **Sublingual:** It is rare for a denture to cause obstruction to sublingual duct

### IV. Amount of saliva

- Dry mouth: Retention is compromised, increased potential to damage mucosa
- Excess saliva: Complicates clinical steps like impression making
- Increased salivation for the first time denture wearers is a common temporary condition, which is a response to foreign objective. Patients need to be assured about this

### V. Consistency of saliva

- Serous type saliva is best for prosthetic management and maintenance
- Thick saliva: Compromises impressions, maxillary denture retention

### VI. Denture retention

- Saliva plays a major role in creating retention and stability to dentures.
- The physical forces which play a major role in saliva are

- Adhesion
- Cohesion
- Interfacial surface tension
- Capillary attraction
- Peripheral seal
- Viscosity
- Surface tension

## ARTIFICIAL SALIVARY SUBSTITUTES

- Artificial saliva with properties similar to natural saliva in which salivary glycoproteins are replaced by carboxymethyl cellulose
- Available as solutions, sprays and gels

### I. Salivary substitutes commonly used in prosthodontics

- Saliva orthana spray
- Saliva orthana gel
- Salivace
- Glandsane
- Salivix pasties
- Moisties

### II. Composition of salivary

- According to Jain M et al 2012

- Sodium carboxymethylcellulose
- Sorbital
- Potassium chloride
- Sodium chloride
- Magnesium chloride
- Calcium chloride
- Di potassium hydrogen orthophosphate
- Potassium di hydrogen orthophosphate
- Sodium fluoride
- Methyl p- hydroxybenzoate
- Spirit of lemon

### III. Uses of salivary substitutes

- Helps in retention of dentures in patients with xerostomia
- Patients with end stage renal disease with dry mouth and reduce thirst
- Patients under radiation therapy
- Sjogren's syndrome
- Antimicrobial activity
- Fluoride containing substitutes causes remineralisation, caries prevention

IV. Indications	V. Contraindications
<ul style="list-style-type: none"> <li>• Full mouth rehabilitations for patients undergoing radiotherapy, chemotherapy</li> <li>• Management of dryness in mouth and throat in conditions like <ul style="list-style-type: none"> <li>➢ Xerostomia</li> <li>➢ Medications</li> <li>➢ Stroke</li> <li>➢ HIV</li> <li>➢ Sjogren's syndrome</li> <li>➢ Bell's palsy</li> <li>➢ Lupus aging</li> <li>➢ Salivary gland disorders</li> <li>➢ Pharyngitis</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Substitutes with carboxymethylcellulose parabens are contraindicated in patients with hypersensitivity, hypertension, pregnancy, renal failure.</li> <li>• Pilocarpine is contraindicated in asthmatic patients</li> </ul>
<b>Side effects</b>	
<ul style="list-style-type: none"> <li>• Itching, tingling, sensation, swelling of face and mouth</li> </ul>	

## CONCLUSION

- Saliva and its components acts like a mirror to the health of an individual
- The knowledge in normal salivary composition, function and flow is important to diagnose any underlying physiologic or pathologic condition and create a better treatment plan.
- The role of saliva plays a critical role in edentulous patients, hence during rehabilitation with complete dentures the dentist should give attention to the nature of saliva for a better result

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*Please Give Your Feedback on this Answer*

**Explain the stages of erythropoiesis with an illustrated diagram (20M)****CONTENTS/SYNOPSIS**

- Introduction
- Definition
- Composition of blood
  - Cells
  - Plasma
- Theories of erythropoiesis
- Sites of erythropoiesis
- Stages of erythropoiesis
  - Stem cells
  - Progenitor cells
    - Burst forming unit BFU-E
    - Colony forming unit CFU-E
  - Proerythroblast
  - Erythroblast
    - Basophilic (early) erythroblast
    - Polychromatic (intermediate) erythroblast
    - Orthochromatic (late) erythroblast
  - Reticulocyte
  - Erythrocyte (Red blood cells)
    - Colour
    - Function
    - Shape
    - Dimensions
    - Normal range
    - Life span
- Factors regulating erythropoiesis
  - General factors
  - Maturation factors
  - Factors affecting haemoglobin production
- References

## INTRODUCTION

- The word Hemopoiesis refers to the development or formation of blood cells
  - Hemo: blood cells
  - Poiesis: the development or production of
- Production of erythrocytes: Erythropoiesis
- Production of leucocytes: Leucopoiesis
- Production of Leucocytes: Thrombopoiesis

### Erythropoiesis

- **Definition:** It is the process of development, differentiation and maturation of RBCs from primitive stem cells

## COMPOSITION OF BLOOD

- Blood is a highly complex fluid, which is composed of two parts liquid plasma (55%) and different types of cells (45%).

### I. Cells

- Red blood cells or corpuscles or erythrocytes
- White blood corpuscles or leukocytes
- Platelets or thrombocytes

### II. Plasma

- Water- It is about 91 to 92 percent
- Solids
  - Sodium, potassium, calcium, magnesium, phosphorus, iron, copper, etc- 0.9 percent.
  - Serum albumin, serum globulin, fibrinogen-7.5 percent.
  - Nonprotein nitrogenous substances like urea, uric acid, carbohydrates, fats, etc.
  - Various enzymes like amylase, protease and lipase are also present
  - The yellow colour of plasma is due to bilirubin and carotene.

## THEORIES OF ERYTHROPOIESIS

Monophyletic theory	Polyphyletic theory
<ul style="list-style-type: none"> <li>• Also known as unitary theory</li> <li>• Proposed by Alexander A Maximow</li> <li>• This theory states that there is a</li> </ul>	<ul style="list-style-type: none"> <li>• Also known as trialistic theory</li> <li>• Proposed by L Aschoff</li> <li>• According to this theory, it states that different group of stem cells</li> </ul>

common parent cell to all the formed elements of blood

forms different blood cells

## SITE OF ERYTHROPOIESIS

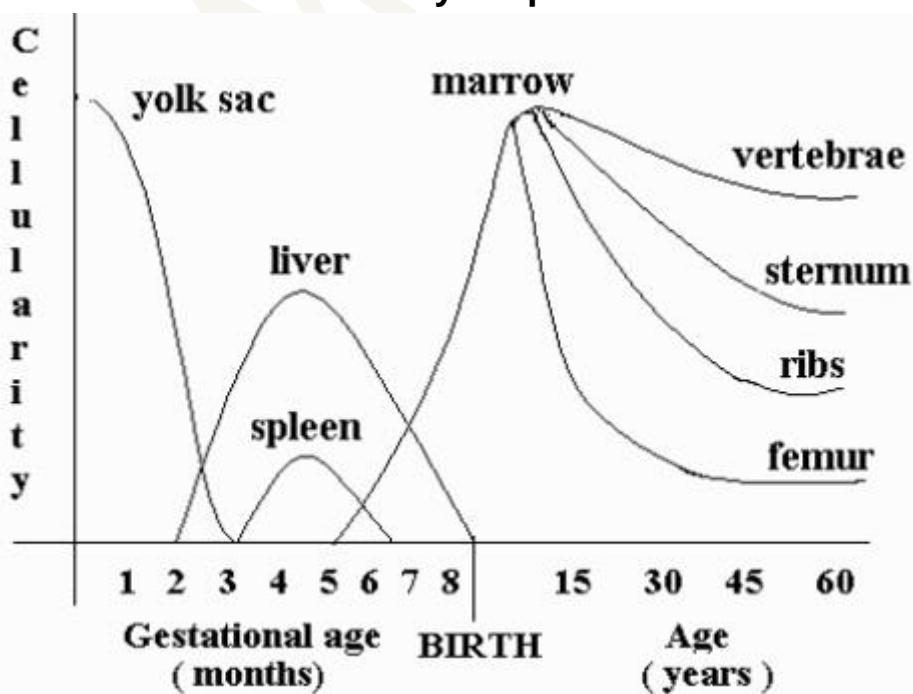
### Intrauterine life

- Mesoblastic stage: 3rd week to 3 months
- Hepatic stage: after 3 months
- Myeloid stage: 3rd trimester
- Site: Yolk sac, liver and spleen

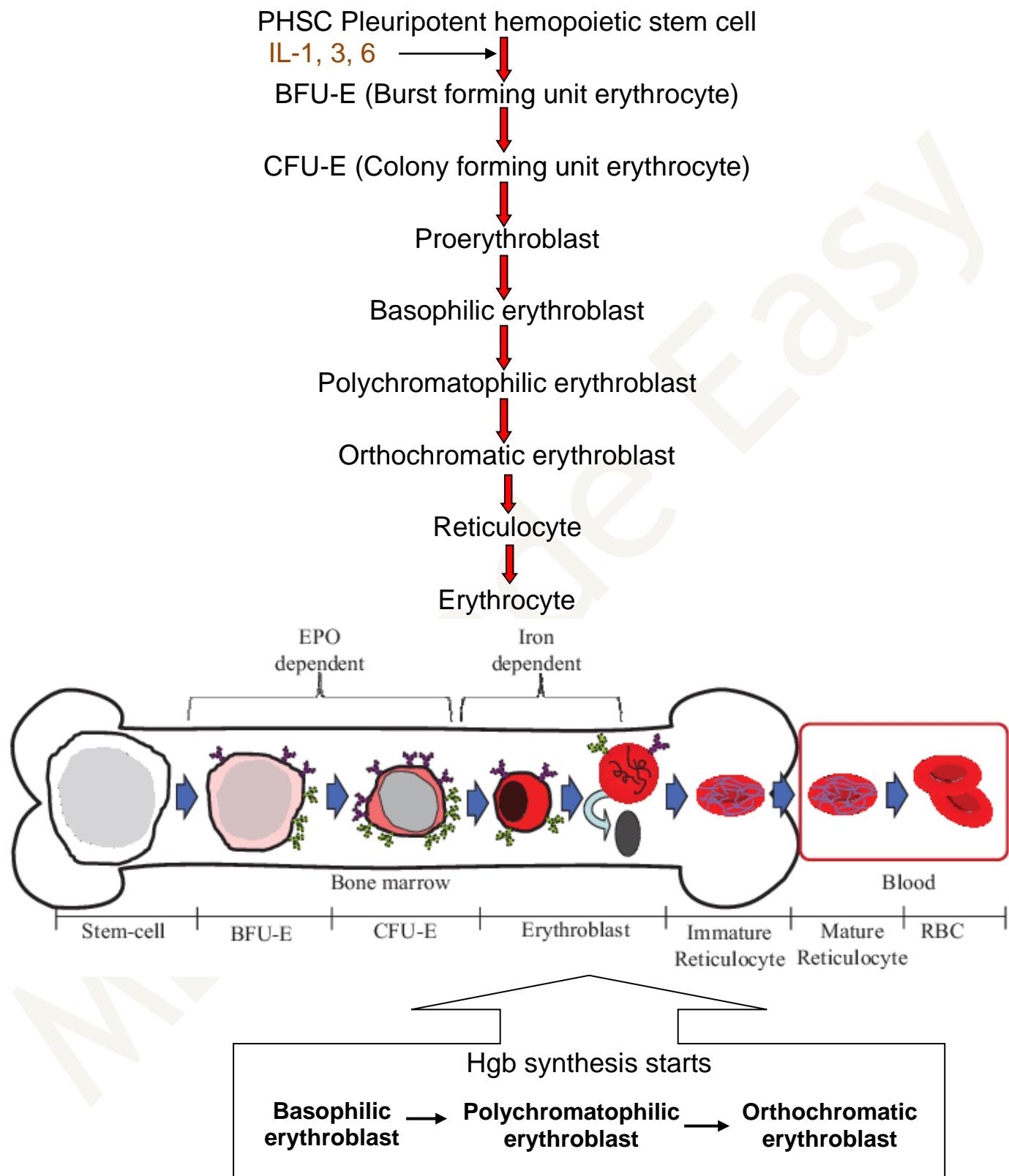
### Intra & Extravascular erythropoiesis

- In children:
  - All bones with red bone marrow
  - Liver and spleen
- In adults ( .20years)
  - Ends of long bones like femur and humerus
  - Skull, Vertebrae, Sternum, Ribs, Pelvis

### Site of erythropoiesis



## STAGES OF ERYTHROPOEISIS



## I. Stem cells

- Have extensive proliferative capacity
- Give rise to new stem cells (Self Renewal)
- Differentiates into any blood cells lines (Pleuriotency)

- Hematopoietic stem cells(HSCs) are bone marrow cells with a capacity to produce all type of blood cells.
- They can differentiate into one or more types of committed stem cells (progenitor cells)

## II. Progenitor cells

- Committed stem cells lose their capacity for self renewal.
- Irreversibly committed.
- BFU-E gives rise each to thousands of nucleated erythroid precursor cells.
- Changes again into colony forming units erythrocyte(CFU-E)
- Regulators: Burst Promoting Activity(BPA)

1. <i>Burst forming unit BFU-E</i>	2. <i>Colony forming unit CFU-E</i>
<ul style="list-style-type: none"><li>• Unipotent progenitor cell</li><li>• Less sensitive to erythropoietin</li><li>• Responds to other stimulus forms</li></ul>	<ul style="list-style-type: none"><li>• Highly sensitive</li><li>• Dependent on erythropoietin</li></ul>

- Although the stem cells which eventually form the mature erythrocytes of the peripheral blood cannot be recognised morphologically, there is a well-defined and readily recognisable lineage of nucleated red cells (i.e. the erythroid series) in the marrow.

## III. Proerythroblast

- The earliest recognisable cell in the marrow is a Proerythroblast or pronormoblast.

- Large cell with 15-20  $\mu\text{m}$  in diameter
- Consists of deeply basophilic cytoplasm and a large central nucleus with nucleoli.
- As the cells mature, the nuclei loses nucleoli and become smaller and denser

- The cytoplasm on maturation replaces dense blue colour into pink staining haemoglobin.
- Each proerythroblast undergoes 4 - 5 replications and forms 16 - 32 mature RBCs.

#### IV. Erythroblast

##### 1. Basophilic (early) erythroblast

- It is a round shaped cell with a diameter of 12-16  $\mu\text{m}$
- Consists of a large nucleus which is slightly more condensed than the proerythroblast and contains basophilic cytoplasm.
- Basophilic erythroblast undergoes rapid proliferation.

##### 2. Polychromatic (intermediate) erythroblast

- Next maturation stage has a diameter of 12-14  $\mu\text{m}$ .
- The nucleus at this stage is coarse and deeply basophilic.
- The cytoplasm is characteristically polychromatic i.e. contains admixture of basophilic RNA and acidophilic haemoglobin.
- The cell at this stage ceases to undergo proliferative activity.

##### 3. Orthochromatic (late) erythroblast

- The cell at this stage is smaller, 8-12  $\mu\text{m}$  in diameter, containing a small and pyknotic nucleus with dark nuclear chromatin.
- The cytoplasm is characteristically acidophilic with diffuse basophilic hue due to the presence of large amounts of haemoglobin.

#### V. Reticulocyte

- The nucleus is finally extruded from the late erythroblast within the marrow and forms a reticulocyte
- The reticulocytes are juvenile red cells devoid of nuclei but contain ribosomal RNA to synthesise haemoglobin.
- They spend 1-2 days in the marrow and circulate for 1-2 days in the peripheral blood before maturing in the spleen, to become a biconcave red cell.
- Have a slightly basophilic hue in the cytoplasm similar to that of an orthochromatic erythroblast.
- Reticulocytes can be counted in the laboratory by vital staining with dyes such as new methylene blue or brilliant cresyl blue.

## VI. Erythrocyte (Red blood cells)

- The mature erythrocytes of the human peripheral blood are non-nucleated cells and lack the usual cell organelles.

<b>1. Colour</b>	<ul style="list-style-type: none"> <li>Red, due to the presence of haemoglobin (90% of weight of RBC)</li> </ul>
<b>2. Function</b>	<ul style="list-style-type: none"> <li>Transports respiratory gases</li> </ul>
<b>3. Shape</b>	<ul style="list-style-type: none"> <li>Biconcave discs with flexibility, larger surface area, facilitates the entrance and exit of oxygen through the RBC</li> </ul>
<b>4. Dimensions</b>	<ul style="list-style-type: none"> <li>Diameter: 7.2 <math>\mu\text{m}</math></li> <li>Thickness: 2.4 <math>\mu\text{m}</math></li> <li>Periphery: 1 <math>\mu\text{m}</math></li> </ul>
<b>5. Normal range</b>	<ul style="list-style-type: none"> <li>4.7 - 6.1 million cells per micro liters in males</li> <li>4.2 - 5.4 million cells per micro liters in females</li> </ul>
<b>6. Life span</b>	<ul style="list-style-type: none"> <li>120 days</li> </ul>

## FACTORS REGULATING ERYTHROPOIESIS

### I. General factors

#### 1. Erythropoietin:

- Promotes the production of pronormoblast
- Promotes release of reticulocytes early
- Conditions triggering are: hypoxia, anemia, higher altitudes, chronic lung diseases, blood transfusions

#### 2. Growth inducers:

- Interleukin 1, 3 and 6
- Colony stimulating factor (CSF-E)

### II. Maturation factors

**Vitamin B12:** Promotes maturation of RBCs and plays an important role in synthesis of folic acid

**Folic acid:** Available in green leafy vegetables, yeast, animal source (liver) and promotes maturation of RBC

### III. Factors affecting haemoglobin production

<b>1. Vitamin C</b>	• Helps in absorption of iron
<b>2. Proteins</b>	• Amino acids are essential for globin synthesis
<b>3. Iron and copper</b>	• Helps in Heme synthesis
• Calcium , bile salts, cobalt and nickel	

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**Please Give Your Feedback on this Answer**

**Discuss the anatomy of alveolingual sulcus and its clinical significance in prosthodontics (15M)**

## CONTENTS/SYNOPSIS

### Introduction

### Alveolingual sulcus

- Anterior region
  - Prosthodontic significance
- Middle region
  - Prosthodontic significance
- Distolingual region
  - Prosthodontic significance
- Retromylohyoid space
  - Prosthodontic significance

### References

## INTRODUCTION

- According to M. M Devan aim of a prosthodontist is not only the replacement of missing area but also the preservation of remaining structures
- A prosthesis must function in harmony with the tissues supporting them and those that surround them.
- Hence it is essential to understand the microscopic and macroscopic anatomy of surround and limiting structures of dentures

## ALVEOLINGUAL SULCUS

- It is the space between the residual ridge and tongue from lingual frenum to the retromylohyoid curtain
- Houses the lingual flange of the denture
- It is divided into three regions:

### I. Anterior region

- Also called Sublingual crescent area or sublingual fold.
- Extends from lingual frenum to premylohyoid eminence.

#### Prosthodontic significance

- To record the lingual border of the impression tip of the tongue should touch upper incisors.
- Provides secondary peripheral seal.
- The lingual flange of the lower denture will be short anteriorly than posteriorly

### II. Middle region

- Also called mylohyoid area starting from premylohyoid fossa till the distal end of the mylohyoid ridge.
- On the lingual surface of mandible near premolar region, sublingual gland lies over the mylohyoid muscle between the mandible and genioglossus muscle
- It curves medially due to mylohyoid ridge and muscle.
- Shallower than other parts of sulcus.
- Maintains peripheral seal during function

#### Prosthodontic significance

- The flange of the mandibular denture should provide adequate space for the sublingual gland

- Achieved by the flange sloping inwards, medially away from the lingual surface of the mandible.
- The border should rest on the floor of the mouth below tongue to accommodate sublingual glands.
- The sublingual gland region is recorded as the premylohyoid eminence while making impression with a low viscosity material
- The border of the mandibular denture is fabricated in such a manner that the fibres of mylohyoid muscles avoid the undercut underneath mylohyoid ridge and rest over the soft tissues below the tongue. Thus the tongue rests over the flange

### III. Distolingual region

- Also called as lateral throat form.
- Neil classified lateral throat form into 3 classes

<b>Class I</b>	<ul style="list-style-type: none"> <li>• No movement to the clinician's finger or mouth mirror when patient is asked to protrude the tongue</li> </ul>
<b>Class II</b>	<ul style="list-style-type: none"> <li>• Long and narrow and is about half of class I flange and twice the length of a class III</li> </ul>
<b>Class III</b>	<ul style="list-style-type: none"> <li>• The entire finger or mouth mirror is displaced. Minimum length and thickness, usually ending the flange 2 - 3 mm below of just at the mylohyoid ridge</li> </ul>

- Consists of retromylohyoid fossa which is bounded by tonsillar pillar lingually, mylohyoid ridge anteriorly, retromylohyoid curtain posteriorly, and floor of the mouth inferiorly.

### Prosthodontic significance

- Flange completes the 'S' form of the denture in here.
- Excellent area to extend denture for positive retention

### IV. Retromylohyoid space

- Explained by Edwards and Boucher
- Does not have sharp boundaries
- Divided into two area: glandular triangle and constrictor square
- Glandular triangle: Includes deep part of the submandibular gland and mylohyoid muscle

- Constrictor square: includes superior constrictor muscle, pterygomandibular raphe, small part of buccinator
- The mucous membrane and superior constrictor forms the retromylohyoid curtain.

### Prosthodontic significance

- The distolingual flange of mandibular denture is influenced by superior constrictor of pharynx and medial pterygoid
- Protruding the tongue activates the superior constrictor and molds the distolingual border of the denture

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Please Give Your Feedback on this Answer

**Bone density classification in implant dentistry (20M)****CONTENTS/SYNOPSIS**

- Introduction
- Etiology of various bone density
  - Frosts mechanostat theory
    - Acute disuse window
    - Adapted window phase
    - Mild overload window
    - Pathologic overload zone
- Bone density classification
  - Bone density D1
  - Bone density D2
  - Bone density D3
  - Bone density D4
- Bone density determination
  - Computerized topography (CT) scan
  - Tactile determination during bone drilling
- Dense compact (d1) bone
  - Advantages
  - Disadvantages
  - Osteotomy preparation in D1 bone
- Dense to thick porous compact and coarse trabecular (d2) bone
  - Advantages
  - Osteotomy preparation of D2 bone
- Porous compact and fine trabecular (d3) bone
  - Advantages
  - Disadvantages
- Fine trabecular (d4) bone
  - Disadvantages
- Conclusion
- References

## INTRODUCTION

- External, internal architecture of bone, bone density plays a key determinant role towards implant success
- The available bone density is important in implant and describes the width, height, length, and angulation of the edentulous area considered for implants.
- Sufficient quantity of bone is the primary condition for the use of endosteal implants.
- In addition, available bone is also described in density, which reflects the hardness of the bone.

## AETIOLOGY OF VARIOUS BONE DENSITY

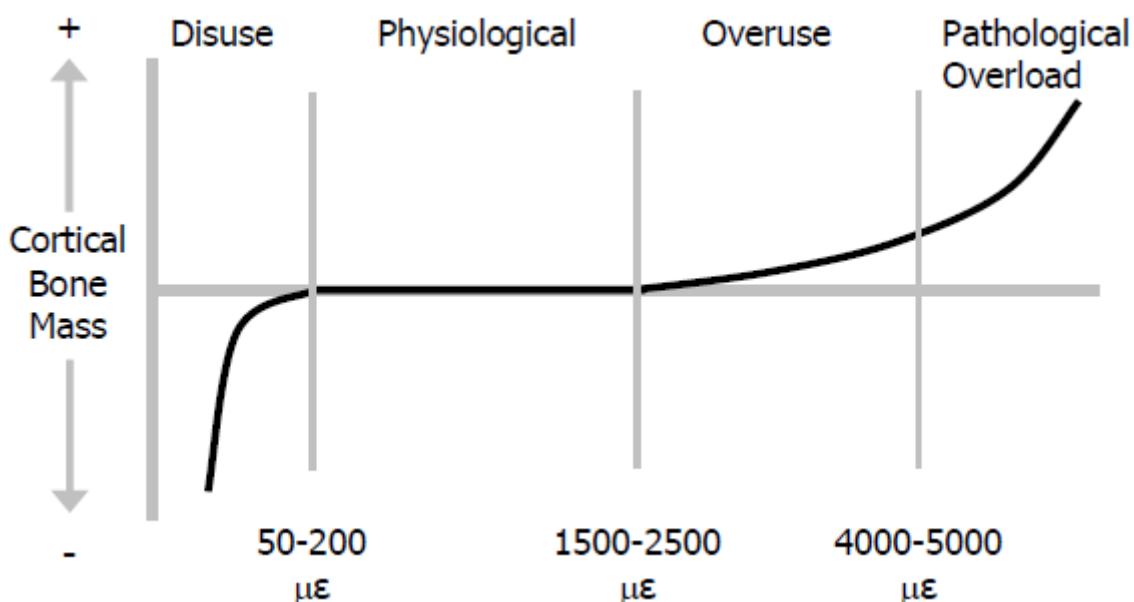
- Hormones
- Duration of edentulousness
- Mechanical influences
- Vitamins

Modelling	Remodelling
<ul style="list-style-type: none"> <li>Independent sites of formation and resorption</li> <li>Results in change in shape and size of bone</li> </ul>	<ul style="list-style-type: none"> <li>Resorption and formation at the same site</li> <li>Replaces previously existing bone</li> </ul>
↓	
<ul style="list-style-type: none"> <li>Adaptive phenomenon</li> <li>Alteration of mechanical forces and development of strain in bone</li> <li>Density evolves as a mechanical deformation from micro strain</li> </ul>	

## Frosts mechanostat theory

1. Acute disuse window	<ul style="list-style-type: none"> <li>Loses all mineral density</li> <li>Disuse atrophy leads to modelling for new bone inhibition</li> <li>Lowest microstrain amount: 0- 50</li> <li>Cortical bone density decreases to 40%</li> <li>Trabecular bone density decreases to 12%</li> </ul>
2. Adapted window phase	<ul style="list-style-type: none"> <li>Microstrain is 50 - 1500</li> <li>Equilibrium of modelling and remodelling</li> <li>Phase is also called homeostatic window of</li> </ul>

	<p>health</p> <ul style="list-style-type: none"> <li>• Consists of 18% trabecular bone and 2 -5% cortical bone</li> <li>• <u>Ideal for an endosteal implant</u></li> </ul>
<b>3. Mild overload window</b>	<ul style="list-style-type: none"> <li>• Microstrain is 1500 - 3000</li> <li>• Greater rate of fatigue microstructure</li> <li>• Bone strength and density decreases</li> <li>• It is a state of bone where there is overload on endosteal implant</li> <li>• Repair: woven bone is weaker than lamellar bone</li> </ul>
<b>4. Pathologic overload zone</b>	<ul style="list-style-type: none"> <li>• Microstrain &lt; 3000 units</li> <li>• Physical fracture of cortical bone</li> <li>• Formation of fibrous tissue</li> <li>• Marginal bone loss in implant overloading leads to implant failure</li> </ul>

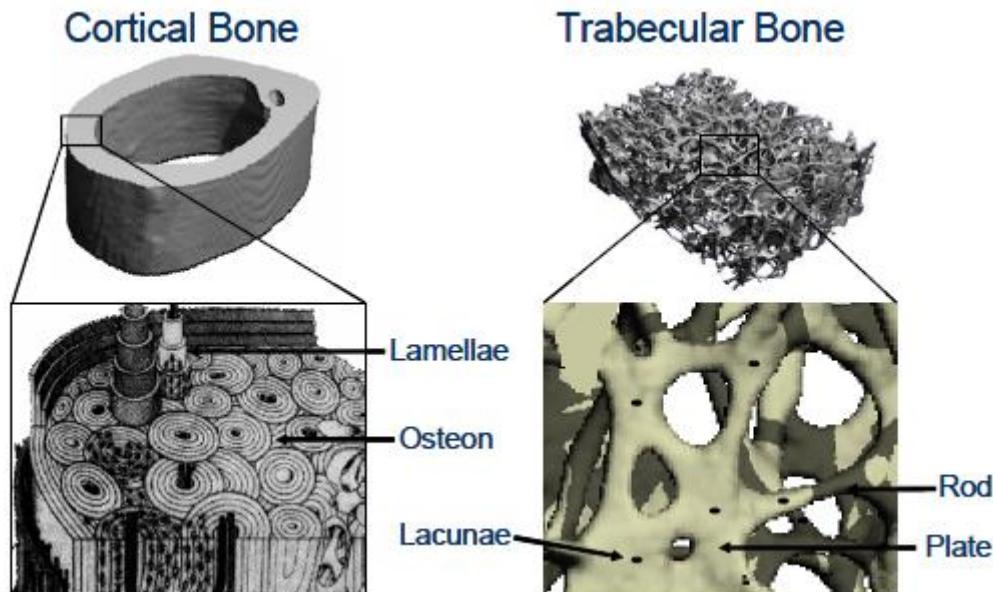


**Frost's mechanostat theory: adaptation of bone to mechanical stimuli**

### BONE DENSITY CLASSIFICATION

- Carl E Misch defined four bone density groups, which vary in both macroscopic cortical and trabecular bone types.
- The surgical protocol, healing, treatment plans, and progressive loading time spans are unique for each bone density type.
- Bone may be classified into four macroscopic decreasing density groups

- Dense compact
- Porous compact
- Coarse trabecular
- Fine trabecular



### Micro structural features of cortical and trabecular bone

#### **Bone density D1**

- Description: Dense cortical
- Tactile analogue: Oak/ maple
- Anatomic location: Anterior mandible
- Hounsfield units: > 1250

#### **Bone density D2**

- Description: Porous cortical and white coarse trabecular
- Tactile analogue: White pine/ spruce
- Anatomic location: Anterior and posterior mandible, anterior maxilla
- Hounsfield units: 850 - 1250

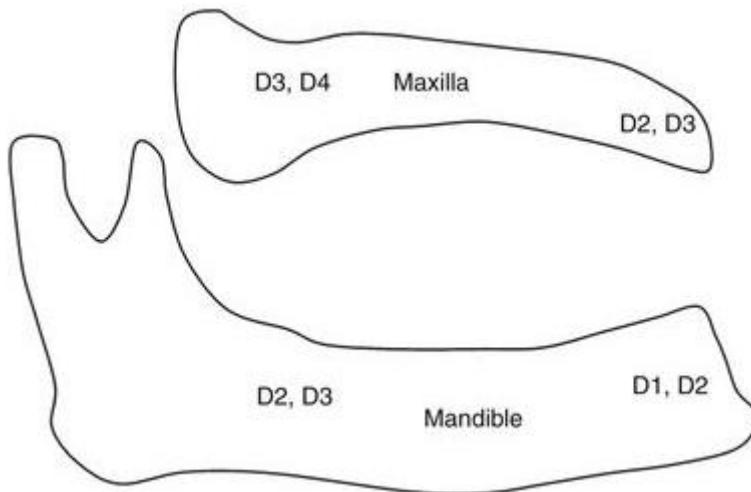
#### **Bone density D3**

- Description: Porous cortical (thin) and fine trabecular
- Tactile analogue: Balsa wood
- Anatomic location: Posterior mandible, anterior and posterior maxilla
- Hounsfield units: 350 - 850

#### **Bone density D4**

- Description: Fine trabecular
- Tactile analogue: Styrofoam

- Anatomic location: Posterior maxilla
- Hounsfield units: 150 - 350



### Bone density determination

<p><b>1. Computerized topography (CT) scan</b></p>	<ul style="list-style-type: none"> <li>• Useful to check for bone density at edentulous sites for treatment planning, before implant placement etc</li> <li>• It gives a 3D volume, bone density, defects, simulation of implants</li> <li>• Measured in Hounsfield units</li> </ul>
<p><b>2. Tactile determination during bone drilling</b></p>	<ul style="list-style-type: none"> <li>• During pilot drilling bone density can be determined by tactile sensation</li> <li>• For higher density bones: higher speed and pressure are needed</li> <li>• Limitations: Perception varies in individuals, needs a lot of experience</li> </ul>

### DENSE COMPACT (D1) BONE

- This homogenous compact bone contains almost no trabecular bone.
- Being dense cortical, it is the hardest bone in the jaw showing the least amount of vascularity.
- Because of limited blood supply, this bone shows very poor bone regeneration capacity.
- Osteotomy should be prepared at higher speed and using a new drill, under maximum flow of chilled saline irrigation to reduce heat generation and bone necrosis.
- This bone type is most commonly found in the mandibular anterior region



Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Strongest bone in the mouth</li> <li>• Implant achieves highest primary stability</li> <li>• Implant achieves higher bone-implant surface contact (BIC) percentage</li> <li>• Fewer implants can be inserted to support a multiple unit prosthesis</li> <li>• Requires only 3 – 4 months for primary healing of implants (osseointegration)</li> <li>• One-stage non-submerged surgical protocol can be practised in most cases</li> <li>• Immediate loading protocol can be practised in selective cases</li> <li>• Progressive bone loading is not required.</li> </ul>	<ul style="list-style-type: none"> <li>• Least amount of vascularity</li> <li>• Slow lamellar bone formation</li> <li>• Chances of bone overheating during osteotomy preparation are very high and may lead to osteonecrosis</li> <li>• Highest rate of failure in implant surgery</li> <li>• Longest time taken for implant placement</li> <li>• Requires drilling at high speed (2500 rpm) using new drills</li> <li>• Requires tapping (thread forming) for implants with non-cutting threads</li> <li>• May require crestal bone modification/drilling for the implant with broader platform than the implant body, to reduce incidence of mechanical overload during its insertion at crest.</li> </ul>

### Osteotomy preparation in D1 bone:

- First drill : 2 mm diameter, 2000rpm
- Provide external or internal irrigation
- Use intermittent pressures (bone dances)

- Give pause for 3-5minutes
- Use new drills
- Drill sequence should be incremental
- Minimal reflection of flap
- Final osteotomy drill should have greater width, height at a slower speed, depth slightly shorter (allows passive fit of implant)
- Implant placement: unthread 1/2 turn to relieve internal stress
- Healing: Slower, minimum 5 months is needed to achieve implant interface maturity
- May give immediate loading after 3 - 4months

### **DENSE TO THICK POROUS COMPACT AND COARSE TRABECULAR (D2) BONE**

- This bone shows a thick layer of compact bone surrounding a core of dense trabecular bone
- Excellent vascularity and osseous healing capacity.
- Most commonly found in the mandibular anterior and posterior regions but may also be present in the maxillary anterior region.
- Ideal implant dimension is 4mm diameter, 12mm height



#### **Advantages**

- Excellent healing at implant surface
- Secure initial rigid interface
- Intrabony blood supply

#### **Osteotomy preparation of D2 bone**

- External irrigation used
- Rotation speed: 2500 rpm
- Pauses for every 5 - 10 seconds (pumping motion)
- Drill sequence is similar to D1 bone

- Crestal bone drills should be used to reduce trauma mechanically
- Bone tap engages lateral or apical cortical bone
- Healing:
  - Excellent blood supply
  - Initial fixation is rigid
  - Healing interval is 4 months
  - Lamellar bone interface < 60%
- Can place abutment

### POROUS COMPACT AND FINE TRABECULAR (D3) BONE



- Composed of the thinner porous compact bone and fine trabecular bone.
- This bone density provides the surgeon with a tactile sense similar to drilling in balsa wood.
- Usually found in the anterior or posterior maxilla or in the posterior mandible.
- The porous compact layer is thinner on the labial aspect of the maxilla and the fine trabecular pattern is more discrete in wider edentulous sites.
- Ideal implant dimension is 4mm diameter with 12 mm height
- Implant body has to be roughened by acid etching

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Excellent blood supply</li> <li>• Time and difficulty for preparation is minimal</li> <li>• Highest survival rate</li> </ul>	<ul style="list-style-type: none"> <li>• Anterior maxilla is narrow</li> <li>• Osteotomy may cause lateral perforations, apical perforations</li> <li>• Implant placement can be done only once, in level with crestal bone</li> <li>• Longer healing period: 6 months</li> </ul>

### Implant designs should be

- Hydroxyapatite coated

- Threaded
- Surface area should be greater
- Press fit

### FINE TRABECULAR (D4) BONE



- Very light density and little to no cortical crestal bone.
- It is the complete opposite spectrum of dense compact (D1) bone.
- The most common location for this type of bone is the posterior maxilla of the long-term edentulous patient.
- These edentulous ridges are often very wide but have reduced vertical height.
- Ideal implant height is 14 mm (minimum 12 mm)
- The tactile sense of this bone is similar to Styrofoam

### Disadvantages

- Obtaining rigid fixation is difficult
- Rotating drill should not be used apart from pilot drill
- Osteotomes can be used to compress osteotomy sites
- Number of implants should be more to improve load distribution
- No cantilever

### CONCLUSION

- Densities vary depending on the location of edentulous ridge and the period of edentulousness
- D1 is the strongest bone and 10 times greater than D4
- Additional bone healing and incremental bone loading will improve bone density

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*Please Give Your Feedback on this Answer*

**CAD CAM applications in prosthodontics (7M)****CONTENTS/SYNOPSIS**

- Introduction
- Objectives of CAD/CAM technology
- Components of CAD CAM systems
  - Scanner/ Data collecting tool
    - Optical scanning devices
    - Mechanical scanning devices
  - Design software
  - Processing devices
    - Milling variants
    - 3D printing
    - Selective laser sintering
    - Steriolithography
- Stages in fabrication of prosthesis using CAD/CAM technology
  - Computer surface digitization
  - Computer aided designing
  - Computer assisted manufacturing
- Applications of CAD/CAM
  - In Fixed prosthodontics
  - In maxillofacial prosthodontics
  - In removable partial denture prosthesis
  - In implant prosthodontics
  - Surgical guides fabrication
- Advantages of CAD/CAM systems
- Limitations of CAD/CAM systems
- Conclusion
- References

## INTRODUCTION

- CAD/CAM is acronym of computer aided designing and computed assisted manufacturing.
- Currently it has become extremely popular and widely being used in all dental laboratories and offices to design and fabricate various prosthetic restorations.

## HISTORY

- CAD/CAM technology was introduced in the year 1989 by Mormann & Brandestinni in Germany
- Dr Duret - developed Sopha system
- Dr Moermann - developed CEREC system
- Dr Andersson - developed Procera system

## OBJECTIVES OF CAD CAM TECHNOLOGY

- It aims towards eliminating the traditional impression methods by designing and machining the restoration with the aid of computer
- To produce chair side restorations
- To improve the qualities of restoration

## COMPONENTS AND STAGES OF CAD/CAM SYSTEM

- There are three stages in fabrication of the prosthesis
    - Computer surface digitization
    - Computer aided designing
    - Computer assisted manufacturing
  - Consists of three components
    - Scanner/ Data collecting tool
    - Design software
    - Processing devices
- The first stage is the computer surface digitization. It consists of collection data using scanners

### I. Scanner

- It includes the data collection tools that measures the jaw and tooth structures in three dimension and transfers them into digital data sets
- The technique of surface digitization is divided into two categories:

1. Optical scanning devices	2. Mechanical scanning devices
<ul style="list-style-type: none"> <li>It collects data of 3D structures in triangulation procedure</li> <li>The source of light and the receptor unit are in a definite angle to each other</li> <li>White light projections or a laser beam can act as source of illumination</li> <li><b>Examples:</b> Lava Scan ST (3M ESPE, white light projections), es1 (etkon, laser beam)</li> </ul>	<ul style="list-style-type: none"> <li>The master cast is read mechanically line by line using a ruby ball and three dimensional measurements are made</li> <li><b>Example:</b> Procera scanner from Nobel Biocare</li> <li>It is a highly accurate scanner with the diameter of the ruby ball set to the smallest grinder in milling system</li> <li><b>Drawbacks:</b> <ul style="list-style-type: none"> <li>Expensive</li> <li>Processing time is longer</li> </ul> </li> </ul>

- Different types of technologies available for computer surface digitization:
  - Optical camera
  - LASER surface scanning device
  - Three dimensional scanning device (digitizer),
  - Photogrammetry
  - Moire fringe displacement
  - Computed tomography (CT scan)
  - Magnetic resonance imaging (MRI)
  - 3D ultrasonography

- The second stage is computer aided designing.
- Once the design is captured through surface digitization 3d processing is done and digitized data is entered into computer
- Finally curve smoothening, data reduction and blocking of undercuts is done at this stage

## II. Design software

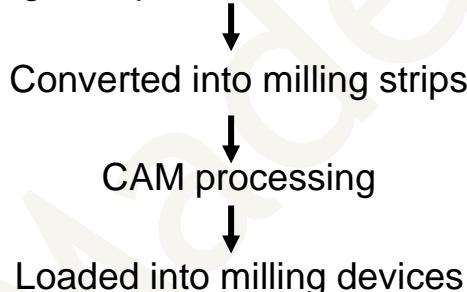
- Designing softwares are used to construct crowns and fixed partial dentures
- Few systems have features to design full coverage crowns, partial crowns, inlay retained FPDs and telescopic primary crowns

- The data available to construct these designs are stored in several data formats
- The basis for all this data is standard transformation language (STL) data
- Several manufacturers use their own data formats based on their specific

- Final stage is computer aided manufacturing.
- In this stage milling is done with computerized electrically driven diamond disks or burs which cut the ingots, also called subtractive method
- Additive methods are rapid prototyping, selective laser sintering in which there is no remaining excess material.
- Few CAD/CAM systems have combination of both the methods

### III. Processing devices

The designing data produced with the CAD software



- Processing devices are distinguished based on number of milling axes
  - 3 axis devices
  - 4 axis devices
  - 5 axis devices

#### 1. Milling variants

<i>i. Dry processing</i>	<i>ii. Wet processing</i>
<ul style="list-style-type: none"> <li>• Used for zirconium oxide blanks with a low degree of presintering</li> </ul> <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• Minimal investment costs for the milling device</li> <li>• Moisture absorption by the zirconium oxide die is nil</li> </ul>	<ul style="list-style-type: none"> <li>• In this process the diamond or carbide cutter used are protected by a spray of cool liquid against overheating of milled material</li> </ul> <p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>• Used for all metals and glass ceramics</li> </ul>

**Disadvantages:**

- Frameworks undergo higher shrinkage

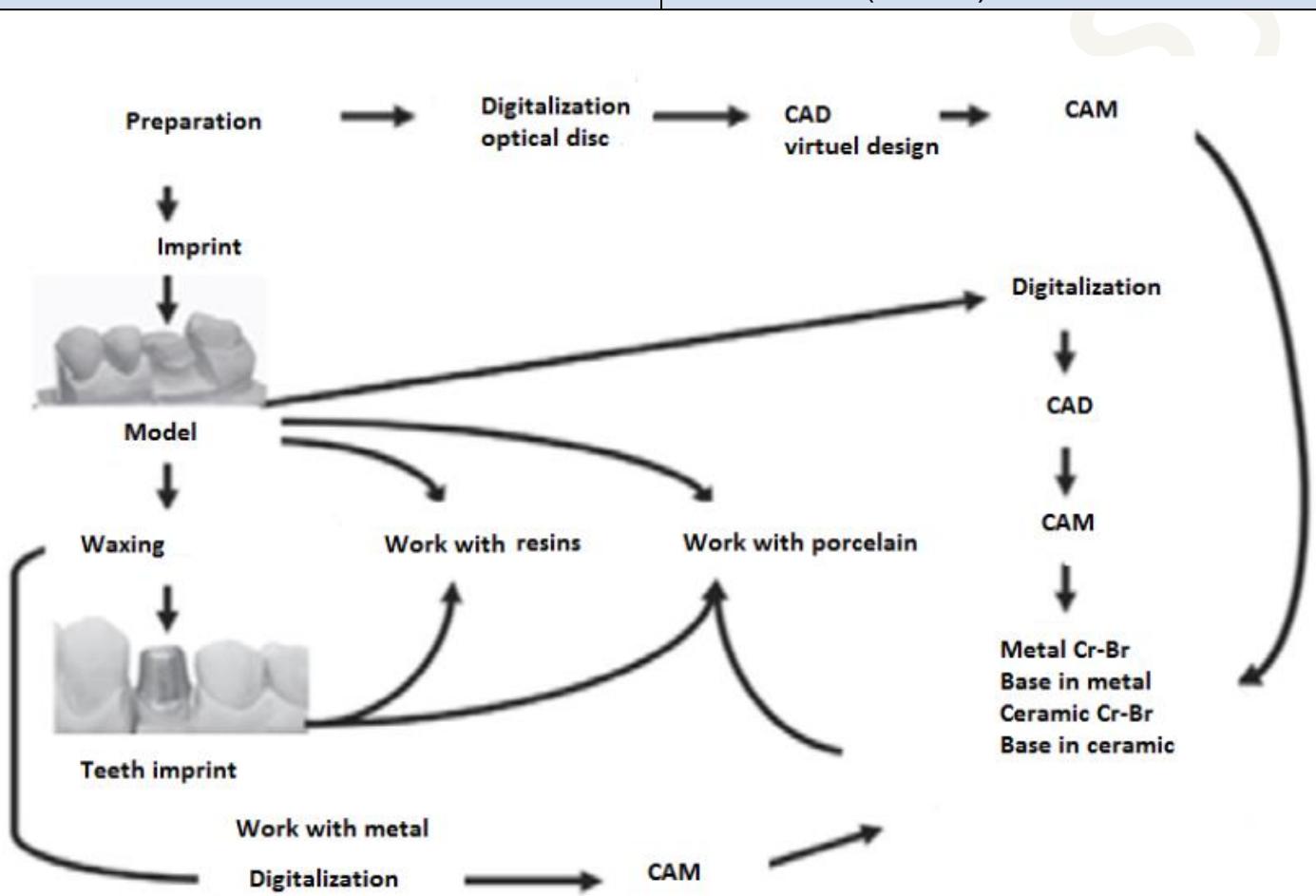
**Examples:**

- Zeno 4030 (Wieland - Imes)
- Lava form and Cercon brain

- Prevents damage due to heat development
- If Zirconium oxide ceramic is used wet processing is recommended

**Examples:**

- Everest (KaVo)
- Zeno 8060 (Wieland - Imes)
- inLab (Sirona)



**2. 3D printing**

- It is a manufacturing approach to build object by adding layer by layer at a time
- Also called as additive manufacturing or rapid prototyping
- Used for fabrication of metal crowns or cores either directly or indirectly.

**3. Selective sintering**

**laser**

- Scanning laser fuses fine material powder to build up structures layer by layer.
- A resolution of 60µm can be obtained

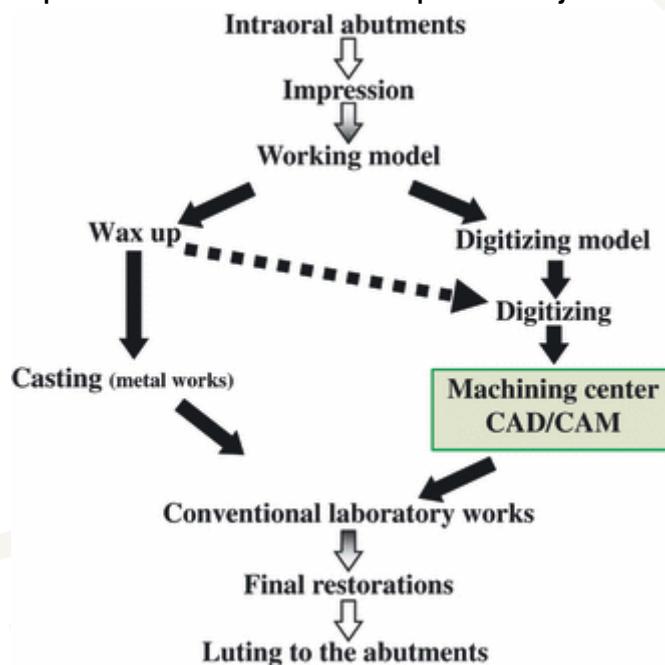
#### 4. Steriolithography

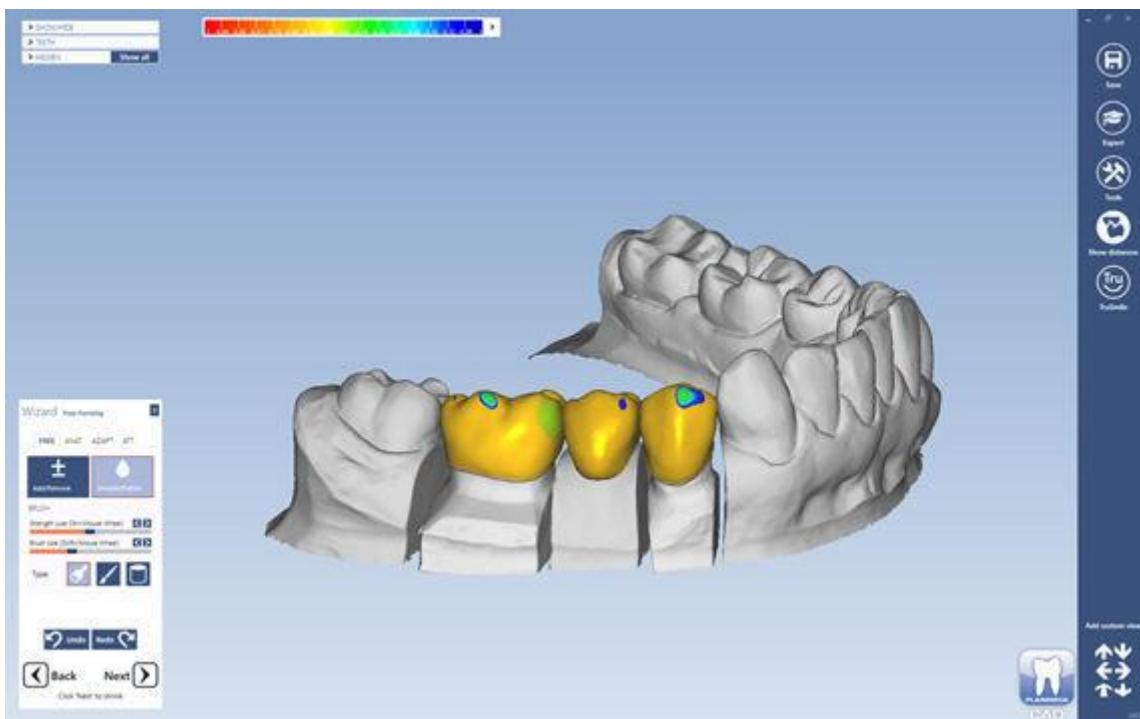
- Invented by Charles Hull
- It is an additive manufacturing technique in which light sensitive polymer is used and cured as layers using ultraviolet laser
- Widely used in rapid prototyping technology

### APPLICATIONS OF CAD CAM TECHNOLOGY

#### I. In Fixed prosthodontics

- The dies of prepared tooth are placed in the scanning platform and data is captured with a non contact laser.
- Using this information, after designing in software a ceramic ingot is placed in the milling chamber.
- Milling diamonds fabricate a precise restoration followed by porcelain build up.
- Fit is confirmed in patients mouth and required adjustments are done





Designing of FPD using CAD software

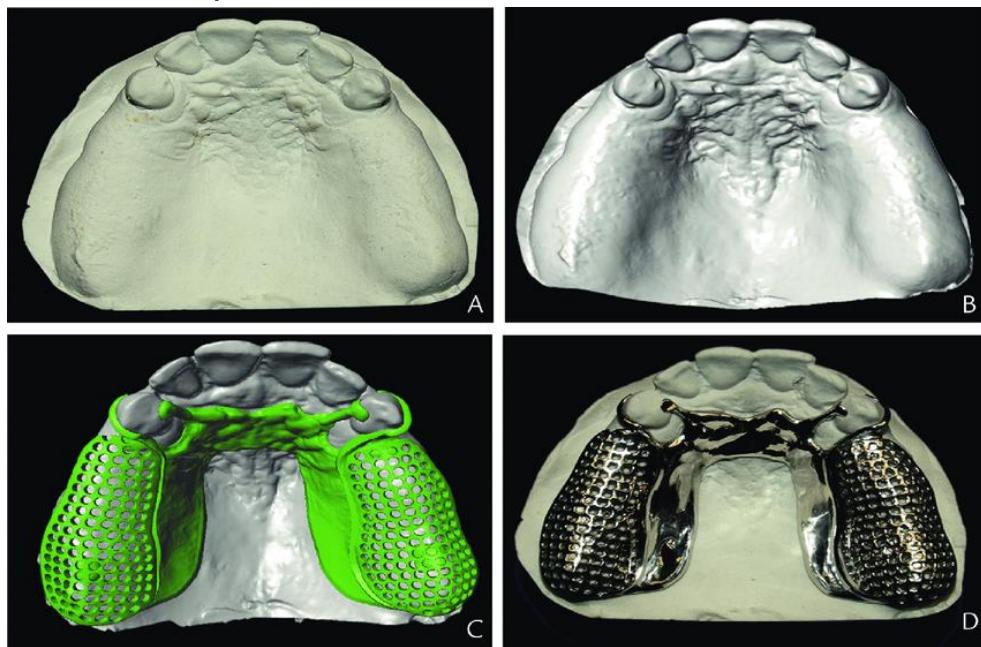
## II. In maxillofacial prosthodontics

- CAD/CAM is widely in use for the fabrication of maxillofacial prosthesis, extraoral radiation devices, customized respiratory masks and facial protection devices.
- 3D images are made by CAD software and surface imaging aids in fabrication of resin modes using lithographic technique and then followed by fabrication of wax pattern
- After trial, wax pattern is again imaged using scanners and 3D data is entered into computer followed by milling to fabricate a maxillofacial prosthesis



### III. In removable partial dentures

- Fabrication of cast partial dentures using Co-Cr alloys or pure titanium and Ti-6Al-4v alloys can be done by CAD/CAM technology
- Using CAD/CAM software a cast partial denture frame work can be fabricated using a 3D scan of patients cast

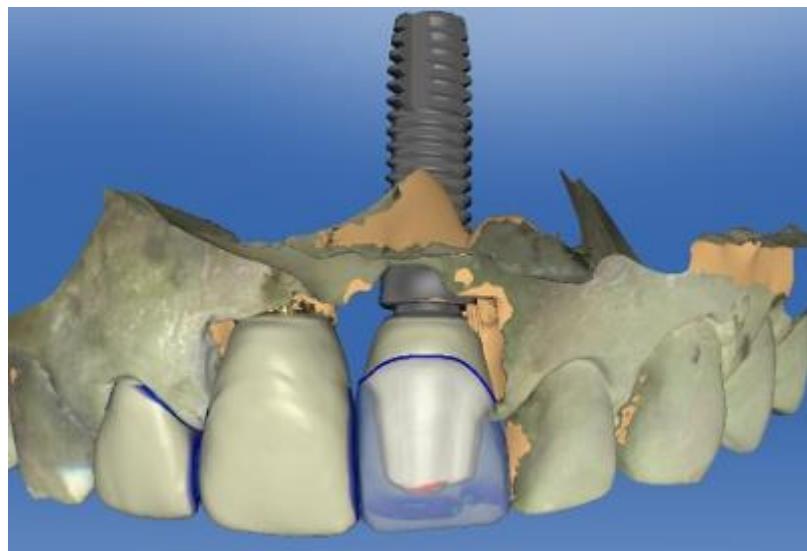


### IV. In implant prosthodontics

- Patient specific customized abutments can be fabricated to obtain accuracy and precision
- Abutments are milled using titanium, hence they have superior biocompatibility and best integration with implant fixtures

#### ***Advantages of CAD/CAM customized implant abutments are:***

- Precision
- Can be milled from titanium
- Coronal preparation will be ideal
- Perfect emergence profile with a shape like a natural tooth
- Correct path of insertion
- $6^{\circ}$  implant axis angle can be created
- Chair side time is reduced



## V. In fabrication of surgical guides

- SLM technology is used for fabrication of stainless steel surgical guides for dental implant placement

### ADVANTAGES OF CAD/CAM SYSTEMS

- Reduced number of appointments
- Simplified procedure
- High precision and accuracy
- Improved quality of restoration
- Chair side restorations can be fabricated
- No requirement of traditional impressions
- Eliminates the use of laboratory equipments and material consumption

### LIMITATIONS OF CAD CAM SYSTEMS

- Higher cost of CAD/CAM systems
- Technique sensitive
- Currently available systems cannot incorporate esthetic veneers with strong cores and frameworks

### CONCLUSION

- Though the CAD/CAM systems are costly, the advancement of these systems at their structural level, outweighs the level of precision and quality of restoration.

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*Please Give Your Feedback on this Answer*

## Denture stomatitis (7M)

### CONTENTS/SYNOPSIS

- Introduction
- Classification
- Etiology
  - Trauma
  - Microorganisms
  - Denture lining materials
  - Denture plaque
  - Denture bases: surface texture and permeability
  - Allergic conditions
  - Systemic factors
  - Local factors
- Clinical manifestations
- Investigations
- Management and preventive measures
- Conclusion
- References

## INTRODUCTION OF DENTURE STOMATITIS

- The word stomatitis means inflammation of oral mucosa
- Denture stomatitis is a pathological reaction of the denture bearing mucosa.
- Also called as denture induced stomatitis, Inflammatory papillary hyperplasia, denture sore mouth, chronic atrophic candidiasis.
- It is one of the common problems in elders wearing complete dentures , with palatal mucosa as common site
- Half of the patients wearing complete denture shows a prevalence of denture stomatitis.

## CLASSIFICATION

### I. According to Newton

Type I	<ul style="list-style-type: none"> <li>• Localized, simple inflammation or pin point hyperemia</li> </ul>
Type II	<ul style="list-style-type: none"> <li>• Generalized or erythematous, simple type with more diffuse erythema involving a part or the entire denture covered mucosa</li> </ul>
Type III	<ul style="list-style-type: none"> <li>• Granular type (inflammatory papillary hyperplasia) commonly involving the central part of the hard palate and the alveolar ridge</li> </ul>

- Type I is trauma induced whereas type II and III are plaque induced
- Candida associated denture stomatitis with angular cheilitis or glossitis: indicates the infection spread from mucosa covering denture to the angle of the mouth or tongue.



Type I



Type II



Type III

### II. According to Budtz - Jorgensen and Bertram (based on type of inflammation)

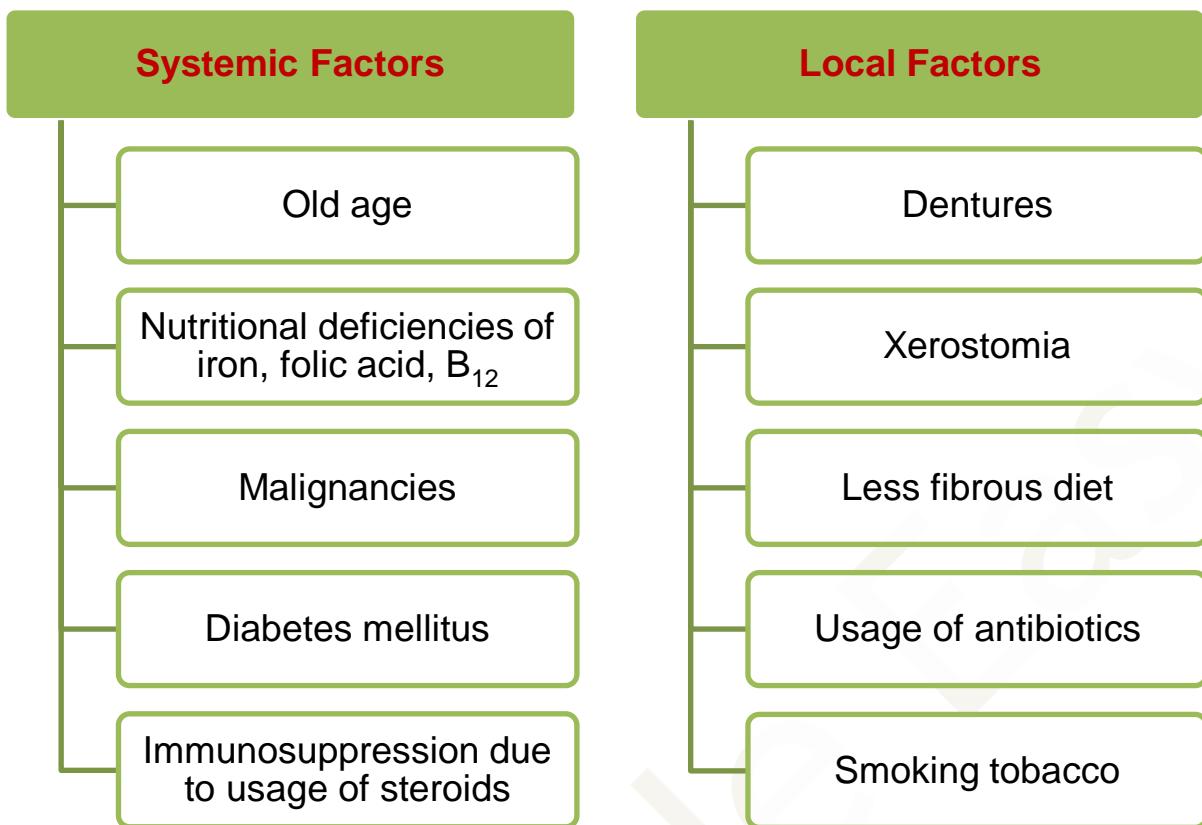
- Simple localized inflammation (Involves a limited area)
- Simple diffuse inflammation (Involves entire denture covering area)
- Granular inflammation (Localized to the central part of hard palate)

**ETIOLOGY**

- Denture stomatitis is a multifactorial originated pathology

<b>I. Trauma</b>	<ul style="list-style-type: none"> <li>• Trauma due to <u>functional deficiencies</u> in prosthesis           <ul style="list-style-type: none"> <li>➢ Ill fitting denture</li> <li>➢ Altered occlusion</li> <li>➢ Altered vertical dimension</li> <li>➢ Improper retention</li> <li>➢ loss of stability</li> </ul> </li> </ul>
<b>II. Microorganisms</b>	<ul style="list-style-type: none"> <li>• <u>Candida albicans</u> is the commonly associated fungal pathogen causing denture stomatitis (candida associated denture)</li> <li>• Denture induced stomatitis or chronic atrophic candidiasis is most common form of oral candidiasis of denture wearers</li> <li>• Denture stomatitis has been associated with           <ul style="list-style-type: none"> <li>➢ Angular cheilitis</li> <li>➢ Acute pseudo membranous candidiasis</li> <li>➢ Atrophic glossitis</li> </ul> </li> </ul>
<b>III. Denture materials lining</b>	<ul style="list-style-type: none"> <li>• <u>Denture liners</u> and <u>tissue conditioners</u> are used to treat traumatized denture bearing mucosa</li> <li>• Materials used commonly are: silicone elastomers, plasticized methacrylate polymers etc</li> <li>• Soft liners are associated with candidal growth, with most commonly detected yeast strains are C. albicans, C. glabrata and C. tropicalis</li> </ul>
<b>IV. Denture plaque</b>	<ul style="list-style-type: none"> <li>• <u>Poor denture hygiene maintenance</u> is one of the common factors of denture stomatitis.</li> <li>• Various factors stimulating plaque accumulation are           <ul style="list-style-type: none"> <li>➢ High carbohydrate diet</li> <li>➢ Wearing dentures day and night</li> <li>➢ Improper cleanliness of denture</li> <li>➢ Reduced salivary flow</li> <li>➢ Prosthesis design</li> </ul> </li> </ul>
<b>V. Denture base</b>	<ul style="list-style-type: none"> <li>• <u>Tissue surface of the denture base</u> usually</li> </ul>

	<p>consists of micro porosities which harbor microorganisms and is difficult to remove mechanically or chemically</p> <ul style="list-style-type: none"><li>• Several studies proved that microbial contamination of tissue surface of denture occurs very quickly leading to adherence of yeasts</li><li>• Surface roughness is also one more factor playing a role in microbial retention and infection</li><li>• According to van reenen, <i>Candida albicans</i> penetrates through unpolished surface of the acrylic denture base easily than the polished surface</li></ul>
<b>VI. Allergy</b>	<ul style="list-style-type: none"><li>• <u>Residual monomers</u> or <u>unreacted materials</u> leaching through the denture base may cause reactions to few patients</li><li>• Eg. Resin monomer, hydroquinone peroxide, dimethyl-p-toulidine, methacrylate denture etc</li><li>• <u>Allergic responses are in the manner of localized or generalized stomatitis, dermatitis, severe toxic reactions, carcinogenic or mutagenic effects</u></li><li>• <u>Contact sensitivity</u> are commonly seen due to denture based resin materials</li><li>• Other forms of allergies are type IV hypersensitivity, urticaria, psoriasis etc</li></ul>



## CLINICAL MANIFESTATIONS

- Mucosa beneath the denture becomes red, extensively swollen, painful with either smooth or granular surface
- Multiple foci of hyperemia is seen in maxilla
- Burning sensation varying in severity is common
- Mucosa inflammation is sharply outlined and restricted to tissues that are in contact with dentures

## INVESTIGATIONS

- In case of candida associated denture stomatitis, a direct smear test (periodic acid - Schiff or KOH) / isolation is performed to confirm the presence of pseudo hyphae or mycelia (> 50 colonies).

