Textbook of
Dental Anatomy,
Physiology and Occlusion

Textbook of Dental Anatomy, Physiology and Occlusion

Editor

Rashmi G S (Phulari) BDS MDS (Oral Path)
Reader
Department of Oral and Maxillofacial Pathology
Manubhai Patel Dental College, Hospital and Oral Research Institute
Vadodara, Gujarat, India

JAYPEE

JAYPEE BROTHERS MEDICAL PUBLISHERS (P) LTD

New Delhi • London • Philadelphia • Panama

Jaypee Brothers Medical Publishers (P) Ltd.

Headquarters
Jaypee Brothers Medical Publishers (P) Ltd.
4838/24, Ansari Road, Daryaganj
New Delhi 110 002, India
Phone: +91-11-43574357
Fax: +91-11-43574314
Email: jaypee@jaypeebrothers.com

Overseas Offices

J.P. Medical Ltd.
83, Victoria Street, London
SW1H 0HW (UK)
Phone: +44-2031708910
Fax: +02-03-0086180
Email: info@jpmedpub.com

Jaypee-Highlights Medical Publishers Inc.
City of Knowledge, Bld. 237, Clayton
Panama City, Panama
Phone: +507-301-0496
Fax: +507-301-0499
Email: cservice@jphmedical.com

Jaypee Medical Inc.
The Bourse
111, South Independence Mall East
Suite 835, Philadelphia, PA 19106, USA
Phone: +267-519-9789
Email: joe.rusko@jaypeebrothers.com

Jaypee Brothers Medical Publishers (P) Ltd.
17/1-B, Babar Road, Block-B, Shaymali
Mohammadpur, Dhaka-1207, Bangladesh
Mobile: +08801912003485
Email: Jaypeedhaka@Gmail.Com

Jaypee Brothers Medical Publishers (P) Ltd.
Shorakhute, Kathmandu
Nepal
Phone: +00977-9841528578
Email: jaypee.nepal@gmail.com

Website: www.jaypeebrothers.com
Website: www.jaypeedigital.com

Inquiries for bulk sales may be solicited at: jaypee@jaypeebrothers.com

Textbook of Dental Anatomy, Physiology and Occlusion

First Edition: **2014**

ISBN: 978-93-5025-940-5

Printed at:

Dedicated to

My Parents (Siddarajaiah K and Premakumari YR)
My brother and sister (Chidananda S and Sushma GS)
My In-laws (Subhashchandra and Shivalingamma Phulari)
My beloved husband (Dr Basavaraj Subhashchandra Phulari)
My little sons (Yashas and Vrishank)
for their love, support and encouragement...

Contributors

Basavaraj Subhashchandra Phulari BDS MDS (Ortho TSMA-Rus) FRCH FAGE
Formerly Faculty
Department of Orthodontics and Dentofacial Orthopedics
Mauras College of Dentistry and Hospital
Oral Research Institute
Mauritius

Priya NK BDS MDS (Oral Path)
Reader
Department of Oral Pathology and Microbiology
College of Dental Sciences
Davangere, Karnataka, India

Rajendrasinh Rathore BDS MDS (Oral Path)
Chairman, Professor and Head
Department of Oral and Maxillofacial Pathology
Manubhai Patel Dental College, Hospital and
Oral Research Institute
Vadodara, Gujarat, India

Rashmi G S (Phulari) BDS MDS (Oral Path)
Reader
Department of Oral and Maxillofacial Pathology
Manubhai Patel Dental College, Hospital and
Oral Research Institute
Vadodara, Gujarat, India

Preface

Dental anatomy forms the basis for all the fields of dentistry. *Textbook of Dental Anatomy, Physiology and Occlusion* is an attempt towards meeting the enormous challenge of providing an all comprehensive, yet simple-to-understand coverage of Dental anatomy, Physiology and Occlusion.

Detailed morphology of deciduous and permanent teeth is narrated in a pointwise and systematic manner which is easier to understand and recall. Apart from the images of typical teeth specimen, numerous clinical photographs are added to demonstrate common variations, anomalies and practical relevance of tooth morphology. Numerous tables, boxes and flow charts throughout the text make understanding and recalling easier. The morphology of each permanent tooth is summarized using flow charts that give the major anatomic landmarks of that tooth and a brief summary of the major features on all five aspects of that tooth.

Separate chapters are dedicated to tooth notation systems, chronology of tooth development, differences between primary and permanent dentitions, pulp morphology, temporomandibular joint and occlusion. Dental students are introduced to the fascinating aspects of dental anatomy such as forensic odontology, evolution of teeth, dental anthropology and comparative dental anatomy.

A separate chapter on tooth carving is included that explains the rationale, armamentarium, basic principles and step-by-step carving procedure. Carving technique for different types of teeth is made self-explanatory using life size high resolution images of actual wax blocks in different stages of carving. The ancillary DVD-ROMs contain visual demonstration of carving procedure for various teeth.

Numerous high quality photographs and professionally done graphic illustrations with informative legends make the text easy to grasp. Incorporation of numerous tables, flow charts and boxes throughout the textbook will give the reader a convenient summary of the key features and also make reviewing easier.

Multiple choice questions (MCQs) given at the end of each chapter in the textbook and the additional MCQs in ancillary DVD-ROMs aid the students in revision and preparation for viva voce and competitive examinations.

It is hoped that the concepts of dental anatomy, physiology and occlusion presented in a simple and logical style in the book will benefit all the undergraduate and postgraduate students of dental sciences and dental auxiliaries.

Rashmi G S (Phulari)
rashmigsphulari@gmail.com

Acknowledgments

With profound sense of gratitude and respect, I express my heartfelt thanks to Dr Rajendrasinh Rathore, Professor and Head, Department of Oral and Maxillofacial Pathology, Manubhai Patel Dental College, Hospital and Oral Research Institute, Vadodara, Gujarat, India, for being a constant source of encouragement and guidance throughout this project while providing me with all the facilities required for completion of this work. I would also like to thank Dr Yashraj Rathore, Trustee, Manubhai Patel Dental College, Hospital and Oral Research Institute, Vadodara, Gujarat, India, for all the support and encouragement shown during this endeavor.

It is my pleasant privilege and honor to express my sincere gratitude and respect to all my revered teachers who have taught me during my undergraduate and postgraduate courses. In particular, I would like to thank Dr Rajiv S Desai, Professor and Head, Department of Oral Pathology and Microbiology, Nair Dental College, Mumbai, Maharashtra, India, my postgraduate guide, for being a constant source of inspiration in my pursuit towards academic excellence. I owe an immense debt of gratitude to my postgraduate teachers Dr Srinivas S Vanaki (Professor and Head) and Dr RS Puranik (Professor), Department of Oral Pathology and Microbiology, PM Nadagouda Memorial Dental College and Hospital (PMNMDCH), Bagalkot, Karnataka, India, for their constant encouragement and guidance in this endeavor and throughout my academic career.

I thank my dear friends Dr Praveena Tantradi, Reader, Department of Oral Medicine and Radiology, Maratha Mandal Dental College, Belgaum, Karnataka, India and Dr Sapna N, Reader, Department of Periodontics, DA Pandu Memorial RV (DAPMRV) Dental College, Bengaluru, Karnataka, India, for their invaluable suggestions and inputs. I thank Dr Sonali Kapoor, Professor and Head, Department of Conservative Dentistry and Endodontics, Manubhai Patel Dental College, Hospital and Oral Research Institute, Vadodara, Gujarat, India, for all the encouragement and support shown during compilation of the book.

I have much pleasure in acknowledging my undergraduate students for familiarizing me with 'students' point of view, and I extend my heartleft gratitude to the postgraduate students and colleagues of Department of Oral and Maxillofacial Pathology, Manubhai Patel Dental College, Hospital and Oral Research Institute, Vadodara, Gujarat, India, for their assistance in compute skills and proofreading.

I thank my beloved husband Dr Basavaraj Subhashchandra Phulari for being there, whenever I needed him, helping me at every step of this project right from the text layout to final proofs and for his help in video shooting the carving procedures for ancillary DVD-ROM. I fondly acknowledge my little sons Yashas and Vrishank for their patience and love.

My heartfelt gratitude goes to Shri Jitendar P Vij (Group Chairman), Mr Ankit Vij (Managing Director), Mr Tarun Duneja (Director-Publishing) and Mr KK Raman (Production Manager) of M/s Jaypee Brothers Medical Publishers (P) Ltd, New Delhi, India, whose exceptional efforts made the production of this book possible. I thank the talented staff of M/s Jaypee Brothers Medical Publishers (P) Ltd, in particular Mr Sunil Kumar Dogra (Production Executive), Mr Gurnam Singh (Sr Proofreader), Mr Anil Sharma (Graphic Designer), Mr Manoj Pahuja (Graphic Designer-Head), Mr Pankaj Kumar Mandal (Typesetter) and Ms Kamlesh Rawat (Proofreader), for their untiring efforts in ensuring that every minute detail is taken care of.

Above all, I thank, the Almighty for all the kindness showered upon me...

Contents

Section 1: Introduction and Nomenclature

1. Introduction to Dental Anatomy **3**
Dentitions in Humans 3
Trait Categories of Teeth 6
Nomenclature of Teeth 6
Dental Formulae in Humans 6
Stages of Dentitions in Humans 7
Parts of Tooth 7
Structure of Tooth 8
Basic Terminologies in Dental Anatomy 9
Anatomic Landmarks on Tooth Surface 10
Arbitrary Divisions of Crown and Root into Thirds 15
Line Angles and Point Angles on the Crown 16
Measurements of Teeth 16

2. Tooth Notation Systems **22**
Universal Notation System 22
Zsigmondy-Palmer System/Symbolic System/Quadrant System/Grid System/Angular System 24
FDI Notation System/Two-Digit System/ISO 3950 Notation/International Numbering System 26

Section 2: Chronology of Tooth Development and Form and Function

3. Chronology of Tooth Development **33**
Tooth Development: An Overview 33
Stages of Tooth Development 35
Root Formation 37
Eruption of Teeth 37
Dentition Stages in Humans 38
Primary Dentition Stage (6 Months to 6 Years) 38
Mixed Dentition Stage (6–12 Years) 43
Permanent Dentition Stage (12 Years and Beyond) 44
Dental Age 46

4. Form and Function of Orofacial Complex **51**
Size of Crown and Root 51
Tooth Form and Jaw Movements 51
Interproximal Spaces and Protection of Interdental Gingiva 52
Proximal Contact Areas 54
Embrasures (Spillways) 56
Facial and Lingual Physiologic Contours of Teeth 59
Curvatures of Cervical Line (CEJ): Mesially and Distally 60

Imaginary Occlusal of Planes and Curves 60
Geometries of Crown Outlines 61

Section 3: Deciduous Dentition

5. Primary (Deciduous) Dentition **67**
Dental Formula for Primary Dentition 67
Significance of Deciduous Dentition 69
Detailed Description of Each Primary Tooth 71
Deciduous Incisors 71
Deciduous Maxillary Central Incisor 71
Deciduous Maxillary Lateral Incisor 74
Deciduous Mandibular Central Incisor 76
Deciduous Mandibular Lateral Incisor 77
Deciduous Canines 79
Deciduous Maxillary Canine 79
Deciduous Mandibular Canine 81
Deciduous Molars 85
Deciduous Maxillary 1st Molar 85
Deciduous Maxillary 2nd Molar 88
Deciduous Mandibular 1st Molar 90
Deciduous Mandibular 2nd Molar 95

6. Differences between Primary and Permanent Dentitions **99**

Section 4: Permanent Dentition

7. The Permanent Maxillary Incisors **111**
Functions of Incisors 111
Common Characteristics (Class Traits) of All Incisors 111
Permanent Maxillary Central Incisor 111
Detailed Description of Maxillary Central Incisor from All Aspects 112
Crown 113
Root 117
Variations 117
Developmental Anomalies 117
Clinical Considerations 117
Permanent Maxillary Lateral Incisor 119
Detailed Description of Maxillary Lateral Incisor from All Aspects 120
Crown 120
Root 123
Variations 123
Developmental Anomalies 126
Clinical Considerations 126

8. The Permanent Mandibular Incisors **128**
Permanent Mandibular Central Incisors 128
Detailed Description of Mandibular Central Incisor from All Aspects 128
Crown 128
Root 132
Variations 132
Developmental Anomalies 132

Permanent Mandibular Lateral Incisors 132
Detailed Description of Mandibular Lateral Incisor from All Aspects 134
Crown 134
Root 139
Variations 139
Developmental Anomalies 140

9. The Permanent Canines 141
Functions 141
Common Characteristics (Class Traits) of Permanent Canines 141
Permanent Maxillary Canine 142
Detailed Description of Maxillary Canine from All Aspects 142
Crown 144
Root 146
Variations 146
Developmental Anomalies 146
Clinical Considerations 146
Permanent Mandibular Canine 147
Detailed Description of Mandibular Canine from All Aspects 148
Crown 148
Root 153
Variations 154
Clinical Considerations 154

10. The Permanent Maxillary Premolars 156
Functions 156
Common Characteristics (Class Traits) of Premolars 156
Maxillary Permanent 1st Premolar 156
Detailed Description of Maxillary 1st Premolar from All Aspects 157
Crown 157
Root 162
Variations 163
Developmental Anomalies 163
Clinical Considerations 163
Maxillary Permanent 2nd Premolar 163
Detailed Description of Maxillary 2nd Premolar from All Aspects 163
Crown 163
Root 169
Variations 169
Developmental Anomalies 169
Clinical Considerations 169

11. The Permanent Mandibular Premolars 172
Permanent Mandibular 1st Premolar 172
Detailed Description of Mandibular 1st Premolar from All Aspects 173
Crown 173
Root 177
Variations 177
Developmental Anomalies 177
Clinical Considerations 177
Permanent Mandibular 2nd Premolar 178
Detailed Description of Mandibular 2nd Premolar from All Aspects 179