## MANAGEMENT AND PREVENTIVE MEASURES

- Based on the source of infection, treatment procedures like correction of ill-fitting dentures, plaque control with effective oral hygiene instructions, antifungal therapy.

- Proper instructions should be given to patients about maintenance of denture like careful brushing and soaking dentures overnight in 0.1% aqueous chlorhexidine.
- Patients with recurrent infections are advised to stop the usage of dentures followed by medications and instructed to a meticulous oral hygiene measure
- Local therapy using nystatin, amphotericin B, miconazole or ketoconazole are preferred than systemic administration of antifungal drugs.
- In case of type III denture stomatitis, surgical removal of the papillae is advised to ensure effective mucosal hygiene.

## CONCLUSION

- Denture stomatitis is a multifactorial pathology and the treatment differs depending on the cause of the disease.
- In most patients the elimination of mechanical and traumatic factors, administration of local antifungal therapy and following proper oral hygiene protocols enables the inflammatory lesions to heal rapidly.

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**Please Give Your Feedback on this Answer**

**Write briefly about geriatric nutrition (7M) (10M)**

**Role of nutrients in geriatric oral health care (6M)**

**Diet for new complete denture patient (7M)**

**Importance of balanced diet in complete denture patients (7M)**

**Nutrition in geriatric patients (7M) (6M) (20M)**

### CONTENTS/SYNOPSIS

- Introduction
- Objectives of nutrition
- Factors affecting nutrition in elderly patients
- Nutritional needs of the elderly
  - Energy values of foods and nutrients
  - Energy needs of the Body
    - Basal metabolism and Basal Metabolic Rate
    - Physical activity
    - Environmental temperature
    - Specific Dynamic Action (SDA) of Food
- Classification of foods
- Recommended dietary allowances (RDA)
  - Calories
  - Carbohydrates
  - Protein
  - Fats
  - Vitamins
  - Minerals
  - Water
  - Recommended Dietary Allowances for the Elderly
- Balanced diets (Indian) for old people over 60 years
  - Balanced diets at high cost
  - Balanced diets at moderate cost
  - Balanced diets at low cost
- Food recommended for the elderly
  - The five food groups

- Vegetable Fruit Group
- Bread - Cereal Group
- Milk - Cheese group
- Meat, Poultry, Fish and Beans Group
- Fats, Sugar and Alcohol Group
- Food Guide Pyramid.
- Procedure for Nutritional guidance of the elderly
- Nutritional deficiency
  - Clinical signs of Nutritional Deficiency
    - Physical signs of Nutrient Deficiencies
    - Effect of nutritional deficiency in oral health of elderly
- Dietary counseling of prosthodontic patients
  - Risk factors for malnutrition in denture patients
  - Nutrition guidelines for prosthodontic patients
- Dietary suggestions for denture wearers.
  - Modification of food selection and food habits
  - Helping new denture wearers learn to chew
    - Biting or incising
    - Chewing or pulverizing
    - Swallowing.
  - Diet for the first day after denture insertion
  - Diet for the second and third days after denture insertion
  - Diet for the fourth day and later
- Conclusion
- References

## INTRODUCTION

- Proper nutrition is essential to maintain health and comfort of oral tissues and to enhance the prognosis of prosthodontic treatment in elderly
- In patients with complete or partial loss to maintain or restore masticatory function, prosthodontic management is important. However, factors like nutritional aspects also play a role in maintenance

## OBJECTIVES OF NUTRITION

- To establish a balanced diet
- To provide temporary dietary supportive treatment
- To predict factors related to denture age groups

## FACTORS THAT AFFECT NUTRITIONAL STATUS

<b>I. Physiological factors</b>	<ul style="list-style-type: none"> <li>• Decline in lean body mass in elderly leads to a decline in the need of calories</li> <li>• Metabolic bone diseases due to vitamin D deficiency</li> <li>• Decrease in gastric secretion leads to malabsorption of essential vitamins like B12</li> <li>• Dehydration causes kidney problems and disturbances in water metabolism</li> </ul>
<b>II. Psychological factors</b>	<ul style="list-style-type: none"> <li>• Elders living alone, physically handicapped with improper care, chronic diseases, reduced economic status are under nutritional deficit risk</li> </ul>
<b>III. Functional factors</b>	<ul style="list-style-type: none"> <li>• Disabilities like arthritis, stroke, hearing, vision impairment may affect nutritional intake</li> </ul>
<b>IV. Pharmacological</b>	<ul style="list-style-type: none"> <li>• Elders commonly take several medications which have side effects like nausea, vomiting, gastrointestinal problems etc which ultimately leads to malnutrition</li> </ul>

## NUTRITIONAL NEEDS OF THE ELDERLY

### I. Energy values of foods and nutrients

- Energy is of prime importance in the life processes
- The study of nutrition is about how the human body metabolizes or transforms the elements of food into energy.
- The energy from food is made available to the body in four basic forms:

- Chemical, for synthesis of new compounds
- Mechanical for muscle contraction
- Electrical, for brain and nerve activity and
- Thermal for regulation of body temperature.
- In nutrition, energy is measured in kilocalories (kcal, formerly calories, or large calories), which provide 1000 times the heat of the gram (g), or small calorie, used in chemistry.
- Thus the nutritional kilocalorie is defined as the amount of heat required to raise the temperature of 1 kilogram (kg) (2.2 lb) of water by  $1^{\circ}\text{C}$  (from 14.5 to  $15.5^{\circ}\text{C}$ ).

## II. Energy needs of the Body

- The overall energy needs of the body are calculated to be the sum of three factors
  - Basal metabolism
  - Energy for physical activity,
  - A small amount of additional energy spent during digestion and absorption of carbohydrates, proteins, and fats in the gastrointestinal tract, called the specific dynamic action, or SDA of food.

Energy requirement = basal metabolism + physical activity + SDA.

<b>1. Basal metabolism and Basal Metabolic Rate</b>	<ul style="list-style-type: none"><li>• The basal metabolic rate (BMR) is defined as the number of kilocalories expended by the organism per square meter of body surface per hour (kcal/m<sup>2</sup>/hour).</li><li>• It is determined by body size, age, sex, and secretions of endocrine glands.</li></ul>
<b>2. Physical activity</b>	<ul style="list-style-type: none"><li>• Muscular activity affects both energy spent and heat production.</li><li>• Energy expenditure increases with muscular activity.</li></ul>
<b>3. Environmental temperature</b>	<ul style="list-style-type: none"><li>• Environmental temperature is an important factor in heat production.</li><li>• When the body is exposed to a low environmental temperature, it automatically</li></ul>

	produces more heat to maintain normal body temperature.
<b>4. Specific Dynamic Action (SDA) of Food</b>	<ul style="list-style-type: none"> <li>Specific dynamic action (SDA) is the term used to describe the expenditure of calories during the digestion and absorption of food.</li> </ul>

## CLASSIFICATION OF FOODS

- By origin
  - Plant food  
Example: Cereals, legumes, fruits, vegetables, sugars, oils.
  - Animal products  
Example: Meat, fish, milk, dairy products, eggs, poultry products.
- By chemical composition
  - Macronutrients
    - Proteins
    - Fats
    - Carbohydrates
  - Micronutrients
    - Vitamins
    - Minerals
- By predominant function
  - Body building foods (Proteins)
  - Energy giving foods (Carbohydrates, fats)
  - Protective foods (Minerals, vitamins)

## RECOMMENDED DIETARY ALLOWANCES (RDA)

- The recommended dietary allowances (RDA, s) are standards commonly agreed upon for assessing and planning to meet nutrient needs at various ages.
- RDA for the elderly currently are based on information from the nutrients and calorie needs of adults up to the age of 50.
- RDA includes two age groupings for energy allowances
  - Persons aged 51 to 75 and
  - Persons aged 76 or older.

- But the RDA for vitamins and minerals includes only one age grouping; those aged 51 and older.

## I. Calories

- With an advancing age there is a decrease calorie requirements due to reduced energy expenditures and a decrease in basal metabolic rate.
  - It has been suggested that energy allowances for persons between 51 and 75 years be reduced by 10% of the amount required as a young adult and
  - For those over 75 years, by 20-25%.
- Several studies show that the average energy consumption of 65 to 74 year old women is about 1300 kilo calories (kcal) and 1800 (kcal) for men of the same age.

## II. Carbohydrates

- They are primary source of energy for most individuals.
- There is no specific dietary requirement for carbohydrates but the recommended range of intake is 50-60% of total calories.
- **Food sources include:** grains and cereals, vegetables, fruits and dairy products.

- Complex carbohydrates like fibers:
  - Promotes normal bowel function
  - Reduce serum cholesterol
  - Prevents diverticular disease.
  - Lowers glycemic response, hence positively affect non-insulin dependent diabetes mellitus.
  - Prevention of cancer of the colon, Crohn's disease and gallstones.

- The best means of reducing calorie intake is to replace foods high in simple sugar and fat with complex carbohydrates (starchy grains and vegetables).

## III. Protein

- Healthy elderly persons require lesser protein to maintain a positive nitrogen balance than younger individuals.

- Old people who are healthy and active require a protein intake of 1g/kg of body weight.
- The 1980 RDA figure, which is 0.8gm/kg wt for those 51 years and over, must be regarded as absolute minimum.
- The protein proportion of energy intake in elderly individuals should be at least 12-14%.
- **Food sources of protein include animal foods:** meat, fish poultry and dairy products. Nuts, grains, legumes and vegetables contain incomplete protein, which, if eaten in the proper combination, is of the same quality as animal sources of protein.

#### IV. Fats

- Fats contribute about 34% of total calories in the diet of the normal adult.
- The energy value of fat is twice that of carbohydrate and protein high fat intakes are undesirable in any age group especially the elders.
- Evidence says that there is a connection between dietary intake of saturated fat, cholesterol, and occurrence of hyperlipidemias, cardiovascular problems, non-insulin dependent diabetes, cancers, and obesity.
- National cholesterol education program of national heart blood and lung institute recommends fat intake to 30% of total calories.
- They also recommend calculating fat intake as a percentage of total calories based on the type of fatty acids found in food as follows,
  - Saturated fats: 8 to 10% of total calories
  - Monounsaturated fats: up to 15% and
  - Polyunsaturated fats: up to 10%
- **Food sources:**

- Highly saturated fats are found in animal fat
- Monounsaturated or polyunsaturated fats are found in liquid oils of vegetable origin such as olive oil and canola oil are recommended because they depress low-density lipoprotein without lowering high-density lipoprotein as polyunsaturated fats do.
- Sources are animal foods, such as dairy products, butter, meats, fish poultry, nuts oils and margarine.

## V. Vitamins

- Vitamin deficiencies in the elderly are apt to be subclinical, but body stress may develop detectable symptoms.
- Individuals who have low calorie intakes, ingest multiple drugs, or have disease states that cause Malabsorption are at greatest risk of hypovitaminosis.
- Among the vitamins that may be particularly low are vitamins A, D, C, B<sub>6</sub>, folic acid and riboflavin.

Vitamin and its sources	RDA
<b>1. Vitamin C (Ascorbic Acid)</b> <ul style="list-style-type: none"> <li>• Abundantly seen in citrus fruits, gooseberries, guava, melons, sprouting seeds, leafy vegetables, spinach, cauliflower, cabbage, tomatoes and drumstick</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 35 mg</li> <li>• Children: 40mg</li> <li>• Adults: 45mg</li> <li>• Pregnant women: 60mg</li> <li>• Lactating Women: 80mg</li> </ul>
<b>2. Vitamin B1 (Thiamine)</b> <ul style="list-style-type: none"> <li>• Cereals, pulses, oil seeds, nut and yeast are good sources.</li> <li>• Thiamine is mostly concentrated in the outer layer (bran) of cereals.</li> <li>• Also present in animal foods like pork, liver, heart, kidney, milk etc</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 0.3-0.5 mg</li> <li>• Children: 0.7-1.2mg</li> <li>• Adults: Males - 1.2-1.5mg, Females: 1.0-1.1mg</li> <li>• Pregnant women: 1.3-1.5mg</li> <li>• Lactating Women: 1.3-1.5mg</li> </ul>
<b>3. Vitamin B2 (Riboflavin)</b> <ul style="list-style-type: none"> <li>• Milk and milk products, meat, eggs, liver kidneys are rich in sources</li> <li>• Cereals, fruits, vegetable and fish have moderate sources</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 0.4-0.6 mg</li> <li>• Children: 0.8-1.2mg</li> <li>• Adults: Males1.5-1.8mg, Females 1.1-1.4mg</li> <li>• Pregnant women: 1.4-1.7mg</li> <li>• Lactating Women: 1.6-1.9mg</li> </ul>
<b>4. Vitamin B3 (Niacin)</b> <ul style="list-style-type: none"> <li>• The rich natural sources of niacin include liver, yeast, whole grains, pulses like beans and peanuts</li> <li>• Milk, fish, eggs and vegetables are moderate sources</li> </ul>	<ul style="list-style-type: none"> <li>• Infants: 0.4 - 0.6 mg</li> <li>• Children: 0.8 - 1.2mg</li> <li>• Adults: Males1.5- 1.8mg, Females 1.1-1.4mg</li> <li>• Pregnant women:1.4 - 1.7mg</li> <li>• Lactating Women: 1.6 - 1.9mg</li> </ul>
<b>5. Vitamin B5 (Pantothenic acid)</b>	<ul style="list-style-type: none"> <li>• Infants: 0.4 - 0.6 mg</li> </ul>

<ul style="list-style-type: none"> <li>Widely distributed in plants and animals.</li> <li>Rich sources are egg, liver, meat, yeast, milk etc.</li> </ul>	<ul style="list-style-type: none"> <li>Children: 0.8 - 1.2mg</li> <li>Adults: Males 1.5-1.8mg, Females 1.1-1.4mg</li> <li>Pregnant women: 1.4 - 1.7mg</li> <li>Lactating Women: 1.6 - 1.9mg</li> </ul>
<b>6. Vitamin B6</b> <ul style="list-style-type: none"> <li>Animal sources such as egg yolk, fish, milk, meat are rich in B6</li> <li>Wheat, corn, cabbage, roots and tubers are good vegetable sources</li> </ul>	<ul style="list-style-type: none"> <li>Infants: 0.3 mg</li> <li>Children: 0.6 - 1.2mg</li> <li>Adults: Males 1.6 - 2.0mg, Females 1.6 - 2.0mg</li> <li>Pregnant women: 2.5mg</li> <li>Lactating Women: 2.5mg</li> </ul>
<b>7. Vitamin B7 (Biotin)</b> <ul style="list-style-type: none"> <li>Biotin is widely distributed in both animal and plant foods</li> <li>The rich sources are liver, kidney, egg yolk, milk, tomatoes, grains</li> </ul>	<ul style="list-style-type: none"> <li>100-300 mg for adults, but this vitamin is abundantly synthesized by the intestinal bacteria</li> </ul>
<b>8. Folic acid</b> <ul style="list-style-type: none"> <li>The rich sources are green leafy vegetables, whole grains, cereals, liver, kidney, yeast and eggs</li> </ul>	<ul style="list-style-type: none"> <li>Infants: 50µg</li> <li>Children: 100 - 300µg</li> <li>Adults: Males 400 µg, Females 400 µg</li> <li>Pregnant women: 800µg</li> <li>Lactating Women: 600 µg</li> </ul>
<b>9. Vitamin B12 (Cyanocobalamin)</b> <ul style="list-style-type: none"> <li>Not seen in plant foods.</li> <li>Animal sources are liver, kidney, eggs, milk, and meat</li> </ul>	<ul style="list-style-type: none"> <li>Infants: 0.3µg</li> <li>Children: 1 - 2µg</li> <li>Adults: Males 3.0µg, Females 3.0µg</li> <li>Pregnant women: 4.0µg</li> <li>Lactating Women: 4.0µg</li> </ul>
<b>10. Vitamin D</b> <ul style="list-style-type: none"> <li>Mainly formed by action of UV rays on 7-DHC in SKIN</li> <li>First hydroxylated in Liver to 2-5 HCC which is main storage and circulatory form of vitamin D</li> <li>Later hydroxylated again in Kidney to</li> </ul>	<ul style="list-style-type: none"> <li>Adults: 2.5µg</li> <li>Lactating mother, pregnancy, adolescent and infants: 5µg</li> <li>1µg = 40 I.U</li> </ul>

<p>1,25 DHCC (calcitriol)</p> <ul style="list-style-type: none"> <li>• Ergocalciferol (D2) is found mainly in plants</li> <li>• Fish and poultry – cod liver oil, shark liver oil &amp; egg yolk</li> <li>• Fats and edible oils: ghee and Butter</li> </ul>	
<p><b>11. Vitamin A</b></p> <ul style="list-style-type: none"> <li>• Retinol is found in foods of animal origin, while carotene is found in both plant and animal sources.</li> <li>• Cereals and pulses: Red gram, soya beans</li> <li>• Vegetables: Carrots, green leafy vegetables and spinach</li> <li>• Fruits: Papaya, tomato, mango and raspberries</li> <li>• Animal sources: Sheep liver, cow's milk, fish liver oils</li> <li>• Fats and edible oils: Butter, hydrogenated oil and ghee</li> </ul>	<ul style="list-style-type: none"> <li>• Requires a small amount for normal functioning of the visual system, maintenance of cell function for growth, red blood cell production &amp; epithelial integrity</li> </ul>
<p><b>12. Vitamin E</b></p> <ul style="list-style-type: none"> <li>• Vegetable oils: wheat germ, sunflower, safflower and soyabean oils</li> <li>• Whole grain cereals</li> <li>• Animal meat and eggs</li> </ul>	<ul style="list-style-type: none"> <li>• Men: 8-10 mg</li> <li>• Women: 5-8 mg</li> </ul>
<p><b>13. Vitamin K</b></p> <ul style="list-style-type: none"> <li>• Green vegetables like turnip, spinach, broccoli, cabbage</li> <li>• Produced by bacterial flora in gut</li> </ul>	<ul style="list-style-type: none"> <li>• Adults: 70-140 mcg</li> <li>• Children: 35 - 75 mcg</li> </ul>

### Hyper vitaminosis:

- Women taking multivitamin containing vitamin D and calcium supplements with vitamin D could exceed the maximum safe intake of vitamin D: 800 IU/kl or 20 $\mu$ g.
- Overdoses of vitamin D can lead to disturbances of calcium metabolism, leading to calcification of soft tissues

- Overdoses of Vitamin A, the other commonly ingested fat-soluble vitamin supplement, result in several cases of toxicity each year.
  - Long-term ingestion of vitamin A supplements containing 5 to 25 times the RDA has resulted in dry, itching skin, bone disorders, headaches, and disturbances blood clotting.
- Long term ingested fat-soluble vitamin supplements, result in several cases of toxicity each year.
- Chronic intake of overdoses of vitamin C can induce copper deficiency anemia, cause false positive reading for glucose in the urine, and increase the risk of urinary stone formation in susceptible individual.
  - Rebound scurvy may occur if high doses are stopped abruptly.
- A high niacin intake may result in flushing headaches, and itching skin.
  - Peripheral neuropathies have resulted from high vitamin B6 intakes for long periods of time

## VI. Minerals

<b>1. Zinc</b>	<ul style="list-style-type: none"> <li>Serum zinc levels of the elderly are lower than in younger adults.</li> <li>Zinc utilization declines with advancing age because intestinal absorption decreases after the age of 65 years.</li> <li><i>Clinical findings:</i> decreased taste acuity, mental lethargy, slow wound healing</li> <li><i>Sources:</i> animal products, whole grains and dried beans</li> </ul>
<b>2. Iron</b>	<ul style="list-style-type: none"> <li>Need for iron is decreased in females due to cessation of mensus, hence lower iron loss is seen after menopause</li> <li>Iron deficiency is uncommon among elderly except for individuals who have diseases that result in blood loss, such as ulcers.</li> <li>A high intake of aspirin may also cause gastric bleeding.</li> <li>R.D.A for iron is 10 mg. for adults over 50 years of age.</li> <li><i>Sources:</i> meat, fish, poultry, whole grains, fortified breads and cereals, green leafy vegetables, dried beans and peas.</li> </ul>

<b>3. Calcium</b>	<ul style="list-style-type: none"> <li>Required to maintain body skeleton</li> <li>RDA: 1000mg (25 - 50 years),</li> <li>For men &gt; 65 years and postmenopausal women: 1500 mg</li> <li>Sources: milk and milk products (hard cheese), dried beans and peas, canned salmon green leafy vegetables and tofu.</li> <li>To receive 1000 to 1500 milligrams of calcium, adults must drink three or four glasses of low fat milk per day, eat 5 to 7 oz of hard cheeses</li> </ul>
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- Mineral bioavailability is affected by the use of other minerals and fiber.
- High intake of zinc can reduce copper absorption and availability.
- A high fiber intake may bind calcium, zinc, and iron thereby limiting absorption of these minerals.
- Thus, the denture patient should be cautioned against indiscriminate use of mega doses of any nutrient or fiber.

## VII. Water

- Dehydration is a common concern in the elderly.
- Dryness of the oral mucosa, hypotension, elevated body temperature, decreased urine output and mental confusion may occur when fluid intake is inadequate.
- The prosthodontist should educate the patient about importance of consuming eight glasses of fluids daily.

### *Recommended Dietary Allowances for the Elderly*

	Men	Women
Age	51+	51+
Weight (kg)	70	55
(lb)	154	120
Height (cm)	178	163
(in)	70	64
Protein (g)	56	44
Vitamin A ( $\mu$ g RE)+	1000	800
Vitamin D ( $\mu$ g )+	5	5
Vitamin E (mg a-TE)	10	8
Vitamin C (mg)	60	60

Thiamine (mg)	1.2	1.0
Riboflavin (mg)	1.4	1.2
Niacin (mg NE)	16	13
Vitamin B6 (mg)	2.2	2.0
Folacin (μg)	400	400
Vitamin B12 (μg)	3.0	3.0
Calcium (mg)	800	800
Phosphorus (mg)	800	800
Magnesium	350	300
Iron (mg)	10	10
Zinc (mg)	15	15
Iodine (μg)	150	150

### BALANCED DIETS (INDIAN) FOR OLD PEOPLE OVER 60 YEARS

Type of Food	Males		Females	
	Veg	Non-Veg	Veg	Non-Veg
Cereals	320	320	220	220
Pulses	70	50	70	50
Green leafy vegetables	100	100	125	125
Other vegetables	75	75	75	75
Roots and tubers	75	75	50	50
Fruits	150	150	150	150
Milk	800	600	300	600
Fats and oils	30	30	30	30
Cheese	50	-	50	-
Meat and fish	-	100	-	100
Eggs	-	40	-	40
Sugar and jaggery	30	30	30	30

- I. Balanced diets at high cost:** These diets contain liberal amounts of milk and/or other foods of animal origin.
- II. Balanced diets at moderate cost:** These diets include only moderate quantities of milk and other animal foods.
- III. Balanced diets at low cost:** These diets contain only small quantities of milk and other animal foods.

One multivitamin mineral tablet is included to provide the essential vitamin and minerals.

## FOOD RECOMMENDED FOR THE ELDERLY

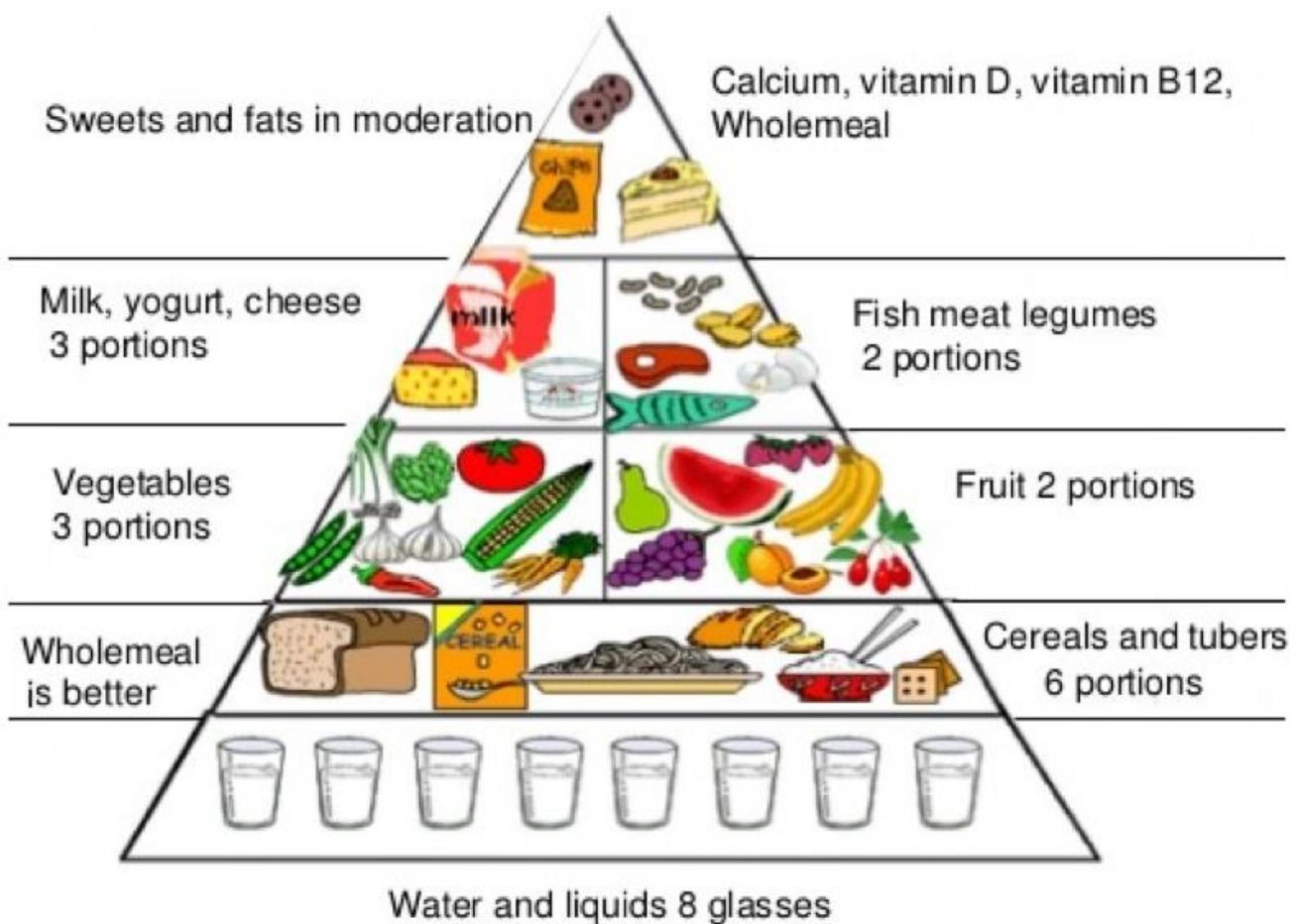
### The five food groups

- All the nutrients necessary for optimal health in the desirable amounts can be obtained by eating a variety of foods in adequate amounts from the five food groups. These are

<b>1. Vegetable    Fruit Group</b>	<ul style="list-style-type: none"> <li>• Four servings of vegetables and fruits, subdivided into three categories           <ul style="list-style-type: none"> <li>➢ Two servings of good sources of vitamin C, such as citrus fruits, salad greens, and raw cabbage</li> <li>➢ One serving of a good source of provitamins A, such as deep green and yellow vegetables or fruits</li> <li>➢ One serving of potatoes and other vegetables and fruits</li> </ul> </li> </ul>
<b>2. Bread - Cereal Group</b>	<ul style="list-style-type: none"> <li>• Four servings of enriched bread, cereals, and flour products</li> </ul>
<b>3. Milk - Cheese group</b>	<ul style="list-style-type: none"> <li>• Two servings of milk and milk based foods, such as cheese (but not butter)</li> </ul>
<b>4. Meat, Poultry, Fish and Beans Group</b>	<ul style="list-style-type: none"> <li>• Two servings of meats, fish poultry, eggs, dried beans and peas, and nuts</li> </ul>
<b>5. Fats, Sugar and Alcohol Group</b>	<ul style="list-style-type: none"> <li>• Additional miscellaneous foods, including fats and oils, sugar and alcohol; the only serving recommendation is for about 2 to 4 tablespoons of polyunsaturated fats, which supply essential fatty acids.</li> </ul>

- In 1992, the U.S. Department of Agriculture developed the Food Guide Pyramid.
- This replaces the former basic four model of milk, fruits and vegetables, and grains.
- The pyramid now contains six categories:
  - Bread, cereal, rice, and pasta.
  - Vegetables.
  - Fruits.

- Milk, yogurt, cheese.
- Meat, poultry, fish, dry beans, eggs, and nuts.
- Fats, oils and sweets.



- The last item on the pyramid, fats, oils, and sweets, is not considered a nutritional category and comes with the warning that they have to be used sparingly.

### Procedure for Nutritional guidance of the elderly

- For giving the preceding information the following step-by-step office procedure is recommended.

<b>Step 1: Determine what the patient is presently eating</b>	<ul style="list-style-type: none"> <li>• This is best done by having the patient keep a 3 to 5 day food diary.</li> </ul>
<b>Step 2: Determine some of the reasons for food selection</b>	<ul style="list-style-type: none"> <li>• It is important to understand the reason that motivates the patient to eat</li> </ul>
<b>Step 3: Evaluate the</b>	<ul style="list-style-type: none"> <li>• Review each day of the food diary and determine</li> </ul>

<i>adequacy of the diet.</i>	if the amounts and kinds of foods actually eaten are more, the same, or less than recommended.
<b>Step 4. Write a Diet prescription.</b>	<ul style="list-style-type: none"> <li>On the basis of information acquired from the diet evaluation sheet and from the personal and medical history, the dentist should be able to prescribe an acceptable personalized diet that is balanced, varied and adequate for the dental oral health problem.</li> </ul>

## NUTRITIONAL DEFICIENCY

### I. Clinical signs of Nutritional Deficiency

- The physical signs of nutrient deficiency are not early indications that a particular nutrient is lacking.
- They develop after period of inadequate intake during which tissue stores are depleted and metabolism is disturbed.
- Table below indicates those physical signs most often associated with malnutrition.

#### 1. Physical signs of Nutrient Deficiencies

Nutrient	Physical signs
i. Protein	<ul style="list-style-type: none"> <li>Edema</li> </ul>
ii. Protein/energy	<ul style="list-style-type: none"> <li>Dull, dry, sparse, easily plucked hair</li> <li>Parotid gland enlargement, Muscle wasting</li> </ul>
iii. Iron	<ul style="list-style-type: none"> <li>Pallor</li> <li>Pale, atrophic tongue</li> <li>Spoon nails</li> <li>Pale conjunctiva</li> </ul>
iv. Niacin	<ul style="list-style-type: none"> <li>Nasolabial seborrhoea</li> <li>Fissuring of eyelid corners</li> <li>Angular fissures around mouth</li> <li>Papillary atrophy</li> <li>Pellagrous dermatitis</li> <li>Mental confusion</li> </ul>
v. Riboflavin	<ul style="list-style-type: none"> <li>Nasolabial seborrhoea</li> <li>Fissuring and redness of eyelid corners and mouth</li> <li>Magenta coloured tongue</li> </ul>

	<ul style="list-style-type: none"> <li>• Genital dermatitis</li> </ul>
vi. <i>Thiamine</i>	<ul style="list-style-type: none"> <li>• Mental confusion, Irritability, Sensory losses</li> <li>• Loss of ankle and knee jerks, Calf muscle tenderness, cardiac enlargement</li> </ul>
vii. <i>Pyridoxine</i>	<ul style="list-style-type: none"> <li>• Nasolabial seborrhoea, Glossitis</li> </ul>
viii. <i>Vitamin A</i>	<ul style="list-style-type: none"> <li>• Bitot's spots (eyes), conjunctival and corneal xerosis (dryness), xerosis of skin, follicular hyperkeratosis</li> </ul>
ix. <i>Folic acid</i>	<ul style="list-style-type: none"> <li>• Glossitis, skin hyper pigmentation</li> </ul>
x. <i>Vitamin B12</i>	<ul style="list-style-type: none"> <li>• Glossitis, skin hyper pigmentation</li> </ul>
xi. <i>Ascorbic acid</i>	<ul style="list-style-type: none"> <li>• Spongy, bleeding gums, petechiae, painful joints</li> </ul>
xii. <i>Iodine</i>	<ul style="list-style-type: none"> <li>• Goitre</li> </ul>
xiii. <i>Vitamin D</i>	<ul style="list-style-type: none"> <li>• Bow legs, Beading of ribs</li> </ul>

- The Prosthodontist has a particular advantage in detecting clinical signs of malnutrition because many classic signs occur in and around the oral cavity.