Crown 179
Root 184
Variations 184
Developmental Anomalies 184
Clinical Considerations 186

12. The Permanent Maxillary Molars 188
Common Characteristics (Class Traits) of Molars 188
Functions of Molars 188
Permanent Maxillary 1st Molar 188
Detailed Description of Maxillary 1st Molar from All Aspects 189
Crown 189
Root 195
Variations 196
Developmental Anomalies 196
Clinical Considerations 196
Permanent Maxillary 2nd Molar 196
Detailed Description of Maxillary 2nd Molar from All Aspects 197
Crown 197
Root 203
Variations 203
Developmental Anomalies 203
Permanent Maxillary 3rd Molar 203
Detailed Description of Maxillary 3rd Molar from All Aspects 204
Crown 204
Root 206
Variations 206
Clinical Considerations 210

13. The Permanent Mandibular Molars 211
Permanent Mandibular 1st Molar 211
Detailed Description of Mandibular 1st Molar from All Aspects 211
Crown 211
Root 217
Variations 217
Developmental Anomalies 217
Clinical Considerations 217
Permanent Mandibular 2nd Molar 217
Detailed Description of Mandibular 2nd Molar from All Aspects 219
Crown 219
Root 224
Variations 224
Developmental Anomalies 224
Permanent Mandibular 3rd Molar 224
Detailed Description of Mandibular 3rd Molar from All Aspects 224
Crown 224
Root 229
Variations 230
Developmental Anomalies 231
Clinical Considerations 231

14. Pulp Morphology **233**

The Terminology 233
Age Related Changes in Pulp Morphology 235
Clinical Applications 235
Detailed Description of Pulp Anatomy of Permanent Teeth 236
Maxillary Teeth 236
Mandibular Teeth 239

Section 5: Class, Arch and Type Traits of Teeth

15. Class, Arch and Type Traits of Incisor Teeth **247**

16. Class and Arch Traits of Canine Teeth **255**

17. Class, Arch and Type Traits of Premolar Teeth **259**

18. Class, Arch and Type Traits of Molar Teeth **267**

Section 6: Dento-osseous Structures: Temporomandibular Joint

19. Dento-osseous Structures: Blood Supply, Lymphatics and Innervation **279**

Skull and Jaws at Birth 279
Development of Skull/Craniofacial Complex 279
Bones of Neurocranium 280
Viscerocranium/Face 280
Maxilla 280
Mandible 282
Blood Supply 286
Venous Drainage of Orodental Tissues 287
Lymphatic Drainage of Orodental Tissues 288
Nerve Supply to Orodental Tissues 289
Trigeminal Nerve (Fifth Cranial Nerve) 290
Innervation of Maxilla 292
Innervation of Mandible 292
Innervation of Palate and Lips 292

20. Temporomandibular Joint **294**

Articular Surfaces 294
Intra-articular Disk 294
Fibrous Capsule 295
Ligaments of TMJ 295
Blood and Nerve Supply to TMJ 296
Muscles of the Joint 296
Mandibular Movements and Muscle Activity 297
Functions of TMJ, Teeth and Muscles 299
Mastication 299
Deglutition 299
Speech 300

Section 7: Occlusion

21. Occlusion **305**
Terms Commonly Used in Discussions about Occlusion and Malocclusion 305
Development of Occlusion 306
Characteristics of Occlusion in Deciduous Dentition 307
Characteristics of Occlusion in Permanent Dentition 315
Types of Cusps 315
Centric Occlusal Contacts 316
Tooth Guidance 317
Imaginary Occlusal Planes and Curves 318

Section 8: Evolution of Teeth, Comparative Dental Anatomy, Forensics and Dental Anthropology

22. Evolution of Teeth, Comparative Dental Anatomy and Forensic Odontology **323**
Evolution of Teeth 323
Comparative Dental Anatomy 325
Forensic Odontology 330

23. Dental Anthropology **332**
Branches/Subfields of Anthropology 332
Dental Anthropology 333
Metric Variation in Teeth 334
Non-metric Variations in Teeth 334

Section 9: Tooth Carving

24. Tooth Carving **341**
Rationale of Tooth Carving 341
Armamentarium 341
General Principles of Carving 342
Preliminary Steps 343
Carving of Maxillary Central Incisor 344
Carving of Maxillary Lateral Incisor 346
Carving of Mandibular Central Incisor 346
Carving of Mandibular Lateral Incisor 346
Carving of Maxillary Canine 346
Carving of Mandibular Canine 349
Carving of Maxillary 1st Premolar 349
Carving of Maxillary 2nd Premolar Carving 352
Carving of Mandibular 1st Premolar 353
Carving of Mandibular 2nd Premolar 355
Carving of Maxillary 1st Molar 356
Carving of Maxillary 2nd Molar 360
Carving of Mandibular 1st Molar 360
Carving of Mandibular 2nd Molar 362

Index *365*

SECTION

1

Introduction and Nomenclature

CHAPTER

1

Introduction to Dental Anatomy

The field of dental anatomy is dedicated to the study of teeth including their development, eruption, morphology, classification, nomenclature and function. Dental occlusion deals with the contact relationship of the teeth in function as in mastication, and also the static morphological tooth contact relationship as at rest. The knowledge of dental anatomy, physiology and occlusion forms a firm basis for all the fields of clinical dentistry and is essential for rendering appropriate treatment to various dental problems. A brief overview of dental anatomy and the related basic terminologies are discussed in this chapter.

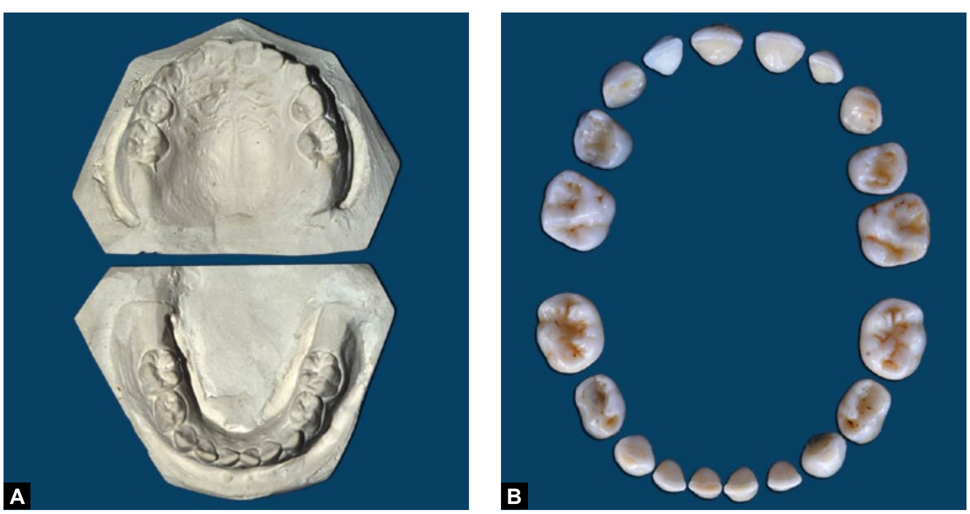
DENTITIONS IN HUMANS

Humans, like most mammals have two sets of teeth, the *deciduous/primary dentition* and the *permanent/secondary dentition*. Such a condition where two generations of teeth are present in a lifetime is called *diphyodonty*. Most sub-mammalian vertebrates are *polyphyodonts* with many successions of teeth necessary to compensate for continual loss of teeth. Teeth in these animals are directly attached to the jaw bone and thus are frequently broken and lost during normal function.

A limited succession of teeth still occurs in most mammals including humans—not to compensate for continual loss of teeth but to accommodate the growth of the face and jaws. In childhood, the face and jaws are small and hence can carry only a few teeth of small size the deciduous dentition. Later, a large increase in the size of jaws occurs with growth necessitating larger teeth. Since the size of the teeth cannot increase once they are formed, the deciduous teeth become inadequate. They are thus replaced by a set of larger and greater number of teeth the permanent or secondary dentition.

Deciduous/Primary Dentition (Figs 1.1A and B)

The primary dentition is called so since they are the first set of teeth to appear in the oral cavity. The term *deciduous* implies that they are shed/fall off naturally similar to the leaves of



Figures 1.1A and B Deciduous/primary dentition: (A) Cast specimen; (B) Human extracted primary teeth arranged in arches in their respective positions

deciduous forest tree. The primary teeth are sometimes also referred to as *milk teeth/baby teeth/lacteal teeth*. These terms are unfortunate and inappropriate since they imply a lack of importance to the first dentition. The terms 'deciduous' and 'primary' are more appropriate and are used interchangeably throughout the text.

The primary dentition consists of a total of 20 teeth, 10 in each jaw. The primary teeth begin to emerge into the oral cavity at about 6 months of age and the child would have his/her complete set of primary teeth by 2½ to 3 years.

Permanent/Secondary/Succedaneous Dentition (Figs 1.2A and B)

There are a total of 32 teeth in the permanent dentition, 16 in each jaw. The permanent teeth are also called as *succedaneous teeth/secondary teeth* since they replace or succeed the primary teeth.

The permanent teeth begin to emerge at 6 years of age and gradually replace the smaller primary teeth. The eruption process is completed by 12 to 13 years except for the posterior most teeth, the four 3rd molars which erupt around 18 to 25 years of age.

There are 32 permanent teeth, but only 20 teeth in the primary dentition. Thus, there are 12 permanent teeth—the molars that erupt into oral cavity but do not replace any primary teeth. Therefore, in strict sense, the permanent molars are not succedaneous teeth as they do not have predecessors.

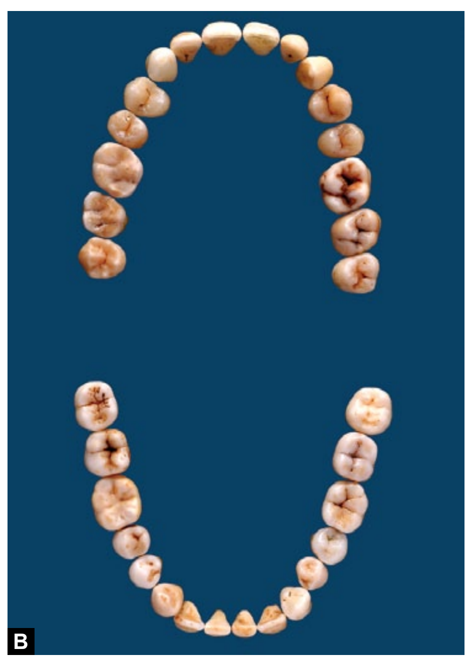
Arrangement in the Dental Arches (Fig. 1.3)

The teeth making up each dentition are arranged in two arches, one in each jaw; *the maxillary* and *mandibular dental arches*. The teeth in the upper jaw, the maxilla are called the *maxillary or upper teeth*. The teeth in the lower jaw, the mandible are called the *mandibular/ lower teeth*.

There are equal number of teeth in maxillary and mandibular dental arches, 10 in primary and 16 in permanent dentition. Furthermore, the teeth in each arch are arranged symmetrically on either side of the median plane. The median plane divides each dental arch into left and right quadrants. Thus, there are four quadrants in oral cavity, namely the *upper right, upper left, lower left* and *lower right* in a clockwise direction. All the four quadrants carry equal number of teeth in the absence of any pathology. The corresponding teeth in left and right side of each dental arch are mirror images, with similar size and form.

Classes of Teeth (Table 1.1 and Fig. 1.4)

All the teeth in human dentitions are not of same shape. Depending on the form and function, there are four classes of teeth in permanent dentition: *the incisors, the canines, the premolars* and *the molars* (**Figs 1.2A and B**). Premolars are found only in the permanent dentition; there are no primary premolars. Therefore, the primary dentition consists of only three class of teeth; *the incisors, the canines* and *the molars* (see **Fig. 1.1**).



Figures 1.2A and B Permanent/Secondary dentition: (A) Dental cast specimen; (B) Human extracted permanent teeth arranged in their respective positions

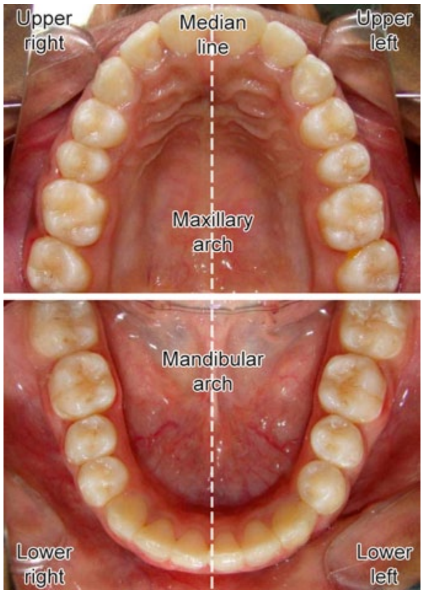


Figure 1.3 Teeth in maxillary and mandibular dental arches are arranged symmetrically on either side of the median plane (Note that the 3rd molar has not erupted yet)

Table 1.1 Classes of teeth in human dentitions

Permanent dentition	*Primary dentition*
Incisors	Incisors
Canines	Canines
Premolars	No premolars in primary dentition
Molars	Molars

Table 1.2 Types of teeth in human dentitions

Classes	*Types of teeth*	
	Permanent dentition	*Primary dentition*
Incisor class	Central and lateral	Central and lateral
Canine class	(Single type)	(Single type)
Premolar class	First and second	(No premolars)
Molar class	First, second and third	First and second (No 3rd molars)

The incisors and canines are collectively known as the *anteriors*, while the premolars and molars are collectively referred to as the *posteriors*.