## 2. *Effect of nutritional deficiency in oral health of elderly*

- Cheilosis
- Painful burning tongue
- Inflammation of oral mucosa
- Xerostomia
- Osteoporosis

## DIETARY COUNSELING OF PROSTHODONTIC PATIENTS

- Patients expectations towards new dentures is that they will be able to eat a greater variety of foods.
- Such patients often are receptive to suggestions aimed at improving the quality of their diets.
- Nutrition screening begins at the first appointment so that counselling and follow up can occur during the course of treatment.

## Risk factors for malnutrition in denture patients

- Unplanned weight gain or loss of >10 lb in the last 6 months
- Undergoing chemotherapy or radiation therapy
- Poor dentition or ill-fitting prosthesis
- Oral lesions – glossitis, cheilosis, or burning tongue

- Severely resorbed mandible
- Alcohol or drug abuse
- Eating less than 2 meals/day

## Nutrition guidelines for prosthodontic patients

- Eat a variety of foods
- Build diet around complex carbohydrates fruits vegetables, whole grains, and cereals.
- Eat at least 5 servings of fruits and vegetable daily
- Select fish, poultry, lean meat, or diet peas and beans every day.
- Obtain adequate calcium
- Limit intake of bakery products high in fat and simple sugars
- Limit intake of processed foods high in sodium and fat
- Consume 8 glasses of water daily.

## DIETARY SUGGESTIONS FOR DENTURE WEARERS.

### I. Modification of food selection and food habits

- The problem of selecting a properly nutritious diet for an elderly person is not simple, because one or more of the following environmental factors may influence food selection and eating habits:
  - Deficient dentition
  - Low income
  - Ingrained food patterns
  - Excessive introspection
  - Loss of independence
- Several modifications in food preparation and service can be used to lift the spirits of the geriatric patient.
- For maximum taste sensation, the use of sharply contrasting flavours in combinations (such as sweet and sour) has proved beneficial.

### II. Helping new denture wearers learn to chew

- The ability to manage the physical consistency of food can be made easier for a new denture wearer if jaw movements are analysed properly
- The process of eating actually involves three steps;

- Biting or incising
- Chewing or pulverizing
- Swallowing.

Function	Problems	Prevented
<b>1. Incision</b>	<ul style="list-style-type: none"> <li>• Causes dislodgment of the denture by the pulling action of over-tensed muscle.</li> </ul>	<ul style="list-style-type: none"> <li>• Prevented by seal created at postdam</li> </ul>
<b>2. Chewing and pulverizing</b>	<ul style="list-style-type: none"> <li>• Less difficult than incising, easier and least complex</li> </ul>	<ul style="list-style-type: none"> <li>• Can prevent by coordination of muscles of mastication and TMJ movements</li> </ul>
<b>3. Chewing and swallowing</b>	<ul style="list-style-type: none"> <li>• Easier to accommodate in new denture wearer</li> </ul>	<ul style="list-style-type: none"> <li>• Liquid diet in the earlier stages followed by soft food and then transform to a firm or regular diet</li> </ul>

<b>I. Diet for the first day after denture insertion</b>	<p>On the first post insertion day, a new denture wearer can choose from the following foods, which are essentially liquids and are arranged according to the four basic food groups.</p> <ul style="list-style-type: none"> <li>➤ Vegetable fruit group; juices</li> <li>➤ Bread cereal group; gruels cooked in either milk or water</li> <li>➤ Milk group fluid milk may be taken in any form</li> <li>➤ Meat group; for the first day or so eggs will be the first food choice; they may taken in eggnogs; pureed meats, meat broths, or soups may also be eaten</li> </ul>
<b>II. Diet for the second and third days after denture insertion</b>	<p>For the second the third post insertion days, the denture patient can use soft foods that require a minimum of chewing.</p> <ul style="list-style-type: none"> <li>➤ Vegetable fruit group in addition to fruit and vegetable juices, tender cooked fruits and vegetables (skin and seeds must be removed) cooked carrots, tender green beans.</li> </ul>

	<ul style="list-style-type: none"> <li>➤ Bread-cereal group: cooked cereals such as cream of wheat and softened bread; boiled rice.</li> <li>➤ Milk group; fluid milk</li> <li>➤ Meat group: chopped beef, ground liver, tender chicken or fish in a cream sauce or even children's junior food preparations; eggs may be scrambled or soft cooked; dried peas maybe used in a thick, strained soup</li> </ul>
<b>III. Diet for the fourth day and later</b>	By the fourth day, or as soon as all the sore spots have healed in addition to the soft diet, firmer foods can be eaten. In most instances, these foods should be cut into small pieces before eating.

## CONCLUSION

- Nutritional deficiencies is one of the common factors towards denture failure.
- Good health and nutrition of older patient is necessary for a successful function of dentures

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**Please Give Your Feedback on this Answer**

## Importance of patient education in prosthodontics (7M)

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  - Denture hygiene and maintenance
  - Recall visits and their importance
  - Importance of Good Diet

#### References

## INTRODUCTION

- Patient education is the prosthodontic service that refers to giving complete information and instructions to a complete denture patient in the use, care and maintenance of the prosthesis.
- Communication is the basic medium of education and can be encouraged by establishing a feeling of trust between the doctor and his patients.
- By careful listening and observing, the dentist learns about the patients problems and expectations regarding denture, his emotional and physical conditions, the health and adequacy of his oral tissues and associated structures, and whether the present dentures are fulfilling the needs of this patient
- According to Webster's New Collegiate Dictionary to educate is to provide with training or knowledge for a specific purpose.
- To motivate is to provide with a motive to impel, to incite.
- A willingness to instruct the patient in the care and use of his dentures and an understanding of his desires are essential to assure a successful prognosis.
- An informed patient will realize when his dentures require attention and will seek treatment before an ill-fitting denture damages the oral tissues
- The dentist must also know anatomy, physiology and psychology so that he can correctly evaluate normal and abnormal situation.
- One of the primary objectives of dentures is to preserve the supporting tissues within physiologic limits.
- Therefore, a patient should be educated to understand his responsibility in denture service.

## UNDERSTANDING THE PATIENT

- The dentist must know human psychology because, the ability to understand the patient's mental attitude is frequently the difference between acceptance and rejection of the denture.
- M.H. House classified the mental attitude of patients as philosophical, exacting, indifferent and skeptical patient.

<b>1. Philosophical patient</b>	<ul style="list-style-type: none"> <li>• The best mental attitude for denture acceptance is the philosophical type.</li> <li>• He is calm, rational, his motivation is generalized, as he desires dentures for the maintenance of health and appearance.</li> </ul>
<b>2. Exacting patient</b>	<ul style="list-style-type: none"> <li>• This type of patient requires extreme care, effort and patience on the part of the dentist.</li> <li>• This patient is methodical, precise and accurate and at times makes severe demands.</li> <li>• He likes each step in the procedure to be explained in detail.</li> </ul>
<b>3. Indifferent patient</b>	<ul style="list-style-type: none"> <li>• The indifferent patient presents a questionable or unfavourable prognosis. He evidences little if any concern; he is apathetic and uninterested and lacks motivation.</li> <li>• He pays no attention to instructions will not cooperate and is prone to blame the dentist for poor dental health.</li> </ul>
<b>4. Skeptical patient</b>	<ul style="list-style-type: none"> <li>• This type of patient is an old denture wearer with negative past experience regarding his complete denture treatment.</li> <li>• Such a person requires genuine concern and patience on part of the dentist.</li> </ul>

- The success of the treatment will depend upon the willingness of the patient to accept his responsibility in the treatment, the use and care of the dentures, and the post-insertion procedures.
- Complete dentures must be constituted in harmony with the maxillofacial structures and the stomatognathic functions of mastication, swallowing, phonation and speech.
- All objectives may be attained, but, because no two mouths are exactly alike and because some vary greatly from the ideal, it is sometimes necessary to compromise one objective to favour a more important one.

## INFORMATION AND INSTRUCTIONS RELATED TO COMPLETE DENTURES

### I. Limitations of usefulness of complete dentures

- The loss of natural teeth is a misfortune which the artificial teeth can reduce but never fully remove.

- Problems created by loss of natural teeth will not be over by just having dentures.
- It is not within the law of nature to compress the vulnerable tissues with dentures whose impression surface is akin to a sandpaper.
- Even the slightest pressure can impede the circulation and decrease the nutrition to the tissues.
- Moreover, the efficiency of natural teeth and dentures has no comparison with a ratio of 10:1 in favour of natural teeth.
- Due to the wide range of movements of the lower jaw and because the force of mastication is exerted by it, the lower denture presents the greatest problem in learning to use complete dentures.
- Limits of functions of oral tissues have to be re-established and extreme non-functional movements cannot be performed.
- Learning to master the movements of the mandible is a gradual process.
- Patient should develop neuromotor skills to be able to hold the dentures.
- The length of time required depends on the ability, the perseverance and the determination of the patient.
- The patient should be made aware of the shortcomings of the prosthesis, and should not be promised too much in the future use of dentures.
- The treatment requires continuous follow-up, check up which includes occlusal corrections, relining or rebasing.

## **II. Understanding the nature of denture foundations**

- Placement of dentures in the mouth provides an unnatural environment to the oral tissues and bone.
- The vulnerable mucosa is compressed between the bone and denture base.
- Pressure or compression is excess of physiological limits of tissue tolerance causes loss of alveolar bony support, overgrowth of soft tissue and excessive denture movements.
- Good health and improved nutrition in addition to scientific methods of treatment will reduce the problems of tissue abuse.
- An adequate protein intake with dietary supplements help to maintain a balance in oral health.

## **III. Oral and general conditions complicating use of complete dentures**

- Educating a prospective denture patient about his oral status and systemic conditions as they apply to him are absolutely necessary.

<b>1. Diabetes mellitus:</b>	<ul style="list-style-type: none"> <li>• Diabetes patients show an abnormally high rate of bone resorption together with decreased tissue tolerance and delayed wound healing.</li> <li>• Such patients should be told that they will require frequent oral examinations, denture adjustments and relines along with effective oral hygiene.</li> </ul>
<b>2. Arthritis</b>	<ul style="list-style-type: none"> <li>• These patients should be made aware that occlusal relationship may change as a result of their disease and that limited jaw function may follow</li> </ul>
<b>3. Anemia</b>	<ul style="list-style-type: none"> <li>• Mucositis, glossitis and angular cheilitis decrease the tolerance to a foreign body in the mouth.</li> <li>• They should be counselled about the diet and pharmacotherapy</li> </ul>
<b>4. Neuromuscular disorders</b>	<ul style="list-style-type: none"> <li>• Lack of neuromotor skill and control can result in instability of the denture base. The use of a denture adhesive may be advised in some patients.</li> </ul>
<b>5. Menopause</b>	<ul style="list-style-type: none"> <li>• Post menopausal osteoporosis results in excessive alveolar bone resorption and chronic tenderness of oral tissues</li> <li>• The condition requires physicians consulting diet, pharmacotherapy and use of soft liner.</li> </ul>

#### IV. Educational factors related to impression and jaw relation recording procedures.

- Considerable instruction may accompany impression making and brief concise explanation of the impression technique should be given with proper emphasis on the role of the patient in that procedure.
- The patient must understand clearly that he is expected to co-operate fully during the impression making procedures.
- Dental education should include a discussion on the harmony and beauty of the human face.

- Diagnostic casts, facial measurements, old and recent photographs, profile records and the patients old dentures if available can be employed to illustrate the discussion.
- Effects of excess and reduced vertical dimension should be explained to the patient while the necessity for accurate jaw records pointed out.
- Should the jaw movements be abnormal, the dentist should explain that compromises may have to be made in the selection of posterior teeth with a possible loss in chewing function.

## V. Patient education at the try-in

- At the try in the dentist should instruct the patient carefully that denture teeth should be shaded and have embrasures and diastemas to simulate natural appearance.
- We should explain that the denture will seem to be bulky at the try in. the patient should be given a mirror and instructed to speak and count.
- Each patient should be accompanied by a close friend or relative at the try in.
- It is absolutely necessary to obtain the complete consent and satisfaction of the patient before proceeding with the construction of the dentures.

## VI. Patient education at the time of placement of dentures

- During the initial insertion, the patient must be educated and prepared to receive the denture.

### 1. Appearance

- The appearance and nervous denture patient has a strained facial expression because he has not been prepared psychologically for the denture.
- The facial expression may seem slightly altered and it takes time for the muscles and lips to relax and assume their natural position around the dentures.

### 2. Speaking with dentures

- At first there is a feeling of full mouth and a crowding of the tongue because the dentures have altered the shape of the mouth.
- Patient will be conscious of something in the mouth, that was not there before and he/she will have to learn to speak.

- However as soon as the lips, tongue and cheeks have been accustomed to the dentures and new muscle habits are formed, this difficulty is overcome easily.
- A good way to learn to speak is by reading aloud before a mirror and carefully enunciating each syllable. Practice and patience resolves all difficulties.

### 3. **Salivary flow**

- Soon after the insertion of dentures, salivary flow is stimulated which declines after 2-3 days unless something is physically wrong with the dentures which can cause irritation.
- Simply swallowing more often is the best remedy and in a few days, the salivary glands will adjust themselves to the presence of dentures and resume normal function.
- Patient should be made aware of these problems in advance of the treatment, otherwise patient will not trust the clinician and the quality of service.
- He should not carry out any adjustments to overcome these inconveniences.
- Patient should be told about feeling of fullness and crowding of the tongue.
- He should be told to rest the tongue in the floor of the mouth.
- Lips and cheeks should be relaxed and not tensed.
- Learning to eat with dentures takes time and requires positive effort from the patient.
- At first the patient should cut soft foods that require little chewing.
- Then he should try and place the bolus of food on both sides simultaneously and chew with controlled vertical movements
- Successful efficient use of dentures is a learned process and patient has to train his musculature in holding the dentures.

### 4. **Tenderness**

- The patient will experience some tenderness and discomfort from the dentures during the first few weeks.
- The reason is that the mucous membrane of the mouth is vulnerable and not evolve to bear stresses placed upon them by the dentures.
- New dentures will require some adjustment.
- The patient should be told to wear the denture continuously for the first 24 hours and then immediately report to the dentist.
- Any irritations or impingements can be detected easily and corrected.

- Later he should be instructed to only wear the dentures at daytime without using them for eating.
- After 1-2 weeks he can start with soft chewy foods and then, as the ridges get accustomed to pressures he can resume his daily diet.
- Parafunctional habits such as clenching and grinding should be avoided.

### **5. Rest to the supporting tissues**

- It is desirable that oral tissues should not remain under continuous stress and therefore it is important to provide rest and natural ventilation by removing the dentures from the mouth at night, during sleeping hours.
- This will allow tissues to recover from effect of stress.
- Those patients who suffer discomfort and loss of sleep after removed of dentures, may provide short periods of rest to oral tissues during the day.

### **6. Denture hygiene and maintenance**

- It is important to know that successful use of dentures also depends on the maintenance of oral and denture hygiene.
- Mouth should be rinsed after food and dentures should be cleansed with a small hand brush using soap and cold water.
- Gritty or abrasive powders or paste should never be used as they remove the gloss and cause scratches which mar the surfaces and destroy the fit of the dentures.
- While cleaning, the dentures should be held over a basin of water to prevent breakage in case of accidental from the hands.
- If should be slipping held in the palm of the hand while clenching the hand against the side of the denture.
- Commercial denture cleanses are available in tablet and powder forms.
- They are dissolved in water, the dentures are soaked overnight and brushed in the morning.
- If the dentures are left out of the mouth for any length of time, they should be placed in a saturated selection of salt and baking soda or a boric acid solution.
- This affords them safe and effective storage.
- The dentures should not be allowed to dry out as moisture is relaxed and they get warped.

## 7. Recall visits and their importance

- Objective of recall visit is to offer continuing health service by ensuring the status of supporting tissues.
- Thorough recall visits one can observe the development of undesirable situations before more damage occurs.
- Recall visit may be fixed every five to six months or one year.

## 8. Importance of Good Diet

- Enquiry into the diet of the patient and his food habits will reveal or bring out useful information on the nutritional intake of the patient.
- The diet should be evaluated by a nutritionist and the deficiencies noted.
- A well balanced diet containing a high percentage of proteins, vitamins and essential minerals and a low percentage of carbohydrates is necessary to keep the supporting tissues of the dentures in good condition.
- Close co-operation between the patient dentist and the physician will result in greater service to the patient.

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**Please Give Your Feedback on this Answer**

**Speech considerations in prosthodontics (7M)****Speech in cleft palate patients (7M)****CONTENTS/SYNOPSIS**

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MDS Made Easy

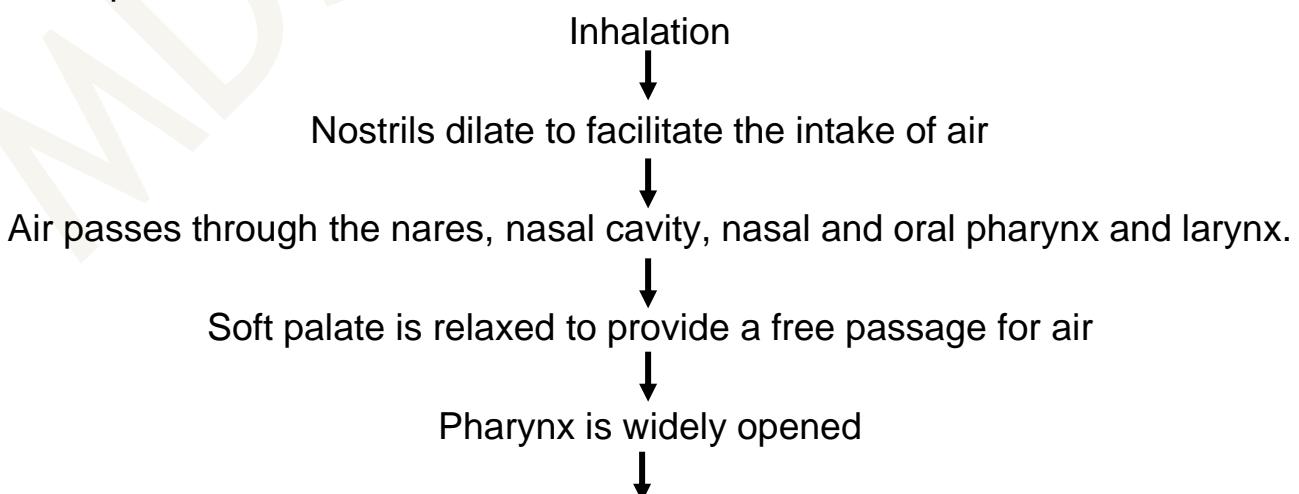
## INTRODUCTION

- Human beings are the only living animals with the unique gift of speech.
- Communication between animals may take place through the sense of touch or smell.
- However the audible signals are perhaps the most efficient means of communication making the humans superior than all.
- Speech may be described as the production of the sound by the larynx(phonation) and its modification by the resonance of air within various spaces between the larynx and the lips(articulation).
- Before discussing the mechanism of speech it is important to make clear a few fundamentals about the physics of sound.
  - Sounds vary in loudness: amplitude of vibrations of the source of sound may vary.
  - Variations in pitch: interpretation of the variation in frequency of vibration.
  - Variations in quality, eg: differences between sounds of different musical instruments.
  - Duration is the fourth way that sound varies.
  - Resonance: sound waves of a particular pitch are conveyed through a medium. Eg. Air
- A feeble sound may be reinforced if it succeeds in causing a large structure to vibrate or resonate.

## MECHANISMS OF SPEECH PRODUCTION

### I. Respiration

- The movement of air in the inspiratory and expiratory phases is essential for the production of sound.



Air passes through the open rima glottides of the larynx into trachea, bronchi and then lungs.

- This process is reversed in exhalation.
- During speech the regular rhythm of inspiration and expiration is disturbed.
- With inspiration occurring rapidly at the end of sentences or at pauses between end of sentences; and expiration is prolonged to last from pause to pause.
- Speech is directly related to expiration and not to inspiration.

## II. Phonation

- Voice occurs due to the passive vibrations of the vocal cords by the current of expired air impinging upon them.
- During part of each vibration, the inner edge of the cords will be in contact thus closing the air space altogether, then the cords are blown apart but their elasticity forces them together again and so the cycle continues.
- The expired air escapes as a series of rapid puffs, the number of puffs being the same as the number of vibrations of the vocal cords.
- Such changes of pressure in the expired air represent a sound.
- The vibration of the cords is mostly horizontal (max: 4mm) and only slightly vertical (0.2 - 0.5mm).

- The primary essential for phonation is that the cords must be sufficiently close together to touch during part of their vibration
- This action is brought about by rotating the arytenoids cartilages medially by means of contraction of transverse arytenoids and lateral cricothyroid muscles.
- The reverse effect of separating the cords and widening the space between them is carried out by contraction of the posterior crico arytenoids which rotate the arytenoids laterally.

## III. Loudness

- Increased pressure of expired air is the chief factor which increases the loudness of speech.
- In low intensities of the voice, the time taken for abduction(outward excursion) of cords is shorter than for adduction(return to midpoint)

- But when the voice is loud the reverse is true.
- With low intensities the glottis is not closed for as long or as firm as for high intensities.

#### IV. Resonation

- Resonation takes place in the prime resonating chambers. They are
  - Nasal cavity
  - Oral cavity
  - Pharyngeal cavity
- The oral chamber are divided into the following spaces, any or all of which may take part in the resononation of sound.

- Between the dorsum of tongue and posterior surface of hard palate.
- Between the dorsum of tongue and anterior surface of hard palate.
- Between the tip of the tongue and the teeth
- Between the teeth and the lips

- Nasal cavity is used as the primary resonating chamber for only 3 English sounds m, n and ng.
- The choice of the chamber is made by placement of soft palate.

- When the soft palate contracts against the pharyngeal wall, the oral cavity becomes the resonating chamber and when it contracts against the tongue, nasal cavity is the resonating chamber

#### V. Articulation

- It is accompanied by the teeth tongue lips and palate which break up the sound as the air stream emerges through the lips and tongue being the only movable factors.

##### 1. **Vowels: A,E,I,O,U.**

- Vowel sounds are produced when the air stream vibrates the adducted vocal cords with resonance playing its part.

- In the vowel sounds the lower of the two pitches is produced by resonance in the pharynx and the upper by the mouth resonance.

## 2. Positions of oral resonators

i. “ah”	<ul style="list-style-type: none"> <li>• The narrowing of the space between the epiglottis and the pharyngeal wall</li> </ul>
ii. “see”, “set”, “sit”	<ul style="list-style-type: none"> <li>• The pharynx is widened and the tongue is arched in the middle and closely follows the shape of the hard palate</li> </ul>
iii. The “u” of “muff”	<ul style="list-style-type: none"> <li>• Either with a flat tongue or with a slight arching at the back</li> </ul>
iv. “aw” and “oo”	<ul style="list-style-type: none"> <li>• Throat cavities are constricted</li> </ul>

## 3. Consonants

- Consonants are produced by an interruption of the passage of air through the pharynx or mouth, by the tongue, teeth or lips before being released.
- Consonants may be voiced or produced without vocal cord vibration in which case they are called breathed

*For example:* “b” is voiced and “p” is breathed.  
“z” is voiced and “s” is breathed.

## 4. Classification of consonants

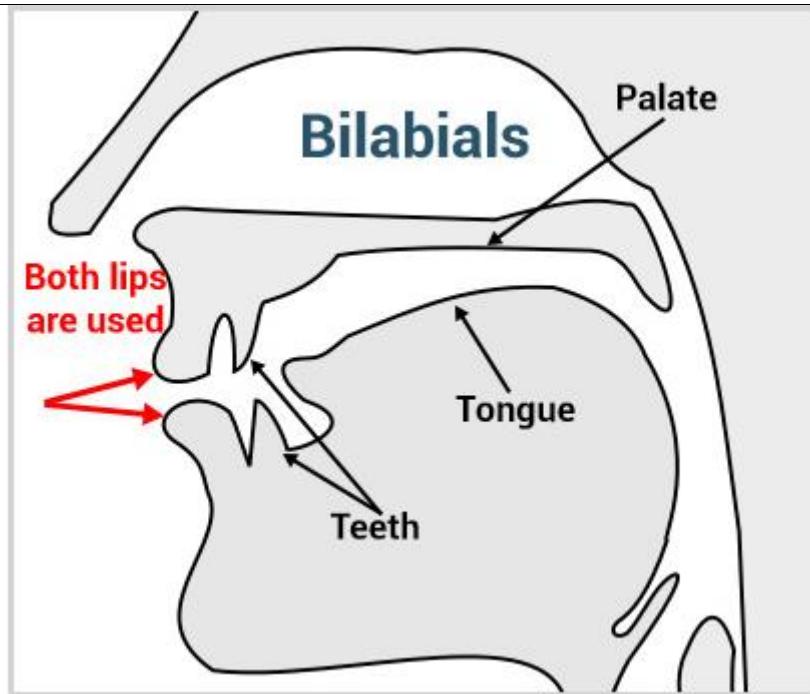
- According to the structure which cause the interruption of the current of expired air.

### i. Bilabial sounds

- Made by contact of the lips.
- Insufficient support of the lips by the teeth.
- Improper anteroposterior positioning of the teeth cause these sounds to be defective

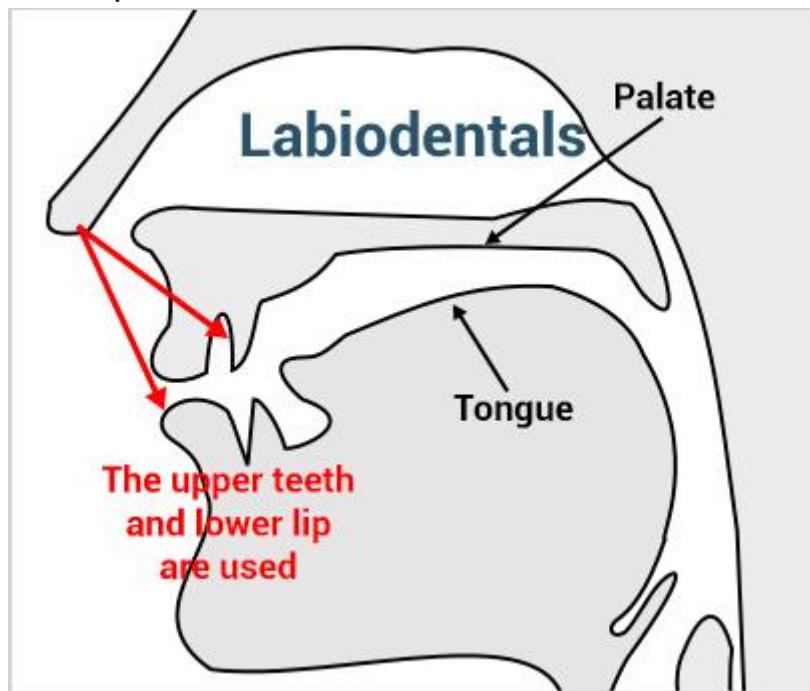
**Example:** “B” “P” “M”.

- In “B” and “P”, air pressure is built up behind the lips and released with or without a voice sound.



### ii. Labiodental sounds

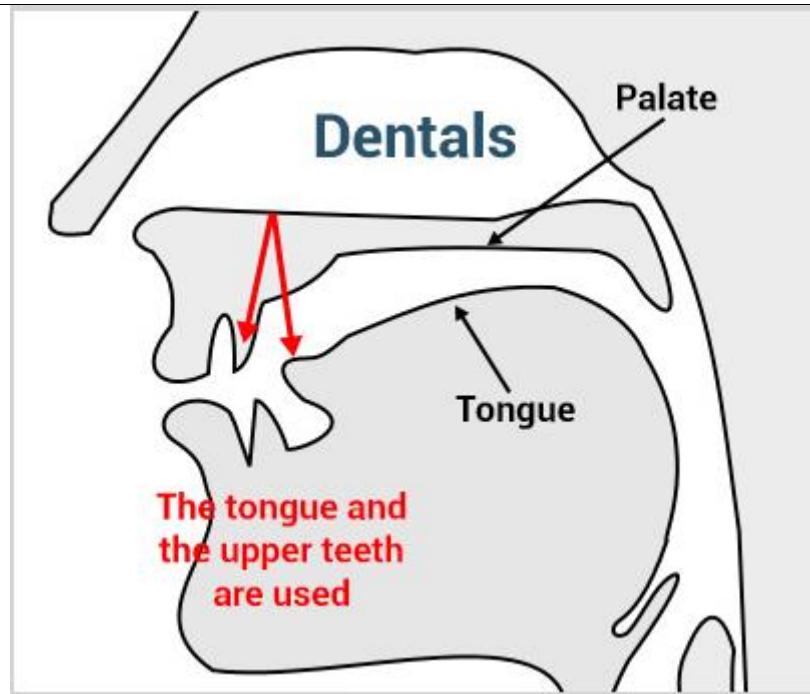
- Made between the upper incisors and the labiolingual centre to the posterior third of the lower lip.



### iii. Linguodental sounds

- These sounds are made with the tip of the tongue extending slightly between the upper and lower anterior teeth.

**Example:** "th" in this.

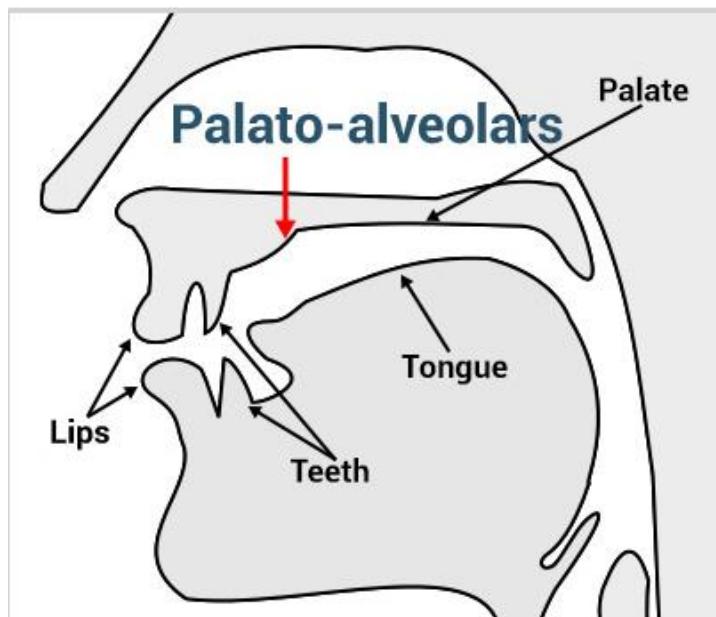


#### iv. *Linguoalveolar sounds*

- Made with the valve formed by the contact of the tip of the tongue with the most anterior part of the palate or the lingual side of the anterior teeth.

**Example:** "T", "D", "S", "Z", "V", "L", "J", "ch", "sh".

- The sibilants—"S", "Z", "sh", "ch" and "J" are alveolar sounds because the tongue and alveolus forms a controlling valve.
- The "s" sound is an important one as it is said to cause the most number of prosthodontic problems.



#### v. *Linguopalatal sounds*

- Truly palatal sounds

**Example:** those in year, she, vision and onion.

**vi. Linguo uvular sounds**

**Example:** “K” “G” “ng”.

Voiceless speech sounds ( created by air alone)		
Fricatives Plosives Affricatives	Air is forced by tongue through a narrow aperture& is associated with friction Explosive release of air A combination of the friction & explosive elements	s, sh, th, f P, t, k ch
Voice speech sounds (created by laryngeally produced noise)		
Vowels Voiced consonants	Formed from continuous vocal cord vibrations; tongue & lip positions impart structural overtones A combination of air produced sounds & laryngeal tone	a, e, i, o, u b,d,j, m,q,r
Classification according to anatomic sound formation		
Palatolingual Tongue & Hard palate Tongue & Hard palate Tongue & soft palate Linguodental Labiodental Bilabial	Tongue is positioned just behind the maxillary incisor teeth with the sides of tongue in contact with maxillary posterior teeth & alveolar ridge Tongue is placed firmly against the anterior hard palate  Posterior dorsal tongue is raised to occlude with soft palate Tip of tongue is placed between maxillary and mandibular teeth Formed by lower lip contacting the incisal edge of the maxillary incisor teeth  These sounds are formed between the lips	s t, d ,n k, g, ng th f,v b,p,m

## NEURAL INTEGRATION

- A very complex and imperfectly understood neurophysiological mechanisms govern the production.
- Movements of the cords require such precision that feedback control is very important.
- The afferent side of the reflex feedback arises partly from the mucosal mechanoreceptors and mostly from corpuscular nerve endings in the joints of the larynx.
- These nerve endings are capable of rapid adaptations to changes in stress in joint capsule.

- Laryngeal muscles are thought to contain a small number of primitive muscle spindles and a larger number of spiral nerve endings presumably controlled by stretch reflexes, the tone of the muscles.
- The principal motor nerves for the muscles of speech are
  - Trigeminal nerve(mandibular division) innervates the muscles of soft palate.
  - Facial nerve innervates the muscles of the periphery of the mouth
  - Glossopharyngeal nerve innervates the muscles of pharynx.
  - Vagus nerve innervates the muscles of soft palate, larynx and pharynx.
  - Hypoglossal nerve innervates muscles of the tongue.
- The motor innervation involved is derived from three pathways
  - The corticobulbar pathway which permits the conscious control of precise movements required.
  - Example: articulation of speech
  - The extrapyramidal pathway which also conveys certain voluntary impulses as well as control of muscle tonus.
  - Cerebellar pathway from cortex to speech muscles the route of automatic coordination.

## PROSTHETIC CONSIDERATIONS

- Speech problems are usually identified immediately following prosthetic treatment.
- When compared to younger individuals, elderly complete denture wearers experience greater difficulty in adapting their speech to new prostheses and also need a longer time to regain their natural speech.
- A frequent cause is impaired auditory feedback.
- Speech adaptation to new complete dentures normally takes place within 2 - 4 weeks after insertion.
- If the problem persists, special measures should be taken by the dentist and if the problem continues by a speech pathologist.

### I. Effect of denture thickness and peripheral outlines

#### 1. Thick denture bases

- Affects the tone and phonetics
- Decrease in air volume
- Loss of tongue room in oral cavity
- Noticeable lisp

- Commonly affects the palatal region
- **Example:** Consonants like "t" and "d" where the tongue makes firm contact with the anterior part of the hard palate and is suddenly drawn downwards producing an explosion sound. Hence any thickening of the denture base in this region may cause incorrect formation of these sounds.
- If the lingual flange of the lower denture is too thick in the anterior region, it will encroach on the space needed by the tongue and this results in faulty production of "s" sound

## 2. Overextensions of denture base

- The periphery of the denture must not be overextended as they encroach the movable tissues
- The depth of the sulcus will vary with the movements of the tongue, lips and cheek during phonation.
- Any interference with the freedom of these movements may result in indistinct speech especially if the function of the lips is hindered.

## 3. Post dam area

- Thickness in post dam are irritate the dorsum of the tongue impeding speech and probably producing a feeling of nausea
- Errors of denture construction in this area involve vowels like "I" and "E" and palatolinguinal consonants like "G" "ng" "K".
- If the post dam seal is inadequate the denture becomes unseated during the formation of those sounds having an explosive effect, requiring the sudden repositioning of the tongue to control and stabilize the denture.

## II. Effect of tooth position on speech

1. **If the lower anterior teeth are arranged too lingually**, the tongue is forced to arch itself up to a higher position and the airway is to be too small and there will be faulty pronunciation in "S" and "two sound lisps".
2. **If the upper anteriors are placed too far lingually**, the contact of the lower lip with the incisal and labial surfaces will be difficult which will hamper the pronunciation of the "f" "v" and "ph" sounds.
3. **If the occlusal plane is set too high**, correct positioning of the lower lip may be difficult and the sound "v" will be pronounced like "f".
4. **If the plane is too low**, the lip will overlap the labial surfaces of the upper teeth and the sound "f" will be pronounced as "v".

- These labiodental sounds “f” and “v” are helpful in determining the anteroposterior positioning of the upper incisors and occlusal plane.

### III. Effect of vertical dimension on speech

- Formation of the bilabials like “P” “B” and “M” requires the lip to make contact.
- With “P” and “B” the lips part quite forcibly so that the resultant sound is produced with an explosive effect whereas in “m” sound the lip contact is passive.
- For this reason “m” can be used as an aid in obtaining the correct vertical height since a strained appearance during lip contact or the inability to make contact indicates that the bite blocks are occluding prematurely.
- With “C” “S” and “Z” sounds the teeth come very close together (interincisal distance is 1-1.5). Therefore if the V.D. is excessive the dentures will contact the and the patient will complain of clicking of teeth.
- Silverman (1956) stated that sibilant sound “S” can be used as a means for determining the correct vertical dimension. He established the “closest speaking space” and used this as clearance area between the dentures.
- He also stated that the whistle and swish sounds are produced during speech due to air abnormally passing over the tongue and interincisal spaces which indicates decreased overjet

### IV. Effect of denture esthetics on speech

- Speech is sometimes related to emotional attitudes towards denture esthetics.
- According to Lawson, when there is any change in the patients mouth, there will be an anxiety reaction.
- Patients who are dissatisfied with their teeth appearance in the dentures, try to overcome this problem by the abnormal movement of the lips, jaws and tongue during speech.

### V. Other causes of speech defects

- Congenital or acquired palatal defects. Example: cleft palate
- Malocclusion is an obvious cause of speech defects
- Severe open bite leads to defective pronunciation of consonants “F” “V” “P” “B” “M” because upper anteriors fail to articulate with the lower lips.
- Difficulty in pronouncing “S” and “Z” with severe open bite will be due to amount of air escaping between hard palate and the tip of tongue will be larger.

- Recessive mandible is another dental defect which affects normal pronunciation of sounds like “P” “B” M” “S” “th”.
- Macroglossia leads to lisping of consonants
- Respiratory problems also cause defects in speech.

## SPEECH IN CLEFT PALATE PATIENTS

- Based on the severity of defect a cleft palate can affect speech and communication in several ways
- A cleft associated with soft palate (velopharyngeal impairment)
  - May have problem with speech especially nasal sounds, as soft palate cannot close the mouth from nose during functional activities.
  - Difficult to make consonant sounds like s, z, sh, as they require to place the tongue on palate to make the sound
  - If there are any missing teeth or misaligned, creates difficulty produce dental sounds such as f, v

## Management

1. **Speech and language therapist (SLT)** will make an initial assessment around 18 - 24 months, followed by further assessment till 3 years old

2. **Surgical repair** is done to close the palate using pharyngeal flap, buccinator flap, pharyngeoplasty

3. **Prosthodontic management :**

- Infant feeding plate
- Palatal obturators
- Speech bulbs
- Palatal lifts

i. <b>Palatal obturator</b>	<ul style="list-style-type: none"> <li>• It is an acrylic body looks similar to dental retainer.</li> <li>• Used to restore masticatory function and improves speech, using the remaining natural tooth and soft tissue.</li> <li>• The primary goal is to separate oral and nasal cavities to allow deglutition and articulation</li> <li>• Helps to prevent ingress of air and fluids after surgery for proper healing</li> <li>• Occlusion can be restored to improve mastication</li> </ul>
ii. <b>Palatal lift prosthesis</b>	<ul style="list-style-type: none"> <li>• It is first described by Gibbons and bloomer</li> <li>• It is a removable device that elevates the velum at its</li> </ul>

	<p>natural blend and holds it in place against the posterior pharyngeal wall speech.</p> <ul style="list-style-type: none"> <li>• Indicated in velopharyngeal impairment</li> <li>• Effective in the treatment of individuals with a neurological impairment</li> <li>• Consists of anterior portion with clasps to the teeth and posterior tail piece</li> <li>• <b>Disadvantage:</b> Velum is held against the posterior pharyngeal wall all the time which may interfere with the production of nasal sounds and nasal breathing</li> </ul>
<p><i>iii. Speech bulb obturator</i></p>	<ul style="list-style-type: none"> <li>• Also called as <b>speech aid appliance</b></li> <li>• Used for treatment of velopharyngeal insufficiency</li> <li>• Fills the pharyngeal space during speech and improves swallowing</li> <li>• Eliminates nasal regurgitation</li> <li>• Combined with partial or complete regurgitation</li> <li>• Consists of an oral denture base section with clasps to the teeth and a posterior palatal strap with bulb</li> </ul>

## METHODS OF SPEECH ANALYSIS

### I. Perpetual or acoustic analysis

- An acoustic analysis is based on the broad band spectrum recorded by a sonograph during the uttering of different phrases.
- By this an objective opinion of the performance of certain sounds may be achieved.

### II. Kinetic method for movement analysis

- Ultrasonics
- X-ray mapping
- Cineradiography
- Optoelectronic articulatory movement tracking
- Electropalatography(EPG)

- Evaluates the speech defects both in experimental and clinical routine
- Determines tongue contact positions and movements

Sears (1949) suggested that the use of palatogram, to study the lingual contact on the palate

- This can be done by placing a pressure indicating substance on the palatal surface of the denture and ask the patient to pronounce words like "S" "T" "D" "N" "L"
- The tongue will mark indicator paste and provide a visible area of contact between tongue and palate which can be compared with normal and adjustments of denture contour were can be made.

## CONCLUSION

- Speech patterns are invaluable as an aid in denture fabrication.
- The restoration of oral functions is one of the major objectives in the science of prosthodontics.
- Since the neuromuscular patterns for speech are the least affected by the removal of the teeth they can be incorporated under neutral functional conditions into other record making procedures
- Every patient's condition should therefore be evaluated to assure that the denture can provide an optimal environment for the rapid co-ordinated muscle movements requisite for acceptable speech.

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**Please Give Your Feedback on this Answer**

**Stents and splints used in prosthetic dentistry (7M)****CONTENTS/SYNOPSIS****Introduction****Definitions****Scope of splints and stents****Splints**

- Concepts of splints
- Occlusal splints
  - Occlusal splint for Temperomandibular Disorders
    - Anterior disocclusion splint/ Anterior bite plane
    - Anterior Repositioning Splint
    - Autorepositional splint (Muscles splint)
    - Full arch stabilization splint
  - Occlusal Splint for Obstructive Sleep Apnoea Syndrome
  - Occlusal splints for cheek biting habit
  - Occlusal splints as mouth protectors (mouth guards)

**Periodontal splints**

- Rationale for providing the periodontal splints
- Classification

**Splints to stabilize dentoalveolar and maxillofacial structure**

- Splints used in dentoalveolar fractures
- Cast cap splinting
- Lingual acrylic splints
- Kingsley splint
- Cast metal splint
- Gunning Splints

**Other Splints :**

- Oral commissure expansion splint : Burn splint
- Hydrostatic appliance
- NTI (Nociceptive trigeminal inhibition tension suppression system)

**Stents**

- Surgical Stents
- Anti-hemorrhagic stent
- Periodontal
- Drainage stent
- Lip stent (compression stent)

- Pedodontic stent
- Intraoral stent for the physically handicapped
- Trismus stent (Dynamic Bite opener, TMJ exerciser)
- Radiation stents
- Fluoride carrier **stent**

Conclusion

References

## INTRODUCTION

- Splints and stents are the devices, which are most commonly used in the maxillofacial prosthetics for minimizing the severity of the maxillofacial defects and for improving the esthetics and function

## DEFINITIONS

- **Splint:** The word splint when it is consider as verb it means “to immobilize, support or brace”. (GPT 8)
- **Splinting:** Joining of two or more teeth into a rigid unit by means of a fixed or
- **Stents (After Charles R. Stent) :** It is a device used in a surgical procedure to keep skin graft in place. It can also be defined as “Any device or mold used to hold a skin graft in place or provide support for anostomosed structures (GPT 8).

## SCOPE OF THE SPLINTS AND STENTS

- These are used to stabilize the deformities of stomatognathic system.
- To hold together the fracture segments, provide stability, and promote healing.
- To avoid complications. Eg: non union, malunion of the fractured fragments.
- They can carry medicaments.
- They stop haemorrhage and allow periodontal packing.
- Direct the radiation, protect the vital tissues from radiation.
- Prevents the scar contracture after major surgeries of the head and neck patients.

## SPLINTS

### I. Concepts of occlusal splints

- By preventing the patient to close the mouth into maximal intercuspal position
- Distributes the forces across masticatory system especially during parafunctional activities by decreasing the frequency
- Normalises the proprioception of periodontal ligament, thus balances the load and allows for muscle symmetry
- Relaxing the fatigued, hyperactive muscles
- Allows the condyles into centric relation
- By exceeding the physiologic interocclusal relaxes the neuromuscular balance

## II. Occlusal splints

### According to Okeson

- Stabilization appliance
- Anterior repositioning appliances

### Others:

- Anterior bite plane
- Posterior bite plane
- Pivoting appliance
- Soft/ resilient appliance

### According to Dawson

- Permissive splints/ muscle deprogrammer
- Directive splints/ non permissive splints

### 1. Occlusal splint for Temperomandibular Disorders

The occlusal splints can be classified as follows :

- Anterior disocclusion splint.
- Anterior repositioning splint.
- Auto positional splint (muscle splints).
- Full arch stabilization splint.

<i>i. Anterior disocclusion splint/ Anterior bite plane</i>	<ul style="list-style-type: none"><li>• The splint is provided in such a manner that it will contact only the mandibular anterior teeth and disoccludes the posterior teeth.</li><li>• The disocclusion of the posterior teeth prevents occlusal interferences present during centric occlusion and thus prevents reflex muscle contraction.</li><li>• <u>Types:</u> Anterior jig, Lucia jig, Hawley's bite plane, anterior deprogrammer, Sved plate</li><li>• <u>Indications:</u> For the treatment of muscle disorders, parafunctional activity</li></ul>
<i>ii. Anterior Repositioning Splint</i>	<ul style="list-style-type: none"><li>• The occlusal splint is provided for all the teeth and thus induces therapeutic position of the</li></ul>

	<p>mandible, forward to maximum intercuspaton position of the patient and freedom is provided to the mandibular condyle to articulate against the thinnest avascular region of the articular disc.</p> <ul style="list-style-type: none"> <li>• Treatment goal is not to alter the mandibular position permanently, but temporarily until the normal condyle disc complex function returns</li> <li>• <u>Indications</u>: to treat disc interference disorders, intermittent or chronic locking, inflammatory disorders</li> </ul>
<i>iii. Autorepositional splint (Muscles splint)</i>	<ul style="list-style-type: none"> <li>• In this type, the splint is provided only to the premolar and molar region.</li> <li>• Since the elevator muscles of the mandible are located behind the teeth, they pull the mandible upwards resulting in articulation of the condyles against the most favourable position.</li> </ul>
<i>iv. Full arch stabilization splint</i>	<ul style="list-style-type: none"> <li>• It is provided in case of bruxism, trauma from occlusion and occlusal interferences.</li> <li>• This splint prevents the contact of the opposing teeth and redirect the occlusal forces and thus protect the dentition.</li> </ul>

## 2. Occlusal Splint for Obstructive Sleep Apnoea Syndrome

### Aim:

- To provide prosthesis for splinting the mandible to maxilla at “protruded position” with increased vertical dimension.
- It was first provided by Clark R.W. (1979) and later proposed by Meyer J.B. et al (1990).

### Pathophysiology:

- As age progresses and more and more fatty tissue deposition takes place in the tissues, the muscles tends to sag.
- When the person is sleeping because of decrease muscle tone and sagging, the tongue as well as the soft palate will droop back and obstruct the airway.
- Because of this patient may experience difficulty in respiration and may leads to snoring.

### **Mechanism of action:**

- When occlusal splints are provided which place the mandible anteriorly (around 4-6 mm or upto edge to edge relation of the anterior teeth) and increase the vertical dimension by about 12-15mm, the muscles of the tongue as well as the soft plate will be under slight tonic contraction position.
- Because of this there will not be any sagging of the tongue and soft palate and thus no obstruction to the airway.

### **3. Occlusal splints for cheek biting habit**

- Occlusal splint is fabricated in such a way that the interocclusal part is extended 3-5 mm beyond the maxillary buccal surfaces
- Prevents the cheek or buccal mucosa getting entrapped between the occlusal surfaces.

### **4. Occlusal splints as mouth protectors (mouth guards)**

- As stated by Romer et al. 1982, around 32-52% of players engaged in contact sports sustain dentoalveolar fractures during the games.
- To protect the dentition and to prevent the damage to the dental and dentoalveolar structure, the mouth protectors are provided.
- The mouth protectors are semi-rigid type of the occlusal splints which prevent the contact of the maxillary and mandibular teeth during a trauma and thus absorb the forces and protect the dentition and adjacent hard and soft tissues.
- The mouth guards may be custom made or also available as preformed.
- The custom made mouth guards are more convenient and effective.

## **III. Periodontal splints**

### **1. Rationale for providing the periodontal splints :**

- The periodontal splints are provided to decrease the mobility of the periodontally weakened teeth.
- The splint allows the wider distribution of occlusal forces.
- The splints allow healing of periodontium during treatment.
- The splints prevent tipping or drifting of periodontally weakened teeth.
- The splints allow comfortable mastication even with the periodontally weakened teeth.

## 2. Classification

### i. Depending upon the duration :

<b>Temporary splints.</b>	Example : Splinting with orthodontic wire and composite resins
<b>Diagnostic or provisional splints.</b>	Example : Splinting done by using provisional restorations or the composite resins.
<b>Permanent splints (periodontal prosthesis)</b>	Example : Splinting done by using acid etched bridges, continuous $\frac{3}{4}$ crowns, pin ledge type retainers.

### ii. Depending upon the relation to the teeth

<b>Fixed splints</b>	<b>Removable splints</b>
Example : Acid edge bridges, continuous $\frac{3}{4}$ crowns, pin ledge type retainers.	Example : Cast partial dentures with continuous clasps and / or with lingual plate and swing lock partial dentures.

### iii. Depending upon the relation on the surface of the teeth

<b>Intra coronal splints</b>	<b>Extra coronal splints</b>
Example : Continuous amalgam restorations, acrylic intra coronal splints reinforced with orthodontic wires and acid etched bridges.	Example : Cast partial dentures, Elbrecht splints and splinting with inter dental wiring.

## IV. Splints to stabilize dentoalveolar and maxillofacial structure

### 1. Splints used in dentoalveolar fractures

- Splints are used to stabilize and immobilize the fracture fragments to achieve bone healing with best possible dental occlusion.

### In dentulous patient :

- The occlusal surfaces of the teeth are the best guide for the reduction or realignment of the fracture fragments.
- After reduction various types of the splints are utilized to stabilize and immobilize.

<i>i. Eyelet wiring</i>	<ul style="list-style-type: none"> <li>• The ligature wire (0.3 to 0.5 mm) are utilized to splint the teeth in the same arch.</li> <li>• The eyelets are provided to immobilize the maxillary and mandibular arch, which are stabilized together</li> </ul>
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	<p>using inter-maxillary fixation.</p> <ul style="list-style-type: none"> <li>• This type of splints cannot be utilized in edentulous patients and the patients with periodontally weakened teeth.</li> </ul>
<i>ii. Splinting by using arch bars</i>	<ul style="list-style-type: none"> <li>• The arch bars like Erich arch bar, Winters arch bar can be utilized along with ligature wires for splinting the individual arches and stabilizing them.</li> </ul>
<i>iii. The arch bars reinforced with acrylic resin</i>	<ul style="list-style-type: none"> <li>• The arch bar is contoured on the realigned cast and it is stabilized by using the cold cure acrylic resin. The reinforced arch bar is utilized for stabilization and immobilization of the fracture fragments.</li> <li>• <b>Advantages:</b> The reinforced arch bars are stronger and more hygienic.</li> </ul>

## 2. Cast cap splinting

- Provides rigid and efficient fixation of the fracture fragment.
- This splint may be capped or left open at the occlusal surface, or it may be hinged. Chromium cobalt, aluminium and gold are common metal used for construction of cast metal splint.

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> <li>• The cast caps provide good rigidity and provide 3-dimensional stability.</li> <li>• They are hygienic and can be utilized in partially edentulous patients.</li> </ul>	<ul style="list-style-type: none"> <li>• Requires minor tooth preparations and the procedure is time consuming, expensive to patient and technique sensitive.</li> </ul>

## 3. Lingual acrylic splints

- This type of the splint are mainly utilized for stabilization of the mandibular fractures. Because of the adverse muscular forces, parasymphyseal fracture of mandible tends towards lingual collapse and overlap the fractured segments.
- Wire loops or arch bar alone that are applied on either side of the fracture line frequently cannot control this collapsing tendency.
- The problem can be overcome by using either cast cap splints or fabrication of simple acrylic resin gingival splint after sectioning the lower arch.

**Advantages :**

- They provide better stability and counteract the muscular forces.
- Parasymphysis fracture frequently occur in combination with subcondylar fracture and placing lingual splint allows removal of inter maxillary fixation at earlier time (3-4 wks) so that chances of fibrous or bony ankylosis can be greatly reduced.

**4. Kingsley splint :**

- Presented by Norman Kingsley in 1880.
- Fabricated for dentulous or edentulous patients, covers the palate and the ridge. The Kingsley splint resembles a metallic stock tray with two metallic wire extension protruding bilaterally from the commissures of the mouth which are utilized to apply the pressure in a particular direction and also helps to stabilize the splint.
- It is especially useful in raising a fractured maxilla.
- After the reduction of the fractures the Kingsley splint tray is relined by impression compound and stabilized.
- External projection helps in stabilization by plaster head gear or crape bandage.

**Advantages :**

- The Kingsley splints can be used for both maxillary and mandibular arch.
- Can be modified to use as trismus splint.
- Used to control post-nasal haemorrhage.

**5. Cast metal splint :**

- When the long-term immobilization is needed then cast metal splints can be utilized for efficient splinting.
- The cast metal splints are usually recommended after orthognathic surgeries. Palatal occlusal splint is particularly useful for fixation of maxillary segmental osteotomy.
- The model surgery is done on the diagnostic models and utilized for fabrication of the metallic splints.
- The cast metal splint consists of two parts.
  - The first part which is connected and attached to the posterior teeth and acts as the anchoring unit.

- The second part which is attached to the anterior teeth is connected to the first part and thus stabilizes the anterior segment of the arch.

**Advantages:** The cast metal splint provides accurate and better rigidity.

### **Splinting in edentulous patients**

#### **1. Gunning Splints**

- The gunning splint was presented by Thomas Brain Gunning (1813-1889).
- The gunning splints are designed to immobilize edentulous or partially edentulous jaws after reduction.
- It holds together fractured segments of mandibular or maxillary bones and immobilizes the jaws in occlusion.
- In case of edentulous patients no hard tissues will be available for stabilization and retention of the splints.
- The retention is mainly obtained by wiring to the underlying bony tissues.
- Types:
  - One piece gunning splint
  - Two piece gunning splint
  - Sectional gunning splints
  - Modified gunning splints

## **V. Other Splints**

#### **1. Oral commissure expansion splint : Burn splint**

- The microstomia (decreasing oral aperture) may result from facial burns, trauma, surgical resection, radiation and other reasons.
- In these conditions to allow freedom of mouth opening, continuous pressure can be applied which leads to stretching of tissues and avoids further wound contracture.
- The burn splint consists of two C-shaped acrylic blocks, which are connected by orthodontic expansion screw.
- The acrylic block is fabricated by recording the impression of the corner of the mouth.
- The orthodontic expansion screw is slowly activated to apply stretching forces at the corner of the mouth.
- After a period of 4 to 6 weeks there will be improvement in the amount of mouth opening.

## 2. **Hydrostatic appliance**

- Commercial name is Aqualizer
- Employs water to balance the biting pressure to treat malocclusion and relieve TMJ pain and symptoms
- Hydrostatic cells distributes the occlusal forces to every tooth contacting the cells

## 3. **NTI (Nociceptive trigeminal inhibition tension suppression system)**

- Introduced by Dr James Boyd
- Appliances uses NTI reflex using an acrylic guard worn on either mandibular or maxillary incisors
- Stock NTI's are relined with self cure acrylics

## STENTS

- Stents are also defined as “an appliance that maintains the tissues in a predetermined position.

### Types of Stents

1. Surgical stents
2. Antihemorrhagic stents
3. Periodontal stents
4. Drainage stents
5. Compression stent for Keloid
6. Nasal stent
7. Trismus stent (dynamic bite opener)
8. Radiation stent
  - Radiation docking devices
  - Stents to protect the adjacent tissues (shielding stent, spacers)
  - Stents to carry the radiation sources
  - Stents to provide bolus during radiotherapy
9. Fluoride carrier stents
10. Medicament carrying stents

### I. **Surgical Stents**

- These devices are used to apply pressure to soft tissues to facilitate healing and to prevent cicatrisation
- or collapse of the healing tissues.

**Rationale for the surgical stents :**

- To prevent deviation of the mandible
- To maintain the depth of lingual vestibule
- To maintain the contours of the face
- To reduce contracture of wounds

**Types:**

- After palatal tori reduction
- Palatally impacted canine
- Mandibular tori.
- After vestibuloplasty
- After tuberoplasty
- For ridge augmentation procedures
- For hemimaxillectomy
- For mandibular defects like marginal resection, segmental resection, hemimandibulectomy

**II. Anti-hemorrhagic stent**

- Mainly used to control post surgical or post extraction bleeding in hemophiliac patients and other bleeding disorder conditions

**III. Periodontal stent**

- It is of labiolingual design and is made prior to the surgery.

**Rationale**

- Used to hold the medicaments and grafts in place.
- To cover exposed root surfaces after gingivectomy
- To reduce irritation to the surgical site by soft tissues and other chemical irritants.

**Advantages**

- The periodontal stent can be modified to stabilize both dental and periodontal tissues.

## IV. Drainage stent

### Indications

- Used for draining large abscesses, commonly associated with periapical areas and space infections
- For draining large cysts of the orofacial region
- Allows escape of blood and bodily fluids
- Prevents aspiration

### Advantages:

- The drainage stents maintains the continuous patency and allows rapid wound healing.
- They can also be utilized to irrigate the cystic lesions.

## V. Lip stent (compression stent)

- It is a device utilized for applying the positive pressure on a keloid of the lip.
- One of the successful conservative form of keloid treatment is by applying pressure for prolonged periods before and after surgical removal of the keloid.
- A stent is fabricated by incorporating a clip to apply continuous pressure on the keloid of the facial region.
- The exact mechanism of action is not known but the proposed reasons may be as follows:
  - The continuous compression leads to ischemia of that area and may decrease proliferation of fibroblasts.
  - Duration of wear: 12 hours / day for 6-12 months.

## VI. Pedodontic stent

- Used to stimulate eruption of unerupted teeth after they are surgically uncovered

## VII. Intraoral stent for the physically handicapped

- This interocclusal stent is designed for aiding the patient in drinking and sucking in nourishment.

## VIII. Trismus stent (Dynamic Bite opener, TMJ exerciser)

- The trismus stent is used to provide physiotherapy for the temporomandibular joint and the muscles of mastication as a mode of treatment for trismus.

- The trismus occurs commonly due to radiation, surgery of maxillofacial region, trauma and infection.
- Mechanism : When the elastic are applied, the two splints tries to move apart and thus apply force to the mandibular arch and results in jaws separation.

## IX. **Radiation stents**

- The radiation stents are the devices used to
  - Direct the radiation source towards the target
  - Protect the adjacent vital tissues
  - Carry the radiation sources
  - Provide the bolus during radiotherapy
  - Recontour certain areas so that therapy can be simplified.

**Docking device:** The stents that are utilized to direct the radiation are called as “Docking devices”.

### Needs

- To direct the radiation to the target tissues.
- To direct the radiation cone to same position and direction in case of divided radiation dose therapy.
- To deflect the adjacent soft tissues out of the line of radiation.

### **Stents for protection of adjacent tissues :**

- Shielding devices
- Spacers

## X. **Fluoride carrier stent**

- After radiotherapy, the teeth are prone for radiation caries.
- To prevent radiation caries, fluoride application is a must.
- The custom made resilient fluoride trays with a space of 0.2 to 0.5 mm are fabricated for the patients and provided.
- The fluoride gel is placed into the fluoride carriers and applied 5 minutes daily after brushing and drying the teeth.
- The fluoride carriers are also indicated for the patients who are suffering from ‘rampant carries’.

## CONCLUSION

- The splints and stents are very useful devices in the field of maxillofacial prosthetics.
- Judicious use of the splints and stents minimizes severity of the problems and improve the prognosis, provide comfort to the patient.
- The splints and stents are the excellent examples for preventive prosthodontic devices in the field of maxillofacial prosthetics.

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*Please Give Your Feedback on this Answer*

**Define Bias. Enumerate different bias that can occur in any research designs (10M)**

## CONTENTS/SYNOPSIS

- Introduction
- Bias
- Sources of bias
- Bias in cross-sectional study
  - Selection Bias
  - Information bias
- Bias in case-control study
- Bias in cohort study
- Bias in randomized control trials
  - Selection Bias
  - Information bias
  - Allocation of intervention bias
  - Compliance bias
  - Contamination bias
  - Lack of intention to treat analysis
  - Hawthorne effect
- Lead time bias
- Publication bias
- Confounding bias
- Bias limiting measures
- Conclusion
- References

## INTRODUCTION

- In research, bias occurs when “systematic error introduced into sampling or testing by selecting or encouraging one outcome or answer over others”.
- Bias can occur at any phase of research, including study design or data collection, as well as in the process of data analysis and publication.
- Some extent of bias is always present in a published study, reviewers of the literature must consider the degree to which bias was prevented by proper study design and implementation.

## BIAS

- Definition- “Any factor or process which tends to produce results or conclusions that differ systematically from the truth”.
- It is any **systematic error** during: Design, Conduct, Analysis and Interpretation of research

## SOURCES OF BIAS

- Investigator
- Participant
- Instruments
- literature
- Statistician
- Extraneous variables

## BIAS IN CROSS-SECTIONAL STUDY

### I. Selection Bias

- The error introduced when the study population does not represent the target population.

#### 1. *Inappropriate choice of sampling frame*

- **Health care access bias:** when the patients admitted to an institution do not represent the cases originated in the community.
- **Length bias sampling:** cases with diseases with long duration are more easily included in surveys. This series may not represent the cases originated in the target population. These cases usually have a better prognosis.
- **Competing risks:** when two or more outputs are mutually exclusive, any of them competes with each other in the same subject.
- Self-selection

## 2. **Non-response bias** - Inability to contact subjects/ Participants

### II. **Information bias**

- Information bias occurs during data collection.

#### 1. **Misclassification**

- Observer/interviewer bias, Recall bias, Reporting bias
- Protopathic bias- Preclinical disease → Exposure → Clinical Disease

### BIAS IN CASE-CONTROL STUDY

#### I. **Selection Bias**

##### 1. **Inappropriate choice of sampling frame**

- Health care access bias, Length-bias sampling, Competing risks

<i>Incidence-Prevalence Bias (Neyman bias)</i>	<i>Berkson's bias</i>
<ul style="list-style-type: none"> <li>When a series of survivors is selected, if the exposure is related to prognostic factors, or the exposure itself is a prognostic determinant, the sample of cases offers a distorted frequency of the exposure.</li> </ul>	<ul style="list-style-type: none"> <li>Hospital based case-control study- first described by Berkson in 1946 for case control studies. It is produced when the probability of hospitalisation of cases and controls differ, and it is also influenced by the exposure</li> </ul>

#### 2. **Detection bias**

- Exposure influences diagnosis of the disease. Exposure can be taken as another diagnostic criterion (diagnostic suspicion bias).