The etymologies (etymology = origin of words) of these dental terms are all from the Latin.

- *Incisors (incidere in Latin = to cut into)*: Incisors are called so because their function is of incising and nipping; incisors are the "cutting teeth".
- *Canines (canis in Latin = dog, hound)*: The canine teeth derive their name from the prominent, well-developed corner teeth in the family.
- *Canidae (dogs)*: These teeth in carnivorous animal are mainly used for prehension of their prey. However their value for prehension has been considerably diminished in humans where the canine teeth function essentially as incisors. They are also referred to as 'cuspids' since these teeth consists of one large primary cusp.
- *Premolars (premolars = before molar teeth)*: The term 'premolars' merely recognizes the anatomical portion of these teeth, that is in front of the molars. They are also sometimes referred to as 'bicuspids' since these teeth commonly (but not always) have two cusps.
- *Molars (molaris in Latin = millstone)*: The term molars refers to the grinding, triturating function of these teeth with their wide occlusal surfaces.

Types of Teeth (Table 1.2 and Fig. 1.4)

Within each class, the teeth may be subdivided into 2 or 3 types depending on their traits. The incisors are further

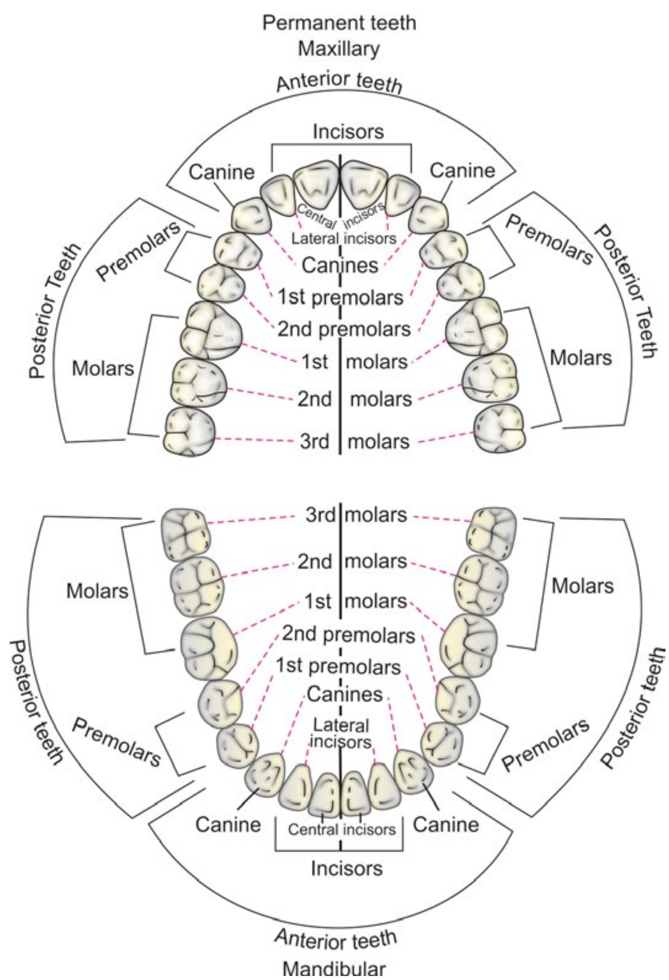


Figure 1.4 Different classes and types of teeth in human permanent dentition

divided into *central* and *lateral incisors*. Among premolar and molar classes, there are *1st* and *2nd premolars,* and *1st, 2nd* and *3rd molars*. The molar class in the deciduous dentition has only two teeth, the *1st* and *2nd molars*.

TRAIT CATEGORIES OF TEETH

While describing the anatomy of a tooth, its morphologic characteristics are compared with that of the other teeth, so that any similarities and differences can be noted. A trait is a distinguishing characteristic, quality or attribute. The tooth traits are categorized as follows:

Set Traits

Set traits/dentition traits distinguish the teeth in the primary dentition from the permanent dentition, e.g. primary teeth have bulbous crowns and constricted necks. Permanent teeth are darker in color, whereas the primary teeth are more whitish.

Arch Traits

Arch traits distinguish maxillary from mandibular teeth, e.g. maxillary molars have three roots, while the mandibular molars have two roots.

Class Traits

Class traits distinguish the four classes of teeth, namely—incisors, canines, premolars and molars, e.g. incisors have straight incisal ridges efficient for cutting, canines have single, pointed cusps for piercing food, and premolars have two or three cusps for shearing and grinding and molars have three to five flattened cusps ideal for crushing food.

Type Traits

Type traits differentiate teeth within one class, e.g. differences between central and lateral incisors, differences between 1st and 2nd premolars, or between 1st, 2nd and 3rd molars. Maxillary central incisor has a straight incisal ridge while that of the lateral incisor is curved with roundened incisal angles.

NOMENCLATURE OF TEETH

Teeth are named by their set, arch, class, type and side. The name of a specific tooth would include information whether it belongs to primary (deciduous) or permanent set, maxillary (upper) or mandibular (lower) arch, which class and type it belongs to and whether it is of left or right side of the mouth. For example:
- Primary maxillary right lateral incisor
- Permanent mandibular left 1st molar.

Tooth notation systems are used to simplify the nomenclature of teeth. This facilitates communication and record keeping. The various tooth notation systems are discussed in detail in Chapter 2.

DENTAL FORMULAE IN HUMANS

The number and type of teeth present in a dentition can be expressed in the form of a dental formula. The dental formulae are used to differentiate the human dentitions from that of the other species. The dental formula is different for primary and permanent dentitions.

Since the left and right halves of the dental arches are exact mirror images, the dental formulae include the teeth present in one side of the mouth only. Different classes of teeth are represented by the first letter in their name, e.g. "I" for incisors, "C" for canine, "P" for premolars and "M" for molars. Each such letter is followed by a horizontal line. The number above the horizontal line represents such type teeth present in the maxillary arch while the number below the line represents such type of teeth present in the mandibular arch.

Dental Formula for Primary/Deciduous Dentition

The primary dentition has the following dental formula: $I\frac{2}{2}C\frac{1}{1}M\frac{2}{2}=\frac{5}{5}=10$ (on each side).

(Expressed as 2:1:2, i.e. two:one: two).

Each quadrant in primary dentition has five teeth; beginning from the midline they are the central incisor, the lateral incisor, the canine, the 1st molar and the 2nd molar. There are 10 teeth on each side of the midline and thus adding to a total of 20 teeth in deciduous dentition.

Dental Formula for Permanent Dentition

In permanent dentition, the premolars are present in addition to incisors, canines and molars; the number of molar teeth is increased to three. The dental formula for permanent dentition is as follows:

$I\frac{2}{2}C\frac{1}{1}P\frac{2}{2}M\frac{3}{3}=16$ (on each side)

$Z\frac{2}{2}C\frac{1}{1}P\frac{2}{2}M\frac{3}{3}=\frac{8}{8}$ (in each quadrant)

(Expressed as 2:1:2:3, i.e. two:one:two:three)

The permanent dentition consists of 32 teeth, 16 in each jaw and 8 in each quadrant. The teeth present in each quadrant from the midline are; central and lateral incisors, canine, 1st and 2nd premolars, followed by 1st, 2nd and 3rd molars.