#### 3. **Non-response bias**

- When participants differ from nonparticipants, for example, The healthy volunteer effect is a particular case- when the participants are healthier than the general population.
- This is particularly relevant when a diagnostic manoeuvre, such as a screening test, is evaluated in the general population, producing an away from the null bias; thus the benefit of the intervention is spuriously increased.

#### 4. **Others- Friend control bias, Missing information in multivariable analysis**

- Friend controls may have a similar exposure status

## II. Information bias

### 1. Misclassification bias

- It is originated when sensitivity and/or specificity of the procedure to detect exposure and/or effect is not standard.
- Exposed/diseased subjects can be classified as non-exposed/non-diseased and vice versa

*i. Differential misclassification:* when misclassification is different in the groups to be compared.

*ii. Non-Differential misclassification:* when the misclassification is the same across the groups to be compared

### 2. Observer/interviewer bias

- The knowledge of the hypothesis, the disease status, or the exposure status (including the intervention received) can influence data recording.

### 3. Recall bias

<i>i. Rumination bias</i>	<i>ii. Exposure suspicion</i>
<ul style="list-style-type: none"><li>• If the presence of disease influences the perception of its causes</li></ul>	<ul style="list-style-type: none"><li>• The search for exposure to the putative cause</li></ul>

**4. Reporting bias** participants can “collaborate” with researchers and give answers in the direction they perceive are of interest.

**5. Protopathic bias** when a exposure is influenced by early (subclinical) stages of disease.

## BIAS IN COHORT STUDY

### I. Selection Bias

#### 1. Inappropriate choice of sampling frame

- Healthier population- Disease outcomes will be less

#### 2. Loss to follow-up/ withdrawal- drop out

#### 3. Non-response

**4. In prospective studies, selection bias is unlikely to occur because the exposure is ascertained before the development of outcome**

## **II. Information bias**

**1. Misclassification bias:** Differential/ Non-differential

- Detection bias
- Observer/ interviewer bias
  - Rummation bias: especially in retrospective cohort

**2. Recall bias, Reporting bias**

**3. Protopathic bias**

## **BIAS IN RANDOMIZED CONTROL TRIALS**

### **I. Selection Bias**

- Minimized because of Randomization
- Losses/withdrawals to follow up
- Non-response bias

### **II. Information bias**

- Minimized because of Blinding
- Misclassification bias
  - Detection bias
  - Observer/ interviewer bias, Recall bias

### **III. Allocation of intervention bias**

- When intervention is differentially assigned to the population.
- It is more common in non-randomised trials.
- In randomised trials it is recommended concealment of the allocation sequence of intervention.

### **IV. Compliance bias**

- In trials requiring adherence to intervention, the degree of adherence (compliance) influences efficacy assessment of the intervention.

### **V. Contamination bias**

- When intervention-like activities find their way into the control group.
- It biases the estimate of the intervention effect toward the null hypothesis.

- It occurs more frequently in community intervention trials because of the relationships among members of different communities and interference by mass media, health professionals, etc

## VI. Lack of intention to treat analysis

- In randomised studies the analysis should be done keeping participants in the group they were assigned to.
- If non-compliant participants or those receiving a wrong intervention are excluded from the analysis, the branches of a randomised trial may not be comparable.
- There are exceptions to the rule of intention to treat analysis.

## VII. Hawthorne effect -

described in the 1920s in the Hawthorne plant of the Western Electric Company (Chicago, IL). It is an increase in productivity—or other outcome under study—in participants who are aware of being observed. For example, laboratory physicians increase their agreement rate after knowing that they participate in a research on reliability of diagnostic tests.

### LEAD TIME BIAS

- The added time of illness produced by the diagnosis of a condition during its latency period.
- This bias is relevant in the evaluation of the efficacy of screening, in which the cases detected in the screened group has a longer duration of disease than those diagnosed in the non-screened one.

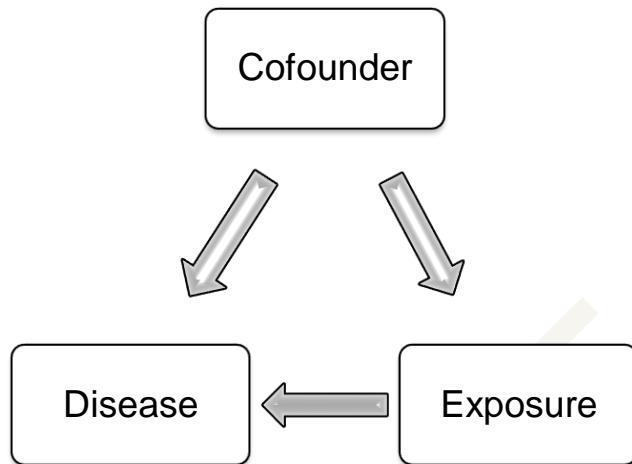
### PUBLICATION BIAS

- When the published reports do not represent the studies carried out on that association.
- Several factors have been found to influence publication, the most important being statistical significance, size of the study, funding, prestige, type of design, and study quality.

### CONFOUNDING BIAS

- Definition: A third variable (not the exposure or outcome variable of interest) that distorts the observed relationship between the exposure and outcome.
- Association between Exposure & Disease is distorted by another third variable/ factor (Confounder)
- Age, Sex , Socioeconomic status are very common sources of confounding.

- Predictive of the occurrence of the disease, the association need not be causal
- Predictive of the occurrence of the disease, independently of its association with the exposure under study.



- The potential confounder cannot merely be an intermediate link in the causal chain between the exposure and disease under study.
- Methods to Control Confounding

Study design	Study design & analysis	Analysis
<ul style="list-style-type: none"> <li>• Randomization</li> <li>• Restriction</li> <li>• Matching</li> </ul>	<ul style="list-style-type: none"> <li>• Matching</li> </ul>	<ul style="list-style-type: none"> <li>• Stratified analysis</li> <li>• Statistical modelling</li> </ul>

## BIAS LIMITING MEASURES

- Scientific collection of sample standardization of instruments, tools, devices, equipments etc.
- Calibration of examiners
- Matching:
  - Prior to the study
  - Matching patients for demographics (such as gender or age)
  - Risk factors (such as body mass index or smoking) can create similar cohorts among identified cofounders
- Blinding:  
It is a procedure in which participants/ interviewer or statistician in a trial are kept unaware of which treatment participants have been assigned to.
- Random allocation (Randomization)

Randomization ensures that each patient has an equal chance of receiving any of the treatments under study, generate comparable intervention groups, which are alike in all the important aspects except for the intervention each group receives.

- Stratification

Stratification is the process of dividing participants of the population into homogeneous subgroups before sampling.

- Restriction

Steps to avoid the occurrence of bias:

Selection bias	Information bias
<ul style="list-style-type: none"><li>• Appropriate study design</li><li>• Appropriate selection of sample</li><li>• Specific criteria for inclusion &amp; exclusion</li><li>• Control group should be similar to experimental group/cases</li><li>• Proper Randomization</li></ul>	<ul style="list-style-type: none"><li>• Explicit criteria for collecting data</li><li>• Detection equal for both groups</li><li>• Hide hypothesis from interviewer and subjects</li><li>• Blinding</li><li>• Maintain contact with subjects to maintain compliance</li></ul>

## CONCLUSION

- The concept of bias is the lack of internal validity or incorrect assessment of the association between an exposure and an effect in the target population in which the statistic estimated has an expectation that does not equal the true value.
- There are many potential sources of bias in research. Bias in research can cause distorted results and wrong conclusions.

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*Please Give Your Feedback on this Answer*

## Explain Mean, Mode and Median (7M)

### CONTENTS/SYNOPSIS

- Introduction
- Central tendency
- Measures of central tendency
  - Mean
    - Arithmetic mean
    - Weighted mean
    - Geometric Mean
    - Harmonic mean
  - Median
    - Advantages
    - Disadvantages
  - Mode
    - Advantages
    - Disadvantages
- Measures of central tendency in distribution
- Choice of appropriate measure of central tendency
- Conclusion
- References

## INTRODUCTION

- In any research, the data collected should be described in a meaningful way and summarized to facilitate interpretation and comparison of data.
- The bulkiness of the data can be reduced by organising it into a frequency table or histogram.
- Frequency distribution organizes the heap of data into a few meaningful categories.
- Collected data can also be summarized as a single index/value, which represents the entire data.

## CENTRAL TENDENCY

- "A measure of central tendency is a typical value around which other figures gather" - Simpson and Kafka

- Central tendency is defined as "the statistical measure that identifies a single value as representative of an entire distribution."

- It aims to provide an accurate description of the entire data. It is the single value that is most typical/representative of the collected data. The term "number crunching" is used to illustrate this aspect of data description.

## MEASURES OF CENTRAL TENDENCY

- The three commonly used measures of central tendency.
  - Mean
  - Median
  - Mode

### I. Mean

- Mean is the most commonly used measure of central tendency.
- There are different types of mean arithmetic mean, weighted mean, geometric mean (GM) and harmonic mean (HM).
- If mentioned without an adjective (as mean), it generally refers to the arithmetic mean.

### 1. Arithmetic mean (or, simply, “mean”)

- It is nothing but the average. It is computed by adding all the values in the data set divided by the number of observations in it.
- If we have the raw data, mean is given by the formula

$$\bar{X} = \frac{\sum X}{n}$$

- Where,  $\Sigma$  (the uppercase Greek letter sigma), X refers to summation, refers to the individual value and n is the number of observations in the sample (sample size).

- The research articles published in journals do not provide raw data and, in such a situation, the readers can compute the mean by calculating it from the frequency distribution (if provided).
- Where, f is the frequency and X is the midpoint of the class interval and n is the number of observations.

### Mean of Grouped Data:

$$\bar{x} = \frac{\sum fx}{n}$$

where:  $\bar{x}$  = mean

f = frequency of each class

x = mid-interval value of each class

n = total frequency

$\sum fx$  = sum of the products of mid – interval values and their corresponding frequency

i. Advantages	ii. Disadvantages
<ul style="list-style-type: none"> <li>The mean uses every value in the data and hence is a good representative of the data.</li> <li>The irony in this is that most of the times this value never appears in the raw data.</li> </ul>	<ul style="list-style-type: none"> <li>The important disadvantage of mean is that it is sensitive to extreme values/outliers, especially when the sample size is small.</li> <li>Therefore, it is not an appropriate measure of central tendency for</li> </ul>

- |  |  |
|--|--|
| <ul style="list-style-type: none"><li>Repeated samples drawn from the same population tend to have similar means.</li><li>The mean is therefore the measure of central tendency that best resists the fluctuation between different samples.</li><li>It is closely related to standard deviation, the most common measure of dispersion.</li></ul> | <p>skewed distribution.</p> <ul style="list-style-type: none"><li>Mean cannot be calculated for nominal or non-nominal ordinal data.</li><li>Even though mean can be calculated for numerical ordinal data, many times it does not give a meaningful value, e.g. stages of cancer.</li></ul> |
|--|--|

## 2. *Weighted mean*

- Weighted mean is calculated when certain values in a data set are more important than the others.

## 3. *Geometric Mean*

- It is defined as the arithmetic mean of the values taken on a log scale. It is also expressed as the  $n^{\text{th}}$  root of the product of an observation.
- GM is an appropriate measure when values change exponentially and in case of skewed distribution that can be made symmetrical by a log transformation.
- GM is more commonly used in microbiological and serological research.
- One important disadvantage of GM is that it cannot be used if any of the values are zero or negative.

## 4. *Harmonic mean*

- It is the reciprocal of the arithmetic mean of the observations.
- HM is appropriate in situations where the reciprocals of values are more useful.
- HM is used when we want to determine the average sample size of a number of groups, each of which has a different sample size.

## II. **Median**

- Median is the value which occupies the middle position when all the observations are arranged in an ascending/descending order.
- It divides the frequency distribution exactly into two halves.
- Fifty percent of observations in a distribution have scores at or below the median. Hence, median is the 50th percentile.
- Median is also known as 'positional average'
- It is easy to calculate the median.

If the number of observations are odd, then  $(n + 1)/2$ th observation (in the ordered set) is the median. When the total number of observations are even, it is given by the mean of  $n/2$ th and  $(n/2 + 1)$ th observation.

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>It is easy to compute and comprehend.</li> <li>It is not distorted by outliers/skewed data.</li> <li>It can be determined for ratio, interval, and ordinal scale.</li> </ul>	<ul style="list-style-type: none"> <li>It does not take into account the precise value of each observation and hence does not use all information available in the data.</li> <li>Unlike mean, median is not amenable to further mathematical calculation and hence is not used in many statistical tests.</li> <li>If we pool the observations of two groups, median of the pooled group cannot be expressed in terms of the individual medians of the pooled groups.</li> </ul>

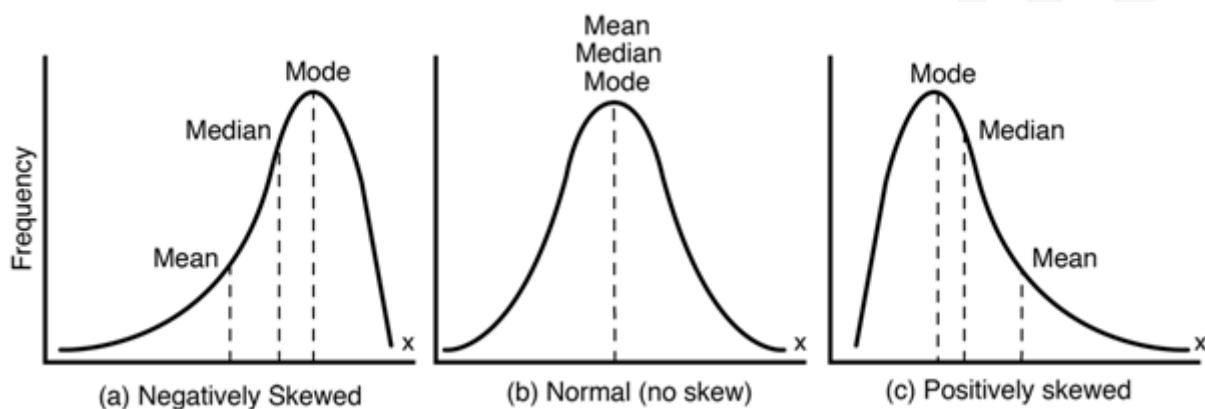
### III. Mode

- Mode is defined as the value that occurs most frequently in the data.
- Some data sets do not have a mode because each value occurs only once.
- On the other hand, some data sets can have more than one mode.
- This happens when the data set has two or more values of equal frequency which is greater than that of any other value.
- Mode is rarely used as a summary statistic except to describe a bimodal distribution.
- In a bimodal distribution, the taller peak is called the major mode and the shorter one is the minor mode.

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>It is the only measure of central tendency that can be used for data measured in a nominal scale.</li> <li>It can be calculated easily.</li> </ul>	<ul style="list-style-type: none"> <li>It is not used in statistical analysis as it is not algebraically defined and the fluctuation in the frequency of observation is more when the sample size is small.</li> </ul>

## MEASURES OF CENTRAL TENDENCY IN DISTRIBUTION

- The relative position of the three measures of central tendency (mean, median, and mode) depends on the shape of the distribution.
- All three measures are identical in a normal distribution.
- As mean is always pulled toward the extreme observations, the mean is shifted to the tail in a skewed distribution.
- Mode is the most frequently occurring score and hence it lies in the hump of the skewed distribution.
- Median lies in between the mean and the mode in a skewed distribution.



## CHOICE OF APPROPRIATE MEASURE OF CENTRAL TENDENCY

- Mean is generally considered the best measure of central tendency and the most frequently used one. However, there are some situations where the other measures of central tendency are preferred.
- Median is preferred to mean when
  - There are few extreme scores in the distribution.
  - Some scores have undetermined values.
  - There is an open ended distribution.
  - Data are measured in an ordinal scale.
- Mode is the preferred measure when data are measured in a nominal scale.
- Geometric mean is the preferred measure of central tendency when data are measured in a logarithmic scale.

## CONCLUSION

- Measures of central tendency is very significant to find representative value, to make more concise data and comparisons, and helpful for further statistical analysis.

- Selection of appropriate method of central tendency is of mere importance in any research.

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**Sample techniques in research (7M)****CONTENTS/SYNOPSIS**

- Introduction
- History
- Sampling
  - Universe
  - Sample
  - Sampling unit
  - Sampling frame
  - Advantages of Sampling
  - Disadvantages of Sampling
  - Ideal requirements of a Sample
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- Non probability sampling/ Non Random sampling
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## INTRODUCTION

- Researchers usually cannot make direct observations of every individual in the population that is being studied.
- Instead, data is collected from a subset of individuals – a sample – and use those observations to make inferences about the entire population.
- Ideally the sample corresponds to the larger population on the characteristic(s) of interest.
- In that case, the researcher's conclusions from the sample are probably applicable to the entire population.
- This type of correspondence between the sample and the larger population is most important when a researcher wants to know what proportion of the population has a certain characteristic – like a particular opinion or a demographic feature.

## HISTORY

- Random sampling by using lottery is an old idea, mentioned several times in the Bible.
- In 1786, Pierre Simon Laplace estimated the population of France by using a sample, along with ratio estimator.
- He also computed probabilistic estimates of the error.
- His estimates used Bayes theorem with a uniform prior probability and it assumed his sample was random.
- The theory of small-sample statistics developed by William Seally Gossett put the subject on a more rigorous basis in the 20th century.

## SAMPLING

- Sampling is a process by which we study a small part of a population to make judgments about the entire population.
  - Sampling involves selecting a number of units from a defined population.
- 
- "The process of selecting a subgroup of a population to represent the entire population".- Research methods glossary
  - In most of the research work and surveys, the usual approach happens to be to make generalizations or to draw inferences based on samples about the parameters of population from which the samples are taken.

- Sample should be truly representative of population characteristics without any bias so that it may result in valid and reliable conclusions.

### I. Universe

- It refers to the total of the items or units in any field of inquiry

### II. Sample

- A sample is a subset of the target population.

### III. Sampling unit

- Each member of the population is called as sampling unit

### IV. Sampling frame

- It is the list containing all sampling units.
- Thus, sampling frame consists of a list of items from which the sample is to be drawn.
- The frame should be a good representative of the population.
- This frame is either constructed by a researcher for the purpose of study or may consists of some existing list of the population.
- Eg. Register, telephone directory etc.

### V. Advantages of Sampling

- **Reduced cost:** It is cheaper to collect data from a part of the whole population and it is economically in advance.
- **Greater speed:** It is quick and has a lot of time for collection of data.
- **Detailed information:** Study of a small universe provides a detailed and comprehensive information.
- **Practical method:** Sampling is the only practical method when the population is infinite

### VI. Disadvantages of Sampling

- Careful sampling selection is difficult
- Experts are required for careful study of the universe.
- If the information is required for each and every unit in the study, then it is difficult to interview each and every person in sampling method.

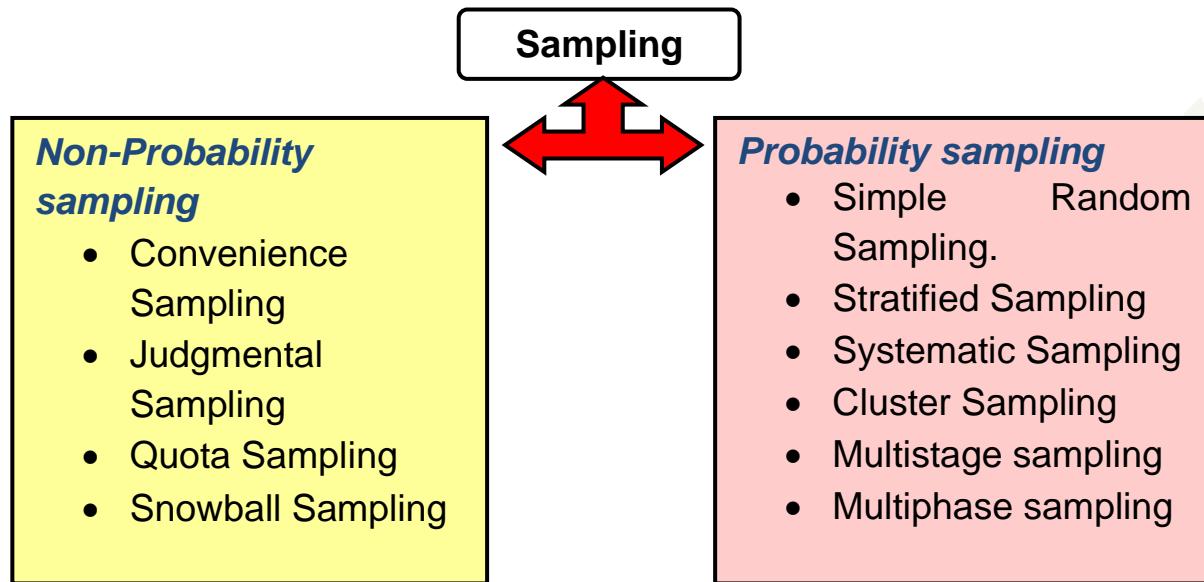
- **Easier:** It is much easier to collect information from many individuals in a universe.

## VII. Ideal requirements of a Sample

<b>V. Efficiency</b>	<ul style="list-style-type: none"> <li>Ability of the sample to yield the desired information.</li> </ul>
<b>VI. Representativeness</b>	<ul style="list-style-type: none"> <li>A sample should be representative of the parent population so that inferences drawn from the sample can be generalized to that population with measurable precision and confidence.</li> </ul>
<b>VII. Size</b>	<ul style="list-style-type: none"> <li>A sample should be large enough to minimize sample variability and to allow estimates of the population characteristics to be made with measurable precision.</li> </ul>
<b>VIII. Measurability</b>	<ul style="list-style-type: none"> <li>The design of the sample should be such that valid estimates of its variability can be made, that is the investigator should be able to estimate the extent to which findings from the sample are likely to differ from the parent population.</li> </ul>
<b>IX. Goal orientation</b>	<ul style="list-style-type: none"> <li>Sample selection should be oriented towards the study objectives and research design.</li> </ul>
<b>X. Feasibility</b>	<ul style="list-style-type: none"> <li>The design should be simple enough to be carried out in practice.</li> </ul>
<b>XI. Cost efficiency and Economy</b>	<ul style="list-style-type: none"> <li>The sample design should be such that it should yield the desired information with appreciable savings in time and cost and with least sampling error.</li> </ul>

## VII. Sampling designs

- The method of selecting a sample is of fundamental importance and depends upon the nature of data and investigation.



### NON PROBABILITY SAMPLING/ NON RANDOM SAMPLING

- It's a sampling procedure which does not afford any basis for estimating the probability that each item in the population has of being included in the sample.
- Also known as Deliberate sampling, Purposive sampling
- This method involves purposive or deliberate selection of particular units of the universe for sample.
- Elements are chosen arbitrarily with no way to estimate the probability of any one element being included in the sample.
- No assurance is given that each item has a chance of being included.

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>Quick, inexpensive and convenient.</li> <li>Questionnaire testing and some preliminary studies during the development stage of a survey</li> <li>Applied social research, when it is unfeasible or impractical to conduct probability sampling.</li> </ul>	<ul style="list-style-type: none"> <li>Reliability cannot be measured</li> <li>No way to measure the precision of the resulting sample.</li> <li>Only way to address data quality is to compare some of the survey results with available information about the population.</li> </ul>

## I. Convenience Sampling

- Convenience sampling is also referred to as
  - Haphazard sampling
  - Grab sampling
  - Opportunity sampling
- Sample is selected from elements of a population that are easily accessible.

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>Simplicity of sampling and ease of research</li> <li>Helpful for pilot studies and for hypothesis generation</li> <li>Data collection can be facilitated in short duration of time</li> <li>Cost effectiveness</li> </ul>	<ul style="list-style-type: none"> <li>Highly vulnerable to selection bias</li> <li>Generalization is unclear</li> <li>High level of sampling error</li> </ul>

## II. Judgmental Sampling

- It is also known as Purposive sampling.
- It's a non-representative subset of some larger population, and is constructed to serve a very specific need or purpose.
- A researcher may have a specific group in mind, such as high level business executives.

- Statisticians often use this method in exploratory studies like pre-testing of questionnaires and focus groups.
- They also prefer to use this method in laboratory settings where the choice of experimental subjects (i.e., animal, human) reflects the investigator's pre-existing beliefs about the population.

Advantage	Disadvantages
<ul style="list-style-type: none"> <li>Reduced cost and time involved in acquiring the sample.</li> </ul>	<ul style="list-style-type: none"> <li>Members of the population will have a smaller or no chance of selection compared to others.</li> <li>Large biases can be introduced if the preconceptions(researchers) are not accurate.</li> </ul>

### III. Quota sampling

- Sampling is done until a specific number of units (quotas) for various sub-populations have been selected.
- There are no rules as to how these quotas are to be filled, quota sampling is really a means for satisfying sample size objectives for certain sub-populations.
- Often used to ensure that convenience samples will have desired proportion of different respondent classes.
- For example, a researcher interested in the attitudes of members of different states towards the ban of smoking in Karnataka, a random sample might miss Kerala or Andhra people(because they may not be in the state).
- To be sure in their inclusion, a researcher could set a quota of 5% Kerala and Andhra people for the sample, this may limit generalizing to the state population.
- But the quota will guarantee that views of Kerala and Andhra are represented in the survey

<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>Relatively inexpensive</li> <li>Easy to administer</li> <li>Desirable property of satisfying population proportions.</li> </ul>	<ul style="list-style-type: none"> <li>Selection Bias</li> <li>Similar to stratified sampling without randomness</li> </ul>

### IV. Snowball Sampling

- It is also known as Chain referral sampling.
- An initial group of respondents is selected, usually at random.
- After being interviewed, these respondents are asked to identify others who belong to the target population of interest.
- Subsequent respondents are selected based on the referrals

Useful tool for building networks and increasing the number of participants

<b>Advantage</b>	<b>Disadvantage</b>
<ul style="list-style-type: none"> <li>Locating hidden populations</li> <li>Locating people of a specific population</li> </ul>	<ul style="list-style-type: none"> <li>Community bias</li> <li>Absence of Randomness</li> <li>Vague overall sample</li> </ul>

## PROBABILITY SAMPLING

- Probability sampling is also known as Random sampling or Chance sampling.
- It is the most recommended method of sampling.
- Every item of the universe has an equal chance of inclusion in the sample.
- Therefore generalizations can be made to the parent population with precision and confidence.

### I. Simple Random Sampling

It's a method of sample selection wherein

- Each element in the population has an equal probability of getting into the sample and all choices are independent of one another.
- It gives each possible sample combination an equal probability of being chosen.
- The probability of being selected is “known and equal” for all members of the population.

Methods of selection of a simple random sampling

- Lottery Method
- Table of Random numbers

1. <i>Lottery method</i>	2. <i>Table of Random numbers</i>
<ul style="list-style-type: none"><li>• Most popular and simplest method.</li><li>• All the items of the population are numbered on separate slips of paper of same size, colour and shape, folded and mixed up in a container.</li><li>• For e.g., if we want to select 10 students out of 100, then we must write their names or roll numbers of all 100 students on slips &amp; mix them and make a random selection of 10 students.</li></ul>	<ul style="list-style-type: none"><li>• When the population is infinite, the lottery method cannot be used and the alternative method is that of using the table of random numbers.</li><li>• Various statisticians like Tippet, Yates, Fisher have prepared tables of random numbers for selecting a random sample.</li><li>• Can be used only when lists are available and items are readily numbered in the infinite populations.</li></ul>

**How to use a random number table:**

- Reproducing first thirty sets of Tippet's numbers

2952	6641	3992	9792	7979	5911
3170	5624	4167	9525	1545	1396
7203	5356	1300	2693	2370	7483
3408	2769	3563	6107	6913	7691
0560	5246	1112	9025	6008	8126

- If we are interested in taking a sample of 10 units from a population of 5000 units, bearing numbers from 3001 to 8000
- Select numbers from the above which are not less than 3001 and not greater than 8000.
- Randomly from left to right, obtaining the following numbers 6641, 3992, 7979, 5911, 3170, 5624, 4167, 7203, 5356 and 7483.
- Random number can be generated through scientific calculator or computers.
- For each press of the key get a new random numbers. The ways of selection of sample is similar to that of using random number table

<b>Advantage</b>	<b>Disadvantage</b>
<ul style="list-style-type: none"> <li>Known and equal chance of selection.</li> <li>Easy method when there is an electronic database.</li> </ul>	<ul style="list-style-type: none"> <li>Complete accounting of population needed.</li> <li>Cumbersome to provide unique designations to every population member.</li> <li>Very inefficient when applied to skewed population distribution (over- and under-sampling problems) – this is not “overcome with the use of an electronic database.</li> </ul>

**II. Stratified Sampling**

- The sample size depends upon the size of the population which is stratified sampling with proportional allocation.
- Depending upon characteristics, they are divided into subgroups (strata) and random sample is drawn independently from each subgroup.
- The consideration for heterogeneity and homogeneity with regard to population is studied.
- Heterogeneous populations is converted into homogeneous sub populations.
- For e.g., residents from urban and rural areas, or different age groups.
- Random or systematic samples of predetermined size will then have to be obtained from each group (stratum).

- The population is separated into homogeneous groups/segments/strata and a sample is taken from each. The results are then combined to get the picture of the total population.

<b>Advantages</b>	<b>Disadvantage</b>
<ul style="list-style-type: none"> <li>Precise estimate of each stratum</li> <li>Better estimate of whole populations by combining strata.</li> <li>More reliable.</li> <li>Detailed information.</li> </ul>	<ul style="list-style-type: none"> <li>More complex sampling plan requiring different sample sizes for each stratum.</li> </ul>

### III. Systematic Sampling

- A type of probability sampling method in which sample members from a larger population are selected according to a random starting point and a fixed, periodic interval.
- This interval is called the sampling interval and is calculated by dividing the population size by the desired sample size.
- Despite the sample population being selected in advance, systematic sampling is still thought of as being random, provided the periodic interval is determined beforehand and the starting point is random.
- E.g. 4 % sample is desire; 1<sup>st</sup> item is selected randomly at first 25<sup>th</sup> , thereafter every 25<sup>th</sup> item will be automatically included.
  - A systematic sample is to be selected from 1200 students of a school.
  - The sample size selected is 100.
  - The sampling interval is, therefore,  $1200/ 100= 12$ .
  - The number of the first student to be included in the sample is chosen randomly.

<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>Known and equal chance of any of the sampling interval being selected.</li> <li>Efficiency do not need to designate every population member, just those early on the list</li> <li>Less expensive and faster than Simple random sampling</li> </ul>	<ul style="list-style-type: none"> <li>Small loss in sampling precision</li> <li>Potential “periodicity” problems</li> </ul>

#### IV. Cluster Sampling

- Cluster sampling is a sampling technique used when "natural" but relatively homogeneous groupings are evident in a statistical population.
- The total population is divided into a number of relatively small sub divisions called "clusters"
- Some of these clusters are randomly selected for inclusion in overall sample.
- Method by which the population is divided into groups (clusters), any of which can be considered a representative sample.

*E.g. Area sampling*

- Then a random sample of clusters is selected, based on a probability sampling technique such as simple random sampling.
- Types of Cluster Sampling:

<b>One stage</b>	<b>Two stage</b>
<ul style="list-style-type: none"> <li>• List all the clusters in the population, and from the list, select the clusters using simple random sampling (SRS) strategy.</li> <li>• All units (elements) in the sampled clusters are selected for the survey.</li> </ul>	<ul style="list-style-type: none"> <li>• The units (elements) in the selected clusters of the first-stage are then sampled in the second-stage, usually by simple random sampling.</li> </ul>

#### V. Multi stage sampling

- This method refers to the sampling procedures carried out several stages.
- Random sampling is applied at all stages
- This method is employed in large country surveys.
- First stage is to select primary sampling units like states then districts followed by towns and families within towns.