STAGES OF DENTITIONS IN HUMANS

Traditionally, three stages/periods of dentitions are recognized in humans. They are the *deciduous dentition period, mixed* (*transitional*) *period* and the *permanent dentition period*.

Deciduous Dentition Period (6 Months to 6 Years)

- The deciduous dentition stage begins from the time of eruption of first primary tooth, usually the mandibular central incisor at around 6 months of age. It lasts until the emergence of the first permanent tooth around 6 years of age.
- During this period there are only deciduous teeth present in the oral cavity.
- Oral motor behavior and speech are established during this period.

Mixed Dentition Period (6 to 12 Years)

- Mixed dentition stage is a transition period when primary teeth are exfoliated in a sequential manner, followed by the eruption of their permanent successors.
- This stage lasts from 6 to 12 years of age. Both primary and permanent teeth are present during this period.
- The mixed dentition period begins with the eruption of permanent 1st molars and mandibular central incisors. It is completed when the last primary tooth is shed.
- During this period, the primary incisors are replaced by the permanent incisors; the primary canines by the permanent canines and the primary molars by the permanent premolars.
- It has to be noted that, the successors of primary molars are the permanent premolars and not the permanent molars.
- Significant changes in occlusion occur during mixed dentition period due to significant growth of jaws and replacement of 20 primary teeth by their permanent successors.

Permanent Dentition Period (12 Years and Beyond)

- Permanent dentition period is well established by about 13 years of age with the eruption of all the permanent teeth except the 3rd molars that erupt late in life (around 18–21 years).
- The permanent molars (6 in each jaw; 3 in each quadrant) have no deciduous predecessors. In other words, the permanent molars do not replace any primary teeth, but erupt distal to the last primary tooth on the dental arch. They extend the dental arches at the back of the mouth as the jaws increase in size with growth.

PARTS OF TOOTH

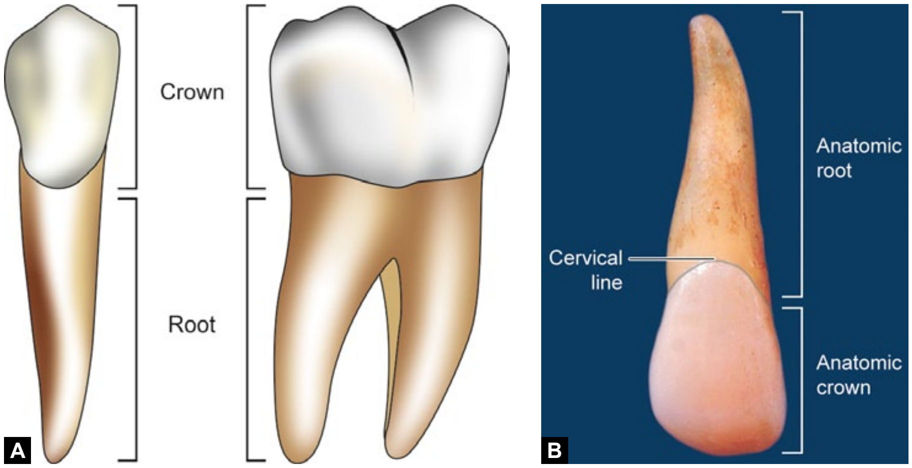
Any tooth has two main parts:

1. Crown
2. Root.

The crown is the portion of the tooth that projects above the gum line into the oral cavity; while the root is that portion of the tooth that is embedded in the jaw bone and anchors the tooth. The crown and root portions are joined at the neck/cervical area. The junction between the crown and root portion is marked by a distinct line the *cervical line* (**Figs 1.5A and B**).

Anatomic crown: Anatomic crown is defined as the part of the tooth that is covered by enamel (**Fig. 1.5B**).

Anatomic root: Anatomic root is that portion of the tooth that is covered by cementum (**Fig. 1.5B**). The cervical line that



Figures 1.5A and B (A) A tooth has two parts—crown and root; (B) An extracted tooth showing anatomic crown and root separated by the cervical line

signifies the cementoenamel junction separates the anatomic crown from anatomic root. The cervical line can be clearly observed on an extracted tooth. This relation does not change with age.

Clinical crown: Clinical crown is the part of a tooth that is visible in the oral cavity (**Fig. 1.6**). Clinical crown is limited by the gingival margin/gums. The clinical crown may be smaller or larger than the anatomic crown. Clinical crown is smaller than the anatomic crown in a newly erupted tooth, where cervical part of the anatomic crown is still covered by gingiva (**Fig. 1.7**). On the other hand, clinical crown may become longer with age, as some part of the anatomic root also gets exposed to oral cavity due to gingival recession (**Fig. 1.8**).

Clinical root: Clinical root is that part of a tooth which is under the gingiva and is not exposed to oral cavity (**Fig. 1.6**). It is longer than the anatomic root on newly erupted teeth as the unexposed part of the crown is considered to be a part of the clinical root (**Fig. 1.7**). In an older person with considerable recession of gingiva, the clinical root is shorter than the anatomic root, as the portion of the root that is exposed to oral cavity is considered to be a part of the clinical crown (**Fig. 1.8**).

STRUCTURE OF TOOTH (FIG. 1.9)

The tooth is composed of three hard mineralized tissues, the *enamel,* the *dentin and* the *cementum*; and one soft tissue component, the *pulp*. Enamel is ectodermal in origin while all other tissues of the tooth are mesodermal in origin.

Enamel

Enamel is the hardest substance in the human body consisting of more than 96 percent inorganic material. It forms a protective covering over the crown portion of the tooth. Enamel is not present in the root portion. Although hard in nature, enamel is extremely brittle due to its high mineral

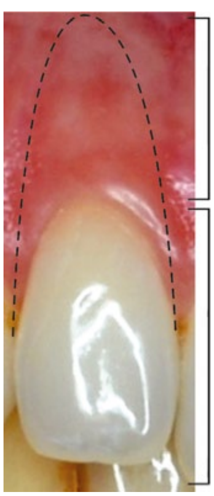


Figure 1.6 Clinical crown in the part of the tooth that is visible in the oral cavity. Clinical root is the part of tooth that is covered by gingiva and not exposed to oral cavity

Figure 1.7 Clinical crown smaller than the anatomic crown in a newly erupted tooth. Here clinical root is longer than the anatomic root

Figure 1.8 Clinical crown longer than the anatomic crown due to gingival recession. Here clinical root is shorter than anatomic root

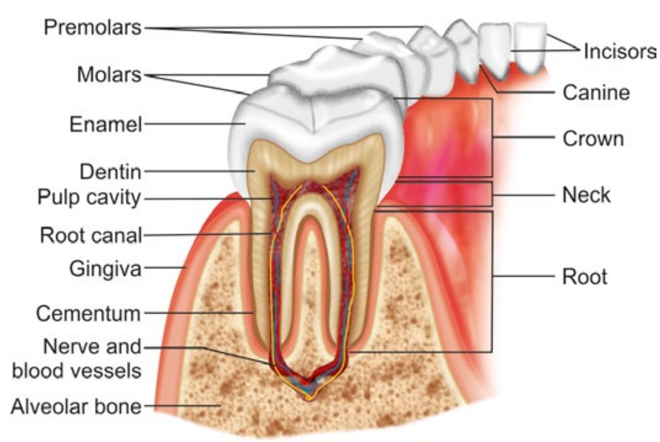


Figure 1.9 Schematic diagram showing various components of a tooth

content. Unlike dentin, cementum or bone, the enamel does not show a continuous formation throughout life. Once the crown formation is complete, no more enamel is deposited. The enamel develops from the enamel organ.

Dentin

Dentin forms the major bulk of the tooth. It is present in both crown and root portions. It is not normally exposed on the surface of the tooth, unless the tooth is badly worn out. Dentin is more resilient owing to its collagenous organic content, supports the enamel and compensates for its brittleness. It develops from *dental papilla* (mesodermal in origin).

Cementum

Cementum is a hard avascular tissue that covers the roots of teeth. It gives attachment to the *periodontal ligament* that binds the tooth to the alveolar bone. Cementum develops from *dental sac* (mesodermal in origin).

Pulp

Dental pulp is the specialized connective tissue that carries blood and nerve supply to the tooth. It is housed in the pulp cavity present at the core of the tooth. The pulp is well protected by the rigid dentin walls all around it. The portion of the pulp in the crown is called the *pulp chamber* and the portion of pulp in the root is called the *pulp/root canal*. Pulp develops from the *dental papilla* (mesodermal origin). Many functions are attributed to pulp including formative, sensory and defensive functions.

BASIC TERMINOLOGIES IN DENTAL ANATOMY

Surfaces of Teeth (Figs 1.10A and B)

Five surfaces can be recognized on the crowns of all the teeth. The fifth surface on the crowns of anterior teeth (incisors and canines) is a ridge (linear elevation) to begin with, when the tooth is newly erupted. However, it soon becomes flattened surface due to wearing (attrition). The surfaces are named according to their positions.

The five surfaces are:

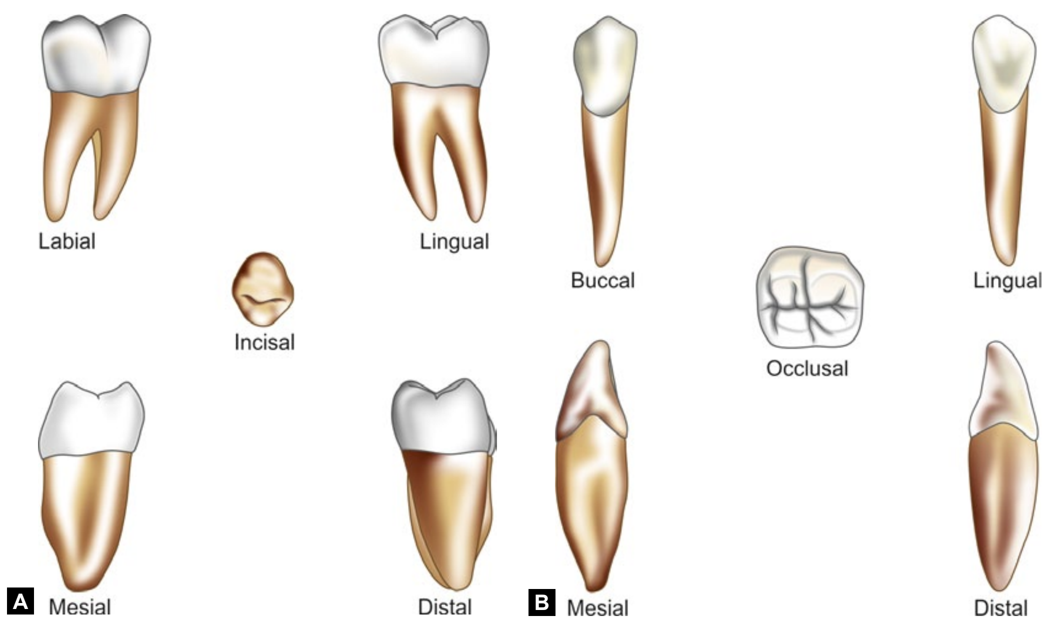
In anterior teeth (Fig. 1.10A)
1. Labial surface
2. Lingual/palatal surface
3. Mesial surface
4. Distal surface
5. Incisal surface

In posterior teeth (Fig. 1.10B)
1. Buccal surface
2. Lingual/palatal surface
3. Mesial surface
4. Distal surface
5. Occlusal surface

Labial/Buccal Surface

In the anterior teeth, the surface towards the lips is called the *labial surface*. The term *buccal surface* is used for the surface of posterior teeth toward the cheeks.

Facial surface is a collective term for referring to both labial and buccal surfaces of the anteriors and the posteriors.



Figures 1.10A and B Crowns of all teeth have five surfaces: (A) Anterior teeth—labial, lingual, mesial, distal, and incisal surfaces; (B) Posterior teeth—buccal, lingual, mesial, distal, and occlusal surfaces

Lingual Surface

The surface of a tooth facing toward the tongue is called the *lingual surface*. It is used for both maxillary and mandibular teeth. In case of maxillary teeth, the term *palatal surface* is sometimes used interchangeably with the term *lingual surface*.

Mesial and Distal (Proximal) Surfaces

The surfaces of the teeth facing toward the adjacent teeth in the same dental arch are called the *proximal surfaces*.

Mesial surface is the surface of the tooth that is nearest to the median line. The surface away from the median line is called the *distal surface*. The mesial surface of a tooth contacts with the distal surface of its adjacent tooth. This arrangement is true for all the teeth except the maxillary and mandibular central incisors, where their mesial surfaces contact each other (**Fig. 1.11**). The distal surfaces of permanent 3rd molars and primary 2nd molars do not contact with any surface as there are no teeth distal to them.

Incisal/Occlusal Surface

The surfaces of teeth that come in contact with those in the opposing jaw during mastication are called the *incisal surface* in case of anterior teeth and *occlusal surface* in case of posterior teeth.