<b>Advantage</b>	<b>Disadvantage</b>
<ul style="list-style-type: none"> <li>• Economic efficiency. Faster and less expensive than SRS.</li> <li>• Does not require a list of all members of the universe.</li> </ul>	<ul style="list-style-type: none"> <li>• Cluster specification error-- the more homogeneous the cluster chosen, the more imprecise the sample results</li> </ul>

## VI. Multi phase sampling

- In this method, part of the information is collected from the whole sample and part from the subsample
- Eg., In a tuberculosis survey physical examination or Mantoux test may be done in all cases of the sample in the first phase.
- In the second phase X-ray of the chest may be done in Mantoux positive cases and in those with clinical symptoms, while sputum may be examined in X-ray positive cases in the third phase only.
- Number in the 2<sup>nd</sup> and 3<sup>rd</sup> phase will become successively smaller and smaller.

### Advantages

- Less costly
- Less laborious
- More purposeful

## ERRORS IN SAMPLING

- Errors in sampling are of two types

I. Sampling errors	II. Non-sampling errors
<ul style="list-style-type: none"> <li>• These are due to faulty sampling design or small size of sample.</li> <li>• Can be reduced and properly estimated through correct sampling technique</li> <li>• Sampling error can be measured for a given sample design and size called as “precision of the sampling plan.”</li> <li>• If the sample size is increased, the precision can be improved.</li> <li>• But increasing the size of the sample has its own limitations viz., expensive, time consuming in collection of data.</li> <li>• Thus the effective way to increase the precision is usually to select a better sampling design which has a smaller sampling error for a given</li> </ul>	<ul style="list-style-type: none"> <li>• It arises at the stage of collection and preparation of data during,</li> <li>• When all units in the sample are not covered due to non-response or non-cooperation.</li> <li>• Observational errors</li> <li>• Interviewers bias</li> <li>• Imperfect experimental technique</li> <li>• Processing errors</li> <li>• Theoretical errors in statistical analysis</li> <li>• Clerical errors or computational errors</li> <li>• Non sampling errors can be reduced by defining the sampling units, frame and the population correctly and by employing efficient people in the investigations.</li> </ul>

sample size at a given cost.

## CONCLUSION

- Normally one should resort to a simple random sampling because under it bias can be eliminated generally and sampling error can be estimated.
- Purposive sampling is considered more appropriate when universe happens to be small and a known characteristics of it is to be studied intensively.
- In situations where simple random sampling cannot be used, other sampling methods should be considered.
- At times, several methods of sampling may well be used in the same study.

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**Please Give Your Feedback on this Answer**

## **Standard deviation (10M)**

## **Standard deviation and coefficient of variation (7M)**

### **CONTENTS/SYNOPSIS**

- Introduction
- Summarization of health data
- Measures of dispersion
  - Range
  - Mean deviation
  - Standard deviation
- Frequency distribution
- Conclusion
- References

## INTRODUCTION

- In health research, for analyzing the collected data it is significant to describe and summarize those data in forms which convey their important characteristics.
- The data collected should be described in a meaningful way and summarized to facilitate interpretation and comparison of data.

## SUMMARIZATION OF HEALTH DATA

- For categorical data/ ordinal data, we use percentages and depict this using bar graphs or pie charts.
- For numerical data/ nominal data, we depict the ‘average’, which is “middle” of the data and the ‘dispersion’, which tells us how far away from the ‘average’ most of the values lie.
  - If data is normally distributed, the average is the **arithmetic mean**.
  - The spread of the data around the mean is depicted by the **standard deviation**. The larger the standard deviation, the more dispersed is the data (i.e., higher is the variance within the data).
- For skewed data, the arithmetical mean does not give an idea of the true average. We therefore use another summary statistic called the **median** (or the 50th centile).
- The bulkiness of the data can be reduced by organising it into a **frequency table or histogram**.
- Frequency distribution organizes the heap of data into a few meaningful categories.
- Collected data can also be summarized as a single index/value, which represents the entire data.

## I. Measures of dispersion

- An average fails to give any idea about the scatter of the values of items of a variable in the series around the true value of average.
- In order to measure this scatter, statistical devices called measures of dispersion are calculated.
- Important measures of dispersion are
  - Range
  - Mean deviation
  - Standard deviation

### Standard deviation (Root Mean Square deviation)

- Is defined as the square root of the arithmetic mean of the squared deviations of the individual values from their arithmetic mean

For small samples

$$SD = (\sigma) = \sqrt{\frac{\sum(x - \bar{x})^2}{N-1}}$$

For large samples

$$SD = (s) = \sqrt{\frac{\sum(x - \bar{x})^2}{N}}$$

#### i. Calculation of standard deviation

- $X = \sum X/n$  -calculate the mean of the group
- $(X-X)$  -subtract the mean from each value
- $(X-X)^2$  -square each deviation from the mean
- $\sum (X-X)^2$ -add the squared deviation from the mean
- $SS/(n-1)$  - divide the sums of the square  $(n-1)$
- $\sqrt{SS/(n-1)}$  -Find the square root of variance

#### ii. Uses of Standard deviation

- Summarizes the deviations of a large distribution from mean in one figure used as unit of freedom
- Indicates whether the variation from the mean is by chance or real
- Helps finding standard error- which determines whether the difference between means of two samples is by chance or real
- Helps finding the suitable size of the sample for valid conclusions

## II. Frequency distribution

- The coefficient of variation is also known as relative standard deviation
- It is a standardized measure of frequency distribution

- A frequency (distribution) table shows the different measurement categories and the number of observations in each category.
- The range is divided into arbitrary intervals called "class interval."
- The width of the class interval can be determined by dividing the range of observations by the number of classes.
- It is advisable to have equal class widths.
- Unequal class widths should be used only when large gaps exist in data.
- The class intervals should be mutually exclusive and non-overlapping.
- Open-ended classes at the lower and upper side (e.g., >100) should be avoided.
- Generally, 6–14 intervals are adequate.
- Frequency distributions may be presented in a table or a graph, including bar charts and pie or sector charts.

## CONCLUSION

- The collected and summarized data can be presented as graphs, charts like bar charts, pie charts, figures, Scatter plot, line plot, box and whiskers plot etc to provide an effective media for analysis and interpretation.

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*Please Give Your Feedback on this Answer*

## Study designs in research (7M)

### CONTENTS/SYNOPSIS

#### Introduction

#### Classification of epidemiological studies (who 1993)

##### Descriptive studies

###### I. Steps in descriptive studies

1. Defining the population to be studied
2. Defining the disease under study
3. Describing the disease by time, place and person
4. Measurement of disease
5. Comparing with known indices
6. Formulation of an etiologic hypothesis

###### II. Uses of descriptive studies

##### Analytical studies

###### I. Case control studies (Retrospective Study)

1. Steps in case control study
  - i. Selection of Cases
  - ii. Selection of Controls/ Matching
  - iii. Collection of Data on Exposure
  - iv. Analysis and interpretation
2. Advantages of Case Control Studies
3. Disadvantages of Case Control Studies

###### II. Prospective cohort studies

1. Steps in Cohort study
  - i. Selection of a cohort
  - ii. Obtaining Data on exposure
  - iii. Selection of comparison groups
  - iv. Follow up
  - v. Analysis
2. Advantages of a Cohort Study
3. Disadvantages of a Cohort Study

##### Experimental studies

###### I. Steps in conducting a RCT

1. Drawing up a protocol
2. Selecting reference and experimental populations
3. Randomization

4. Manipulation or intervention
5. Follow-up
6. Assessment of outcome

Conclusion

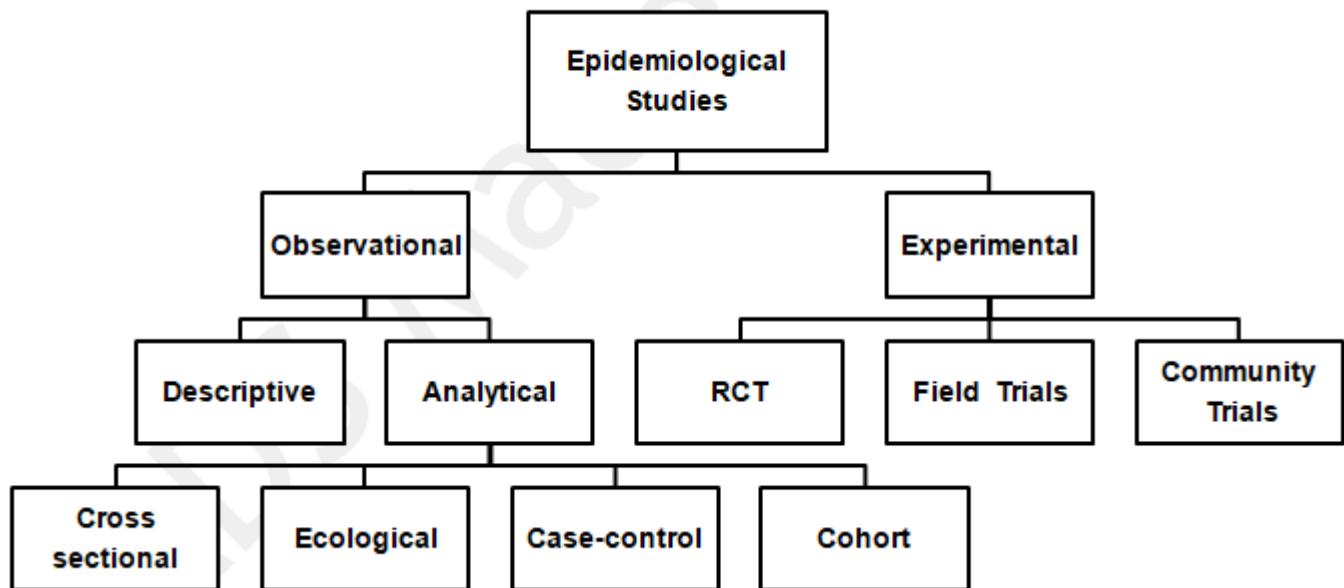
References

MDS Made Easy

## INTRODUCTION

- Research is a quest for knowledge through diligent search or investigation or experimentation aimed at the discovery and interpretation of new knowledge.”  
-Health Research Methodology, WHO.
- Methodology- Procedures by which researchers go about describing, explaining and predicting phenomenon.

## CLASSIFICATION OF EPIDEMIOLOGICAL STUDIES (WHO 1993)



## DESCRIPTIVE STUDIES

- Descriptive studies are usually the first phase of an epidemiological investigation.
- These studies are concerned with observing the distribution of disease in human populations and identifying the characteristics with which the disease seems to be associated.
- Descriptive study allows the generation of hypothesis, which can then be tested by analytical or experimental study designs.

### I. Steps in descriptive studies

1. Defining the population to be studied	2. Defining the disease under study
<p>• Define the population in terms of size and other characteristics.</p>	<p>• Stating the Clinical definition – Operational definition of the disease to facilitate diagnosis.</p>

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>Population forms the denominator</li> <li>Epidemiologists are men in search of the denominator</li> </ul> | <ul style="list-style-type: none"> <li>If the definition is not valid, it would be a powerful source of error</li> </ul> |
|--|--|

### 3. Describing the disease by time, place and person

- Frequently the distribution of the disease is described in terms of time, place and person
- Time- Year, season, month, week, day, hour of onset, duration etc.
- Place- Climatic zones, country, region, urban/rural, local community, towns, cities, institutions, etc.
- Person- Age, sex, marital status, occupation, social status, education, birth order, family size, height, weight, blood pressure, personal habits, etc.

<i>i. Time Distribution</i>	<ul style="list-style-type: none"> <li>3 kinds of time trends/ fluctuations in disease occurrence.</li> <li>Short term fluctuations- Epidemics</li> <li>Periodic fluctuations</li> <li>Seasonal trends- Eg. URT infections- winter, GIT infections- summer, malaria- rainy season</li> <li>Cyclic trends- Eg. Measles in pre- vaccination period- 2-3 years, influenza pandemics- 7- 10 years</li> <li>Long term fluctuations or secular trends</li> <li>Changes in the occurrence of disease over a long period of time, generally several years or decades</li> <li>Eg. Coronary heart disease, cancers, dental caries</li> </ul>
<i>ii. Place Distribution</i>	<ul style="list-style-type: none"> <li>Geographical pathology</li> <li>Geographic variations of disease can be classified as...</li> <li>International variations</li> <li>National variations</li> <li>Rural- urban variations</li> <li>Local variations</li> <li>Migration studies</li> </ul>
<i>iii. Person Distribution</i>	<ul style="list-style-type: none"> <li>Define persons by age, sex, marital status etc.</li> <li>May not necessarily represent etiological factors, but they contribute to the understanding of the natural history of the disease</li> </ul>

- To identify high risk groups

#### 4. Measurement of disease

- Measurement of health related states or events
- Disease load
- Mortality and morbidity data
- Two kinds of studies based on the time period of the study

<i>i. Cross-sectional studies/ community (population) surveys/ prevalence study</i>	<i>ii. Longitudinal studies/ incidence study</i>
<ul style="list-style-type: none"> <li>• Cross sectional studies entails the collection of data on, as the term implies, a cross section of the population, which may comprise the whole population or a proportion (a sample).</li> <li>• They provide <u>a prevalence rate at a point in time (point prevalence)</u>.</li> <li>• Exposure &amp; effect are measured simultaneously</li> <li>• Easy &amp; economic</li> <li>• Often the first step in an investigation</li> </ul>	<ul style="list-style-type: none"> <li>• Exposure &amp; outcome are measured at different times</li> <li>• Same individuals are observed at different times over a period</li> <li>• Useful in studying the natural history of the disease, risk factors</li> <li>• Difficult &amp; expensive comparatively</li> <li>• They <u>provide a prevalence rate over a period of time (period prevalence)</u>.</li> </ul>

#### 5. Comparing with known indices

- The essence of any epidemiologic study is
- To make comparisons
- To ask questions
- Can be helpful in finding the etiology
- Identifying the high risk groups
- Assessing the efficacy of health care delivery systems and strategies

#### 6. Formulation of an etiologic hypothesis

- Hypothesis is a supposition arrived at from an observation or reflection
- It is the final step in a descriptive study.

## II. Uses of descriptive studies

- Data pertaining to morbidity and mortality of communities.
- Provide clues to etiology & help in formulating the etiological hypothesis
- Provide background data for planning, organizing and evaluating health services
- Contribute to research by describing variations in disease occurrence by time, place and person.

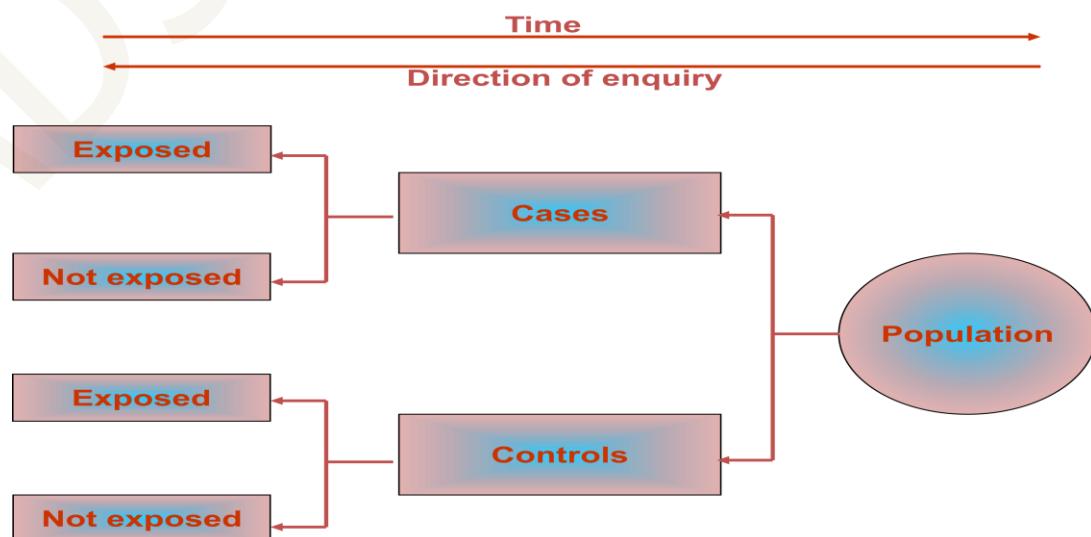
## ANALYTICAL STUDIES

- Analytical studies are observational means used in the epidemiological investigations **to test the specific etiologic hypothesis**.
- The term “analytical” implies that the study is designed to establish the cause of the disease by looking for associations between exposure to risk factor and disease occurrence.

## I. Case control studies (Retrospective Study)

- The design is relatively simple, except that, it is “backward looking” (retrospective), based on the exposure histories of the cases and controls.
- A common first approach to test causal hypothesis.
- Increasingly used to know the causes of diseases, especially rare diseases.
- Features
  - Both exposure and outcome have occurred before the onset of the study
  - Study proceeds backwards, from effect to cause
  - Use a control or comparison group to support or refute an inference

## Design of a case control study



## 1. Steps in case control study

### i. Selection of Cases

- The cases for case – control studies are often those of hospital patients or from a physician's private practice, or from disease registers.
- Cases selected should be representative of all cases of the diseases under consideration.
- Newly diagnosed cases within a specified period (incident cases) are preferred to prevalent cases, since such a choice may eliminate the possibility that long term survivors of a disease were exposed to the investigated risk factor after the onset of the disease.
- The inclusion and exclusion criteria must be specified.

- The **sources of cases** may be:
  - All cases admitted to or discharged from the hospital, clinic within a Specified period.
  - All cases reported or diagnosed during a survey or surveillance Programmed within a specified period.
  - Incident or newly diagnosed cases
  - Incident cases in an ongoing cohort study
  - Deaths with a record of causes of death

### ii. Selection of Controls/ Matching

- It is crucial to set up control groups of people
- The sources of comparison may be:
  - A probability sample of a defined population, if the cases are drawn from that population.
  - A sample of patients admitted to or attending the same institution as the Cases.
  - A sample of relatives or associates of the cases.
  - A group of persons selected from the same source of population as the cases matched with the cases on other risk factors.
- The methods of selecting controls are either by matching or using unmatched controls.

- Matching means that the controls are selected which have certain characteristics in common with the cases.
- The characteristics are those that would confound the effect of the putative risk factors. This can be done on a one to one basis (individual matching) or on a group matching basis (frequency distribution matching).

Advantage	Disadvantage
<ul style="list-style-type: none"> <li>• The major advantage of matching is to cancel out the confounding effects of the competing variables and to guarantee the comparability of cases and controls in that regard.</li> </ul>	<ul style="list-style-type: none"> <li>• The disadvantage of matching is the tendency of over matching i.e. matching on numerous variables.</li> </ul>

- One must never match on the exposure variable included in the study hypothesis.
- Use of unmatched controls allows greater flexibility in studying various interactions, especially when there are multiple risk factors.

### iii. *Collection of Data on Exposure*

- Such a data may be amassed through interviews, questionnaires and examination of records. Because this information is a basic component of the study, the following precautions must be taken:

- Observation must be objective and well standardized.
- The investigator and the interviewer must be blinded
- The same procedure must be used for all groups.

### iv. *Analysis and interpretation*

Involves two steps

- Exposure rates among cases and controls
- Estimation of disease risk associated with exposure (odds ratio)

## 2. *Advantages of Case Control Studies*

- Feasible when studying rare diseases.
- Relatively efficient , requiring a smaller sample than a cohort study
- Little problem with attrition

- Is sometimes the earliest practical observational strategy for determining an association

### **3. Disadvantages of Case Control Studies**

- The absence of epidemiological denominators makes the calculation of incidence rates impossible.
- Temporality is a serious problem in many case control studies where it is not possible to determine whether the attribute led to the disease condition or vice versa.
- There is a great chance for bias in the selection of cases and controls.
- It may be difficult or impossible to obtain information on exposure if the recall period is too long.
- Selective survival, which operates in case control studies, may bias the comparison. There is no way to ascertain whether the exposure was the same for those who died and those who survived.
- Measurement bias may exist, including selective recall or misclassification. There is possibility of the Hawthorne Effect; with repeated interviews, respondents may be influenced by being under study.
- Case control studies are incapable of disclosing other conditions related to the risk factor.

## **II. Prospective cohort studies**

- Usually undertaken to obtain additional evidence to refute or support the existence of an association between suspected cause and disease

### **1. Synonyms**

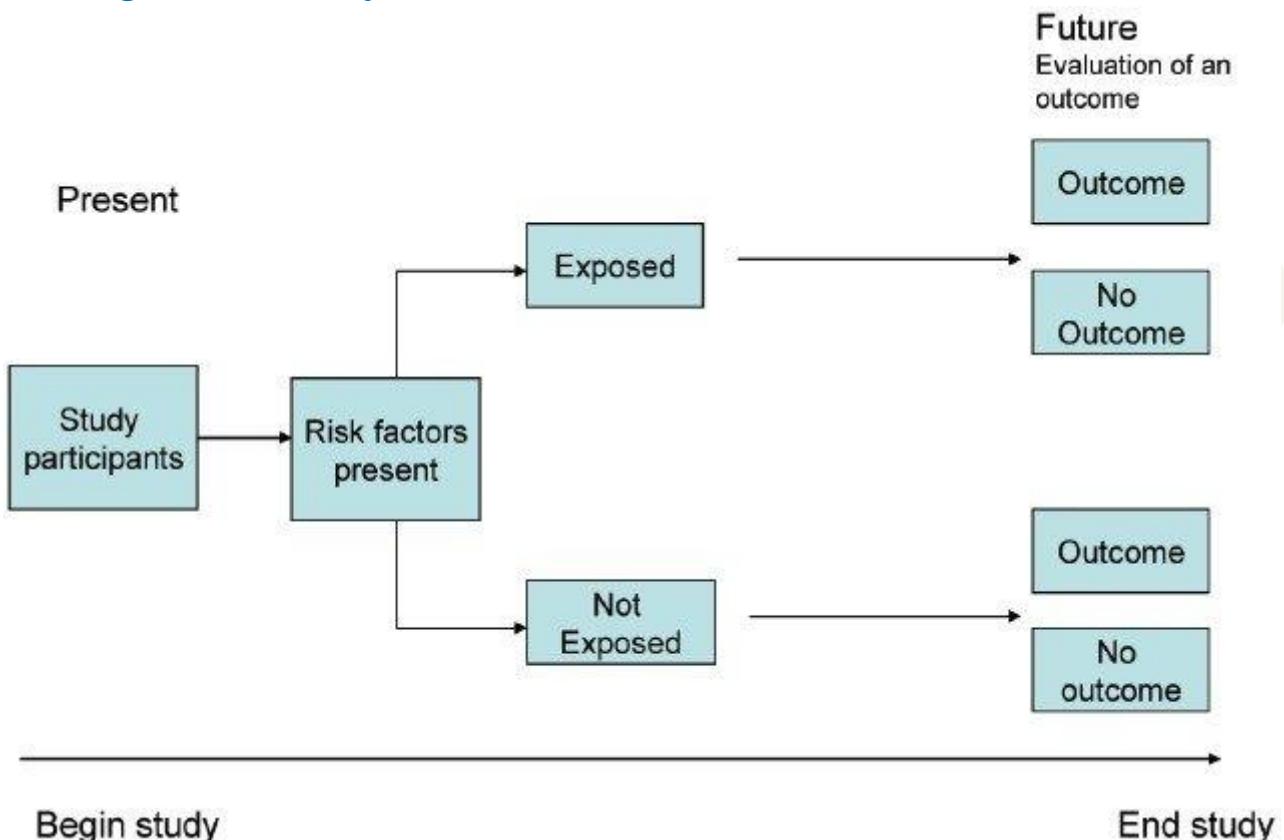
- Incidence study
- Forward looking study
- Longitudinal study
- Prospective study

## **2. Features**

- Cohorts are identified prior to the appearance of the disease under investigation
- Study groups are observed over a period of time to determine the incidence of disease

- The study proceeds from cause to effect

### 3. Design of the study



### 4. Steps in Cohort study

<b>i. Selection of a cohort</b>	<ul style="list-style-type: none"> <li>A community cohort of a specific age or sex.</li> <li>An exposure cohort, eg: radiologist, smokers</li> <li>A birth cohort</li> <li>A military cohort</li> <li>A diagnosed or a treated cohort</li> </ul>
<b>ii. Obtaining Data on exposure</b>	<ul style="list-style-type: none"> <li>Information can be obtained from <ul style="list-style-type: none"> <li>➤ Cohorts</li> <li>➤ Review of records</li> <li>➤ Medical examination or special tests</li> <li>➤ Environmental surveys</li> </ul> </li> <li>Information about exposure should facilitate classification of cohort members <ul style="list-style-type: none"> <li>➤ According to whether or not they were exposed</li> </ul> </li> </ul>

	➤ According to the degree of exposure
iii. Selection of comparison groups	<ul style="list-style-type: none"> <li>Internal comparisons</li> <li>External comparisons</li> <li>Comparison with general population</li> </ul>
iv. Follow up	<ul style="list-style-type: none"> <li>Periodic medical examination of each member</li> <li>Reviewing physician and hospital records</li> <li>Routine surveillance of morbidity and mortality records</li> <li>Mailed questionnaires, telephone interviews, periodic home visits</li> </ul>
v. Analysis	<ul style="list-style-type: none"> <li>Data is analysed in terms of <ul style="list-style-type: none"> <li>➤ Incidence rates of outcome among exposed and non-exposed</li> </ul> </li> <li>Estimation of risk <ul style="list-style-type: none"> <li>➤ Relative risk</li> <li>➤ Attributable risk</li> </ul> </li> </ul>

5. Advantages of a Cohort Study	6. Disadvantages of Cohort Study
<ul style="list-style-type: none"> <li>Incidence measures can be calculated and compared for both groups.</li> <li>Has knowledge of antecedent – consequent relationship which is necessary to determine whether or not there is a cause- effect relationship.</li> <li>Because the presence or absence of the risk factor is recorded before the disease occurs, there is no chance of bias being introduced.</li> <li>There is also less chance of encountering the problem of selective survival or selective recall; although selection bias can still occur because some subjects who contracted the disease will have been eliminated from</li> </ul>	<ul style="list-style-type: none"> <li>These studies are long term and thus are not always feasible; they are relatively inefficient for studying rare diseases.</li> <li>They are very costly in time, personnel, space and patient follow-up.</li> <li>Sample sizes required for cohort studies are extremely large, especially for infrequent conditions.</li> <li>the most serious problem is that of attrition or loss of people from the sample or control during the course of the study .</li> <li>There may also be attrition among investigators, who may lose interest, leave for another job or become involved in another</li> </ul>

consideration at the start of the study.

- Cohort studies are capable of disclosing other diseases related to the same risk factor.
- If a probability sample is taken from the reference population, it is possible to generalize from the sample to the population with a known degree of precision.

project.

- Over a long period, many changes may occur in the environment, among individuals or in the type of intervention, and then these may confuse the issue of association and attributable risk.
- Over a long period, study procedures may influence the behavior of the persons investigated in such a way that the development of the disease may be influenced accordingly (Hawthorne Effect).
- A serious ethical problem may arise when it becomes apparent that the exposed population is manifesting significant disease excess, before the follow up period is completed.

## EXPERIMENTAL STUDIES

- An experiment can be viewed as the final or definitive step in the research process, a mechanism for confirming or rejecting the validity of ideas, assumptions, postulates and hypothesis about the behaviour of objects, or effects upon them, which result from interventions under defined sets of conditions.
- Experimental epidemiology is often equated with Randomized controlled trials

### Steps in conducting a RCT

The basic steps in conducting a RCT include the following

#### 1. *Drawing up a protocol*

- One of the essential features of a randomized controlled trial is that the study is **conducted under a strict protocol**.
- The protocol specifies the aims and objectives of the study, questions to be answered, criteria for the selection of study and control groups, size of the

sample, the procedures for allocation of subjects into study and control groups, treatments to be applied - when and where and how to what kind of patients, standardization of working procedures and schedules as well as responsibilities of the parties involved in the trial, up to the stage of evaluation of outcome of the study.

- Sometimes, before a protocol is completed, **preliminary (pilot) studies** have to be made to find out the feasibility or operational efficiency of certain procedures, or unknown effects, or on the acceptability of certain policies.

## 2. **Selecting reference and experimental populations**

- i. **Reference or target population:** It is the population to which the findings of the trial, if found successful, are expected to be applicable (e.g., a drug, vaccine or other procedure). A reference population may be as broad as mankind or it may be geographically limited or limited to persons in specific age, sex, occupational or social groups.
- ii. **Experimental or study population:** The study population is derived from the reference population. It is the actual population that participates in the experimental study. Ideally, it should be randomly chosen from the reference population, so that it has the same characteristics as the reference population. The participants or volunteers must fulfil the following three criteria :
  - they **must give "informed consent"**, that is they must agree to participate in the trial after having been fully informed about the purpose, procedures and possible dangers of the trial;
  - they should be representative of the population to which they belong (i.e., reference population); and
  - they should be qualified or eligible for the trial.

## 3. **Randomization**

- Randomization is the "heart" of a control trial.
- Randomization is a statistical procedure by which the participants are allocated into groups usually called "study" and "control" groups, to receive or not to receive an experimental preventive or therapeutic procedure, manoeuvre or intervention.
- Randomization is an attempt to **eliminate "bias"** and allow for comparability.
- It ensures that the investigator has no control over allocation of participants to either study or control group, thus eliminating what is known as "selection bias".

#### 4. Manipulation or intervention

- to intervene or manipulate the study (experimental) group by the deliberate application or withdrawal or reduction of the suspected causal factor as laid down in the protocol.

#### 5. Follow-up

- This implies examination of the experimental and control group subjects at defined intervals of time, in a standard manner, with equal intensity, under the same given circumstances, in the same time frame till final assessment of outcome.

#### 6. Assessment of outcome

- RCTs assess response variables, or outcomes (end points), for which the groups are compared.
- Most trials have several outcomes, some of which are of more interest than others.
- The primary outcome measure is the pre-specified outcome considered to be of greatest importance to relevant stakeholders (such as patients, policy makers, clinicians, funders) and is usually the one used in the sample size calculation
- Other outcomes of interest are secondary outcomes (additional outcomes). There may be several secondary outcomes, which often include unanticipated or unintended effects of the intervention.
- Adverse effects may be missed if they are not sought.

### CONCLUSION

- Research methodology is the science of studying how research is done systematically.
- Biomedical research is the broad area of science that involves the investigation of the biological process and the causes of disease through careful experimentation, observation, laboratory work, analysis, and testing.
- Thorough knowledge on various research methods and research process are essential for the researchers for conducting a quality research.

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**Please Give Your Feedback on this Answer**

## Tests of significance of biostatistics (7M)

### CONTENTS/SYNOPSIS

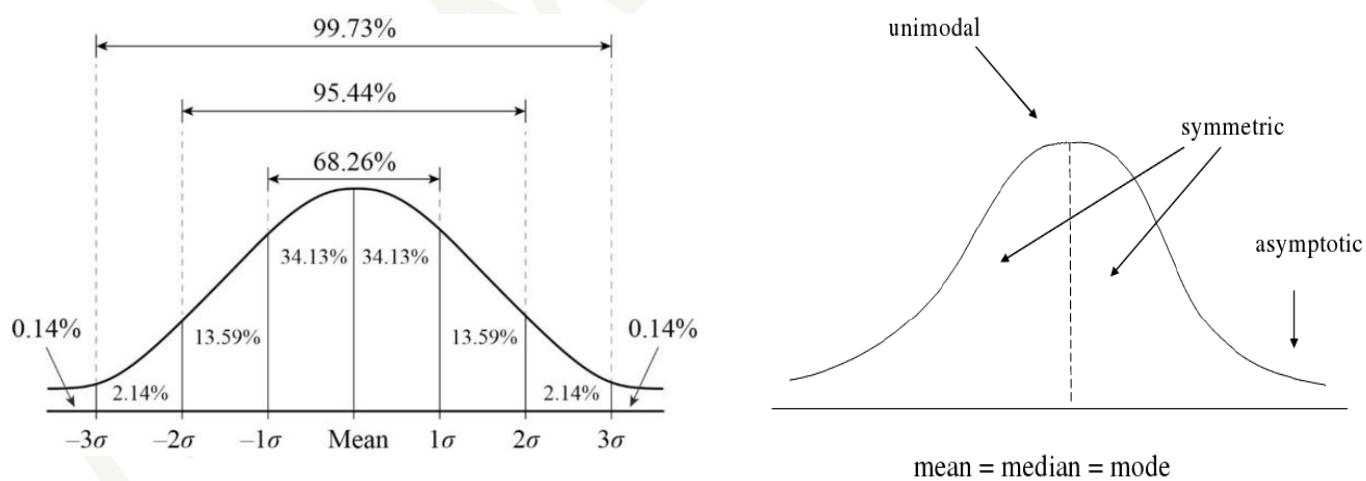
- Introduction
- Normal distribution & normal curve
- Stages in performing a test of significance
- Tests of significance
- Parametric tests
- Large sample tests
  - Z-test/ [Standard normal test]
- Small sample tests :
  - t-test [student's t test]
    - Independent sample t-test/ unpaired t- test/ pooled t-test
    - Paired t-test
  - Variance ratio test or F-test [ANOVA]
  - Chi Square test
- Non parametric tests
  - Chi Square test
  - Paired samples - Wilcoxon signed rank test [Matched pairs test]
  - Unpaired samples- Wilcoxon-Mann-Whitney test [U test]
  - Fisher's exact probability test
  - Correlation
- A posteriori / post hoc comparisons ("after this")
  - Bonferroni correction
  - Tukey's HSD procedure
  - Scheffe's procedure
  - Newman- Keuls procedure
  - Dunnett's procedure
- Limitations of tests of significance
- Choice of an appropriate statistical significance test to be used
- Conclusion
- References

## INTRODUCTION

- Statistics is an important and integral part of research methodology. It is a pervasive force on which the entire spectrum of clinical decision making is dependent.
- Tests of significance are one of the central concepts in statistics.
- These are the mathematical methods by which the probability of an observed difference occurring by chance is found.
- Hence they are used to estimate the probability that the relationship observed in the data occurred purely by chance or was there a relationship between the variables thereby testing the hypothesis proposed at the start of the study.
- They constitute a common yardstick that can be understood by many people and also communicate essential information about a research project.

## NORMAL DISTRIBUTION & NORMAL CURVE

- First observed by **Abraham de moivre** in 1733
- A theoretical, continuous, symmetrical, unimodal distribution of infinite range.
- Most of the biological variables like height, weight etc follow normal distribution.
- Also called as Gaussian distribution & represented by a curve called normal Curve.



- Bell shaped
- smooth curve
- Perfectly symmetrical
- Does not touch the baseline

- Mean, median & mode = 0
- Standard deviation = 1.
- Total area = 1
- Two inflections

## STAGES IN PERFORMING A TEST OF SIGNIFICANCE

- State the null hypothesis of no or chance difference and the alternative hypothesis.
- Determine P, i.e., probability of occurrence of your estimate by chance or simply accepting or rejecting your null hypothesis
- Draw conclusion on the basis of P value, i.e., decide whether the difference observed is due to chance or play of some external factors on the sample

## TESTS OF SIGNIFICANCE

### I. Parametric tests

- Their model specifies certain conditions about the parameters of the population from which the research sample is drawn.
- Used for quantitative data.

### II. Nonparametric tests or distribution free tests

- Their model does not specify conditions about the parameters of the population from which the research sample is drawn.
- Used for qualitative data.

## PARAMETRIC TESTS

### I. Large sample tests

- When the sample size is greater than 30.
- Generally, 2 types of data may be encountered while testing hypothesis for large samples.
- When data is qualitative → test for proportion [ $\chi^2$  test]
- When data is quantitative → test for means [Z-test]

## Z-test [Standard normal test]

- Most frequently used in research studies.
- Used when the population variance is known.

Difference in means

$$Z = \frac{\text{Difference in means}}{\text{S.E. of mean}}$$

## II. Small sample tests

- When the sample size is smaller than 30.
- Sample does not follow the normal distribution, hence it is based on the assumption that the population from which the sample is drawn follows the normal distribution .

### 1. t-test- [student's t test]

- It was first discovered by W.S. Gosset in 1908 & popularized by Fisher in 1926.
- Follows t distribution & is used when the population variance is not known.
- Probability 'p' of this value is determined by referring to t-table.
- It is ratio of observed difference between two means of small samples to the standard error of difference in the same
- Used to find the significance of difference between proportions

i. Independent sample t-test/ pooled t-test/ unpaired t- test	ii. Paired t-test
<ul style="list-style-type: none"> <li>• Individuals of two different or separate groups or samples drawn from two populations.</li> </ul> $t = \frac{\bar{X}_1 - \bar{X}_2}{\text{S.E.}} \quad \text{S.E.} = \sigma \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$	<ul style="list-style-type: none"> <li>• Used when each individual gives a pair of observations.</li> </ul> $t = \frac{d}{\text{S.E.}}$ <ul style="list-style-type: none"> <li>• E.g. Before &amp; after the clinical trial.</li> </ul>
Steps	Steps
<ul style="list-style-type: none"> <li>• Null hypothesis</li> <li>• Find the observed difference between means of two samples (<math>\bar{X}_1 - \bar{X}_2</math>)</li> <li>• Calculating standard error of difference between the two means</li> <li>• Calculate the 't' value</li> </ul>	<ul style="list-style-type: none"> <li>• Null hypothesis</li> <li>• Find the observed difference in each set of paired observations before and after of the same sample (<math>\bar{X}_1 - \bar{X}_2 = \bar{X}</math>)</li> <li>• Calculating mean of the differences</li> <li>• Work out the standard error of the</li> </ul>

<ul style="list-style-type: none"> <li>• Determine the degrees of freedom</li> <li>• Comparison with the table value to find the level of significance</li> </ul>	mean <ul style="list-style-type: none"> <li>• Calculate the ‘t’ value</li> <li>• Determine the degrees of freedom</li> <li>• Comparison with the table value to find the level of significance</li> </ul>
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## 2. Variance ratio test or F-test [ANOVA]

- Developed by Fisher & Snedecor based on F distribution.
- Used for the comparison of variance of two independent samples to test whether the two samples are from the same normal population or from the two normal populations.

$$F = \frac{\sigma^2_1 \text{ based on variation between the group}}{\sigma^2_2 \text{ based on variation within the groups}}$$

- Also used in the context of analysis of variance [ANOVA] for judging the significance of more than one means at one & the same time.

### Types

- One way ANOVA / the F-test
- Two way ANOVA
- Three way /factorial ANOVA

## 3. Chi Square test

- Chi square test for quantitative data
- Used for comparing a sample variance to a population variance.

$$X^2 = \frac{\sigma^2 s}{\sigma^2 p} (n-1)$$

## NON-PARAMETRIC TESTS

### I. Chi Square test

- $\chi^2$  test for qualitative data
- Derived from the Greek letter chi [ $\chi$ ]
- pronounced as “Kye”
- A very versatile test, developed by Karl Pearson.
- Used to test the association between two events [To test a given hypothesis]  
e.g. Cause & effect.
- To find the goodness of fit.

- To test the difference between two or more proportions.

$$X^2 = \sum \frac{(\text{Observed frequencies } [O] - \text{Expected frequencies } [E])^2}{\text{Expected frequencies } [E]} \frac{\text{Row total} \times \text{Column total}}{\text{Expected frequency } [E] = \text{Grand total}}$$

### Drawbacks

- Tells us about the association but fails to measure the strength of association.
- Test is unreliable if the expected frequency in any one cell is less than 5.
- Correction is done by subtracting 0.5 from  $|O-E|$  — Yates's correction
- Not applicable when there is 0 or 1 in any of the cells (Resort to Fisher's exact probability test)

## II. Paired samples - Wilcoxon signed rank test [Matched pairs test]

- Find the differences between each pair of values & assign rank to the differences from the smallest to the largest without regard to sign.
- In case there are ties, then we would assign each of the tied observation the mean of the ranks which they jointly occupy.
- The actual signs of each difference are then put to the corresponding ranks & the test statistic  $T$  is calculated which happens to be the smaller of the two sums. [The sum of the negative ranks & the sum of the positive ranks]
- Calculated value must be equal to

## III. Unpaired samples- Wilcoxon-Mann-Whitney test [U test]

- Used to determine whether two independent samples have been drawn from the same population.
- Applies under very general conditions.
- Rank the data jointly taking them as belonging to a single sample in either an ascending or descending order.
- Now find the sum of the ranks assigned to the values of the 1<sup>st</sup> sample  $[R_1]$  & 2<sup>nd</sup> sample  $[R_2]$  separately, then work out the test statistic.

$$U = n_1 + n_2 \frac{n_1 (n_1+n_2)}{2} - R_1$$

or smaller than the table value in order to be considered significant.

#### IV. Fisher's exact probability test

- Used in place of  $\chi^2$  test if there are 0 or 1 in any of the cells or any expected value is  $< 1$
- Any cell frequency is  $< 5$  or more than 20% of the expected frequencies are  $< 5$ .

		Outcomes		
		Yes	No	Total
Intervention	Yes	a	b	$a + b$
	No	c	d	$c + d$
Total		$a + c$	$b + d$	N

Where  $N = a + b + c + d$

$$P = \frac{(a + b)! (c + d)! (a + c)! (b + d)!}{N! a! b! c! d!}$$

#### V. Correlation

- The extent to which two variables are dependent on each other.
- Magnitude of the relationship is given by  $r$  which ranges from  $+1$  to  $-1$
- Spearman's correlation test: Developed by famous statistician Charles Spearman in the early 1900s.
- Pearson's correlation is used for quantitative data.

#### A POSTERIORI / POST HOC COMPARISONS ("AFTER THIS")

- For comparison of three or more group means we apply the analysis of variance (ANOVA) method to decide if all means are equal or there is at least one mean which is different from others. If we get a significant result, we can conclude that there is difference in group means.
- To know what specific pairs of group means show differences post-hoc multiple comparison procedures.

- The set of comparisons is referred as a 'family of test'.

<b>1. Bonferroni correction</b>	<ul style="list-style-type: none"> <li>• Significance level is divided by the number of comparisons desired</li> <li>• <math>\alpha = 0.05 / x</math></li> <li>• Difficulty in proving statistical significance</li> </ul>
<b>2. Tukey's HSD procedure</b>	<ul style="list-style-type: none"> <li>• It is applicable to only pair wise comparisons of all groups amongst themselves</li> <li>• Considered as most accurate and powerful (able to detect a difference if it exists)</li> </ul>
<b>3. Scheffe's procedure</b>	<ul style="list-style-type: none"> <li>• Like bonferroni correction, lowers the value of alpha, but more accurately</li> <li>• Used to make comparisons of all sorts</li> <li>• Difficult of all post hoc test</li> </ul>
<b>4. Newman- Keuls procedure</b>	<ul style="list-style-type: none"> <li>• Like Tukey's, this post-hoc test identifies sample means that are different from each other.</li> <li>• Newman-Keuls uses different critical values for comparing pairs of means. Therefore, it is more likely to find significant differences.</li> </ul>
<b>5. Dunnett's procedure</b>	<ul style="list-style-type: none"> <li>• Variation of HSD procedure</li> <li>• Best suited if we want to compare one control group with several other groups</li> </ul>

### LIMITATIONS OF TESTS OF SIGNIFICANCE

- Tests are only useful aids for decision making not decision making itself.
- Do not explain the reasons why does the difference exist.
- Results are based on probabilities and as such cannot be expressed with full certainty.
- Inferences based on them cannot be said to be entirely correct evidences concerning the truth of the hypothesis

### CHOICE OF AN APPROPRIATE STATISTICAL SIGNIFICANCE TEST TO BE USED

- Association between two variables: Chi square test
- Correlation between two variables: Pearson's or Spearman's test.
- One group on two occasions: Paired t-test

- One group on 3 or more occasions: ANOVA
- Two separate groups: unpaired t-test, Mann-Whitney U test
- 3 or more separate groups: ANOVA

First Variable	Second variable	Examples	Appropriate test
Continuous	Continuous	Age and systolic blood pressure	Pearson correlation coefficient $\rho$ ; Linear regression
Continuous	Ordinal (O)	Age and satisfaction	Group the continuous variable and calculate Spearman correlation coefficient [ $\rho$ ]; possibly use one-way analysis of variance (ANOVA)
Continuous	Dichotomous unpaired	Systolic blood and gender	Student's t-test
Continuous	Dichotomous paired	Difference in systolic blood pressure before versus after treatment.	Paired t-test
Continuous	Nominal	Haemoglobin level and blood type	ANOVA (F-test)
Ordinal (O)	Ordinal (O)	Correlation of satisfaction with care (O) and severity of illness (O)	Spearman correlation coefficient ( $\rho$ ); Kendall correlation coefficient ( $\tau$ )
Ordinal	Dichotomous unpaired (DU)	Satisfaction (o) and gender (DU)	Mann-Whitney U test
Ordinal	Dichotomous paired (DP)	Difference in satisfaction before versus after program	Wilcoxon matched-pairs-rank test.
Ordinal	Nominal (N)	Satisfaction (o) and	Kruskal-Wallis test

		ethnicity (N)	
Dichotomous (D)	Dichotomous unpaired (DU)	Success/ failure (D) in treated/ untreated groups [DU]	Chi-square test; Fisher exact test
Dichotomous (D)	Dichotomous paired (DP)	Change in Success/ failure (D) before versus after treatment [DP]	McNemar Chi-square test
Dichotomous (D)	Nominal (N)	Success/ failure (D) and blood type (N)	Chi-square test

Reference: Jekel, Katz teal; Textbook of Epidemiology, Biostatistics and Preventive Medicine.

## CONCLUSION

- Tests of significance play an important role in conveying the results of any research and thus the choice of an appropriate statistical test is very important as it decides the fate of outcome of the study.
- Hence the emphasis placed on tests of significance in clinical research must be tempered with an understanding that they are tools for analysing data & should never be used as a substitute for knowledgeable interpretation of outcomes.

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## Two - way ANOVA (7M)

### CONTENTS/SYNOPSIS

- Introduction
- Analysis of variance
  - Basic principles of ANOVA
  - Assumptions of ANOVA
  - Steps
  - Calculating F ratio
  - Types of ANOVA
    - One-way ANOVA
    - N -way ANOVA
  - Test of choice
- Conclusion
- References

## INTRODUCTION

- Statistics is an important and integral part of research methodology
- It is a pervasive force on which the entire spectrum of clinical decision making is dependent.
- It is a technique specifically designed to test or identify the means of more than 2 quantitative population are equal

## ANALYSIS OF VARIANCE

- Developed by Sir Ronald A. Fisher in 1920.
- Analysis of variance is useful to assess the significance of differences between sample means which are more than two in number.
- Also known as Variance ratio test or F-test or ANOVA.
- It is a parametric test used for quantitative data.

### I. Basic principle of ANOVA

- To test for differences among the means of the populations by examining the amount of variation within each of these sample, relative to the amount of variation between the samples

### II. Assumptions of ANOVA

- Experimental errors of data are distributed normally
- Equal variance between treatments
- Samples are selected randomly and independently

### III. Steps

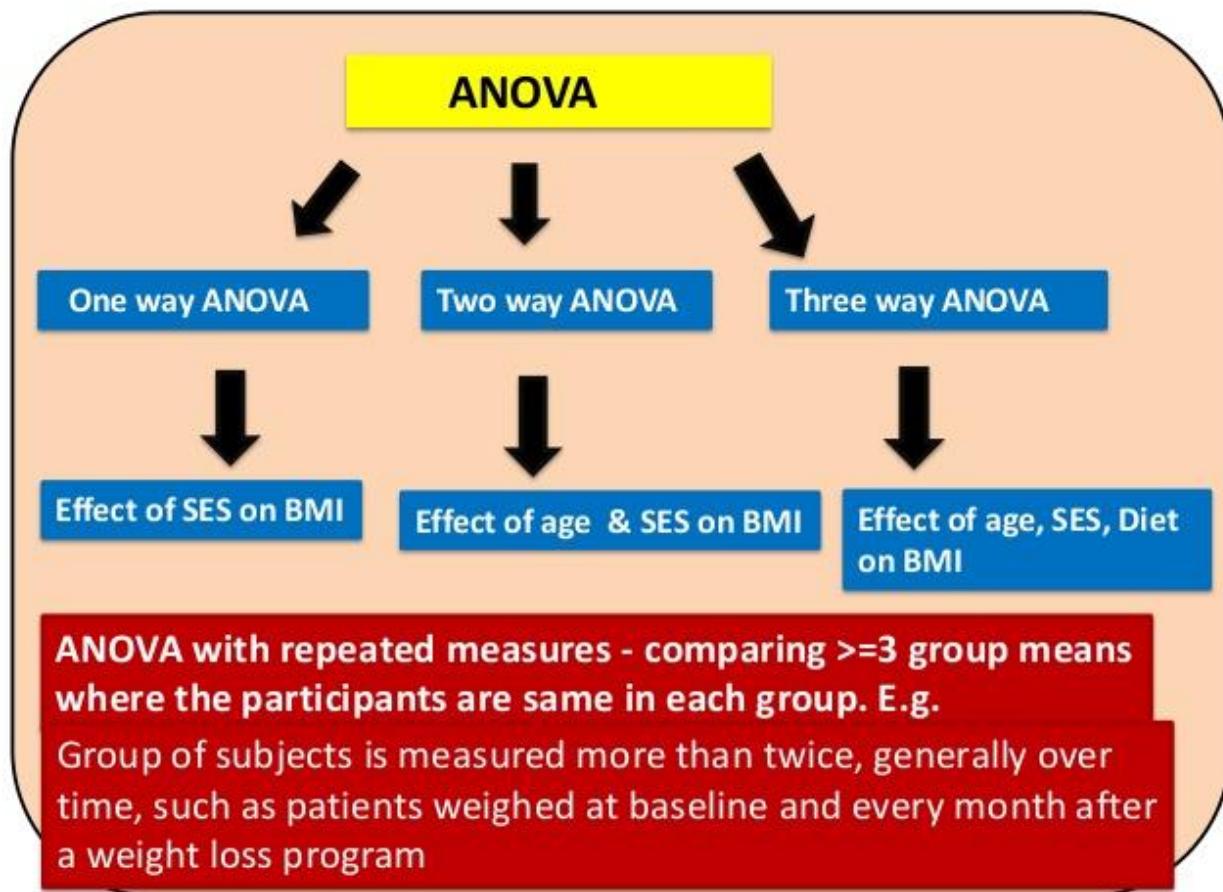
- State the null hypothesis
- Find the sum of the squares between the means
- Find the sum of the squares within the means
- Calculate the F - ratio
- Determine the degrees of freedom
- Comparison with the F-table value to find the level of significance

### IV. Calculating F ratio

$\sigma^2_1$  based on variation between the group

$F = \sigma^2_2$  based on variation within the groups

## V. Types of ANOVA



### 1. One-way ANOVA

- If the design includes only one independent variable(ex: treatment), the techniques called one-way analysis, regardless of how many different treatment groups are present.

### 2. N-way ANOVA (Two way ANOVA, Three way /factorial ANOVA)

- If it includes more than one independent variable (ex: treatment, age group, gender) the technique is called N-way ANOVA

## VI. Test of choice

- If the depended variable is continuous & all of the independent variable are categorical(I.e., nominal, dichotomous, or ordinal), the correct multivariable technique is ANOVA.
- One group on 3 or more occasions- ANOVA is the test of choice to be used.
- 3 or more separate groups - ANOVA

## CONCLUSION

- Test statistic, F, is calculated and compared with its probable value (to be seen in the F-ratio tables for different degrees of freedom for greater and smaller variances at specified level of significance) for accepting or rejecting the null hypothesis.

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## Stem cells (6M)

### CONTENTS/SYNOPSIS

#### Introduction

##### I. Classification of stem cells based on their differentiation potential,

1. Totipotent cells
2. Pluripotent cells
3. Multipotent
4. Unipotent

##### II. According to their origin and differentiation potential

1. Embryonic stem cells
2. Adult cells

##### III. Dental mesenchymal stem cells:

1. Dental pulp stem cells (DPSCS)
2. Periodontal ligament stem cell (PDLSC):
3. Stem cells from apical papilla (SCAP)
4. Dental follicle stem cells (DFSC)
5. Stem cells from human exfoliated deciduous teeth (SHED)
6. Gingival mesenchymal stem cells (GMSC)
7. Epithelial cell rests of malassez (ECRM)

#### Tissue engineering: role of stem cells in regeneration

#### References

## INTRODUCTION

- Stem cells are cells that can differentiate into other types of cells, and can also divide in self-renewal to produce more of the same type of stem cells.
- **Definition** as cells that have clonogenic and self-renewing capabilities and differentiate into multiple cell lineages
- term "stem cell" was proposed for scientific use by the Russian histologist Alexander Maksimov (1874- 1928) at congress of hematologic society in Berlin
- Stem cells have two important characteristics: self-renewal and differentiation potential.
- Self-renewal refers to their ability to renew themselves through mitosis, even after long periods of inactivity (Bianco et al., 2010).
- The differentiation potential entails stem cells to differentiate into a different phenotype.
- These two qualities, together, allow stem cells to proliferate and regenerate missing or compromised tissues.

## I. CLASSIFICATION OF STEM CELLS BASED ON THEIR DIFFERENTIATION POTENTIAL

### 1. Totipotent cells

- Can differentiate into cells of all three germ lines as well as cells of the extraembryonic tissue.

### 2. Pluripotent cells

- Differentiate into cells of all three germ lines but not in cells of the extraembryonic tissue,

### 3. Multipotent

- Able to differentiate into cells of only one or two germ lines

### 4. Unipotent

- Able to differentiate into only one cell type

## II. ACCORDING TO THEIR ORIGIN AND DIFFERENTIATION POTENTIAL

### 1) Embryonic Stem Cells:

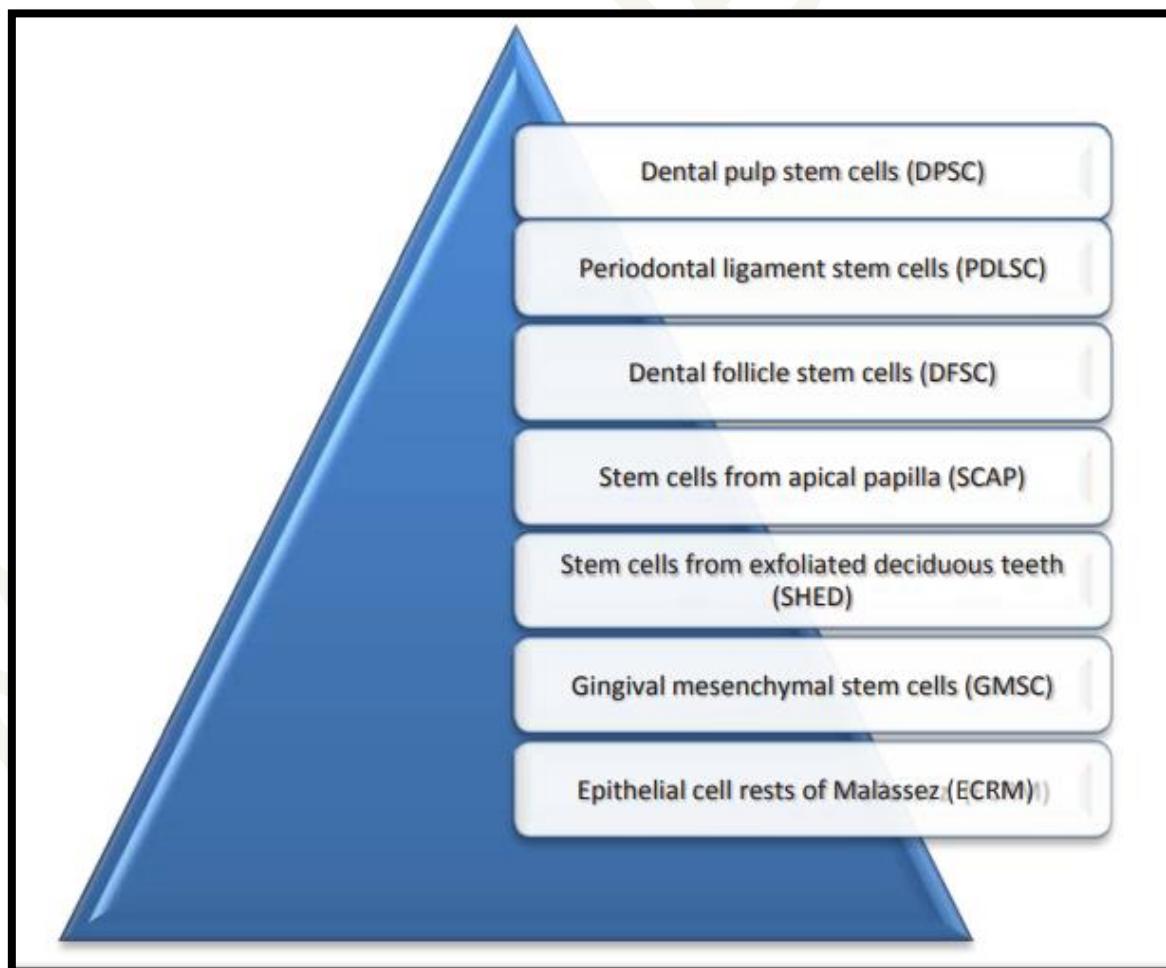
- Derived from inner cell mass of blastocyst stage of embryonic development prior to implantation in the uterine wall
- Can give rise to the cell of three germ layers
- Highly pluripotent

**2)Adult cells:**

- Found in epithelium, bone marrow, adipose tissue, liver, nervous system, teeth, and periodontal ligament (Barker, 2014)
- Multipotent cells
- Function is to replace cells which are injured or lost.
- They undergo into self-renewal and differentiation to repair injured tissues
- Common source is the **bone marrow (hematopoietic stem cells)** or **bone marrow stromal cells (mesenchymal stromal stem cells)**
- Mesenchymal stem cells can effectively regenerate destroyed periodontal tissue.
- They have been shown to form cementum, periodontal ligament and alveolar bone in vivo after implantation into periodontal defects in beagle dogs

**III.DENTAL MESENCHYMAL STEM CELLS**

- MSCs has been found in oral tissues, they cause lesser complications



## 1. Dental pulp stem cells (DPSCs)

- Gronthos et al first identified and isolated the odontogenic progenitor population cell in adult dental pulp
- It has clonogenic abilities, rapid proliferative rates, and capacity to form mineralized tissues
- They have the ability to regenerate a dentin-pulp-like complex that is composed of mineralized matrix with tubules lined with odontoblasts, and fibrous tissue containing blood vessels in an arrangement similar to the dentin-pulp complex found in normal human teeth.

## 2. Periodontal Ligament stem cell (PDLSC):

- Melcher, 1976 had proposed that only cells derived from PDL can differentiate into fibroblasts, cementoblast and osteoblast to form the attachment apparatus
- Seo et al 2004 conducted study on extracted human third molars attributed this property of regeneration to the **multipotent stem cells in the PDL**
- These periodontal ligament stem cells (PDLSCs), had self-renewal ability, multipotent capacity, to able to differentiate into cementoblasts/osteoblasts, adipocytes, and collagen-forming cells.

## 3. Stem Cells from Apical Papilla (SCAP)

- They are derived from apical papilla of developing permanent teeth
- Sonoyama et al suggested that they are capable of forming of root dentin.
- SCAP can give rise to primary odontoblasts, which complete root formation under the influence of the epithelial root sheath of Hertwig

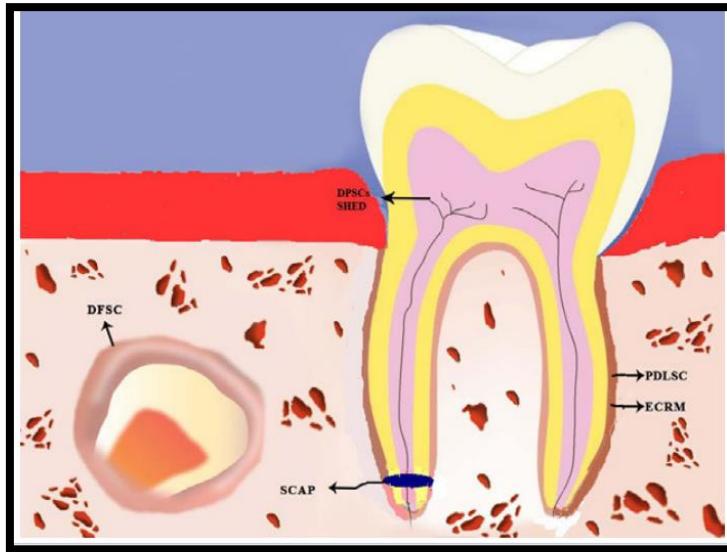


Figure 1: location of dental stem cells

#### 4. Dental Follicle Stem Cells (DFSC):

- Dental follicle is an ectomesenchyme derived connective tissue sac surrounding the developing tooth bud from which arises the alveolar bone, cementum and periodontal ligament.
- DFSCs are relatively easy to harvest
- Procured from the follicles of unerupted third molars.
- DFSCs have the potential for regenerate the entire root of the teeth.
- They express Wnt5a proteins
- These proteins help in formation of non-mineralized PDL and mineralized alveolar bone and cementum

#### 5. Stem cells from Human Exfoliated Deciduous teeth (SHED):

- These multipotent stem cells are found in exfoliated human deciduous teeth.
- Readily harvested.
- Higher proliferation rate
- Increased bone formation
- SHED in inducing the new tissue formation
- SHED have been found to elevate regulatory T cells and downregulate T-helper 17 cells, hence have significant immunomodulatory capacity

## 6. Gingival Mesenchymal stem cells (GMSC):

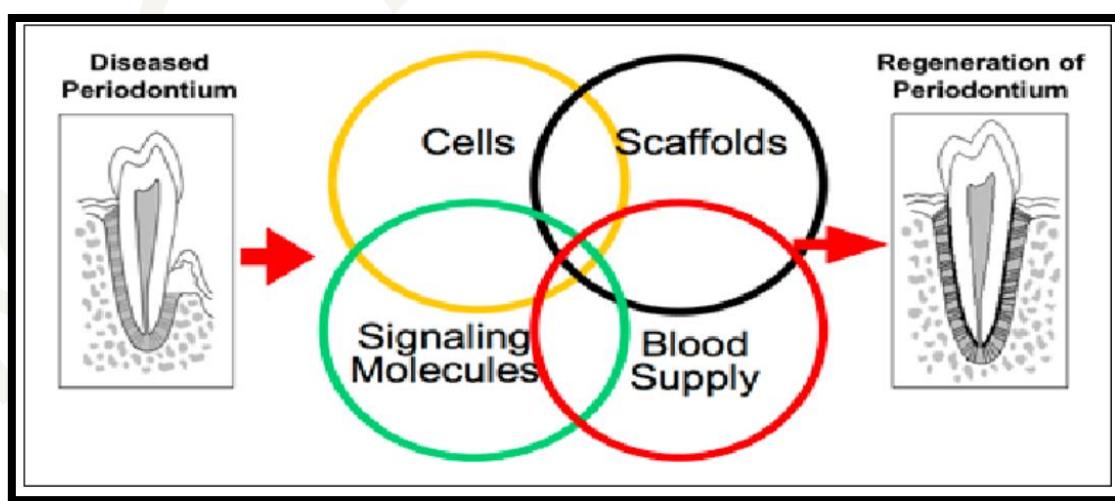
- Isolated from the lamina propria of the gingiva
- In a canine model with class III furcation defects, the transplanted GMSCs significantly enhanced the regeneration of the damaged periodontal tissue, including the alveolar bone, cementum, and functional periodontal ligament

## 7. Epithelial Cell Rests of Malassez (ECRM):

- These are remnants of the Hertwig's epithelial root sheath from which arise, all the periodontal structures.
- Xiong J, et al. suggested they help in epithelial mesenchymal interactions
- Help to differentiate into bone, cementum and periodontal ligament

## TISSUE ENGINEERING: ROLE OF STEM CELLS IN REGENERATION

- Tissue engineering as proposed by Langer, et al. comprises of multiple progenitor cells, signaling molecules and conductive extracellular matrix scaffold, along with an adequate blood supply
- Scaffolds act as extracellular matrix creating an environment for cell proliferation and differentiation
- Signaling molecules also referred to as immunomodulatory polypeptides are essential to enhance cellular activities such as cell proliferation, differentiation, migration and apoptosis
- stem cells thriving within the scaffolds process the signals and carry out tissue periodontal regeneration.



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