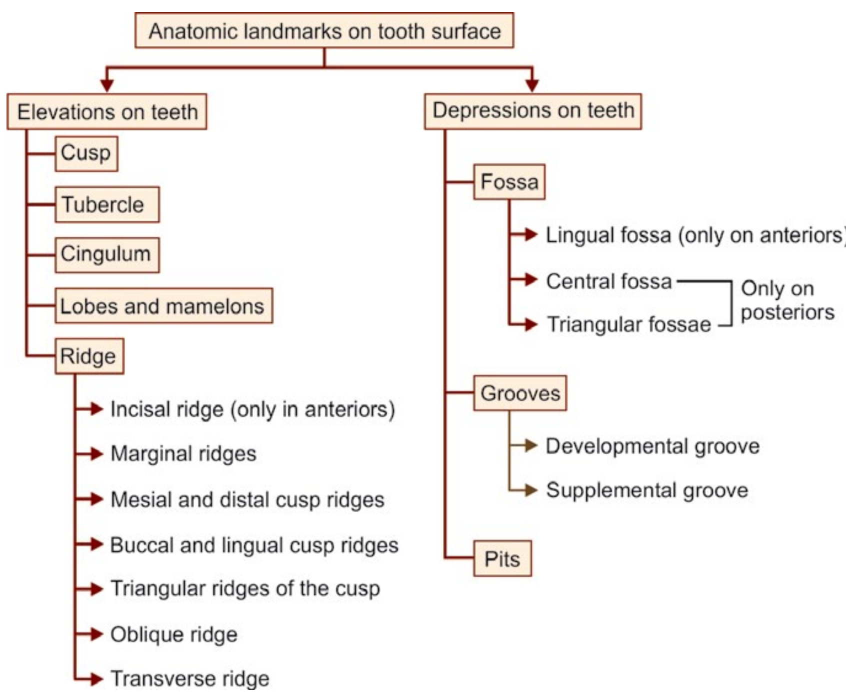
ANATOMIC LANDMARKS ON TOOTH SURFACE (FLOW CHART 1.1)

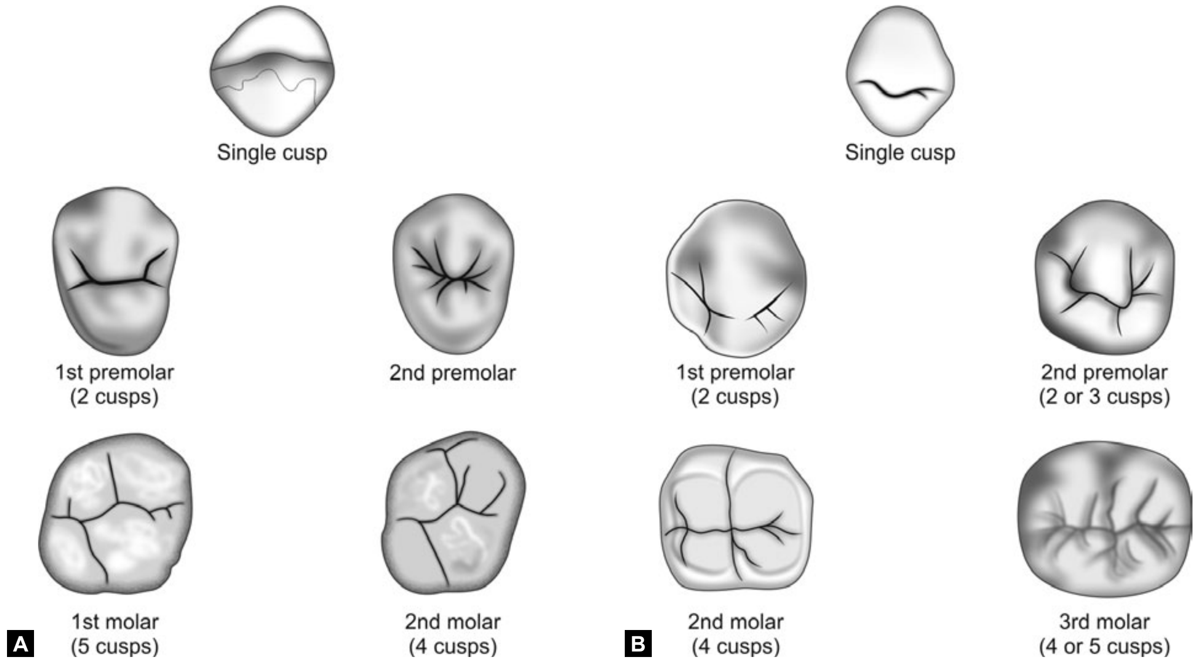
Cusp

Cusp is an elevation on the crown portion of a tooth making up a divisional part of the occlusal surface. Cusps are present in the posterior teeth and the canines (**Figs 1.12A and B**).

Figure 1.11 Maxillary and mandibular central incisors are the only teeth in which mesial surfaces face each other. In all other teeth mesial surface is in contact with distal surface of the adjacent tooth. (M = mesial surface, D = distal surface)

Flow chart 1.1 Anatomic landmarks on tooth surface





Figures 1.12A and B Cusp are present in the canines and posterior teeth. Canine have a single cusp, premolars generally have 2 cusps and molars have 4 to 5 cusps. (A) Maxillary teeth; (B) Mandibular teeth

- Canine teeth have a single cusp; they are often called as the *cuspids*.
- Premolars generally have two cusps with an exception of the mandibular 2nd premolar which frequently has three cusps. Premolars are therefore also called as the *bicuspids*.
- Maxillary and mandibular 1st molars have five cusps, while other molars generally have four cusps.

The number of cusps present in different types of teeth is listed in **Table 1.3**.

Each cusp is a gothic pyramid with four sides formed by four ridges that run down from the cusp tip (**Fig. 1.13**):

- Mesial and distal cusp ridges (cusp slopes)
- Buccal/lingual cusp ridge
- Triangular ridge of the cusp.

There are two cusp slopes on either side of the triangular ridge. In case of canines, there is a *labial ridge* analogous to the buccal ridge posterior teeth; there is a lingual ridge analogous to triangular ridge of posterior teeth.

Table 1.3 Number of cusps in different types of teeth

Tooth type	*Maxillary arch*	*Mandibular arch*
Incisors	0	0
Canines	1	1
Premolars	2	2 in 1st premolar 3 or 2 in 2nd premolar
Molars		
1st molar	4 +1 accessory cusp (cusp of Carabelli)	5
2nd molar	4	4
3rd molar	4 or 3	4 or 5

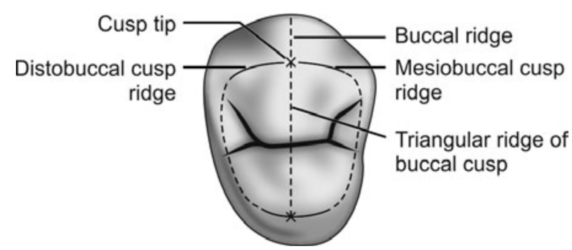


Figure 1.13 Each cusp has a cusp tip and four ridges running down from the cusp tip. Cusp tip and four ridges of the buccal cusp of a premolar tooth is shown here

Tubercle

It is a smaller elevation on some portion of the crown produced by an extra formation of enamel. A tubercle may be found on the lingual surface of a maxillary lateral incisor (**Fig. 1.14**).

Cingulum

Cingulum (Latin word for "girdle") is a mound on the cervical third of the lingual surfaces of anterior teeth (**Figs 1.15A and B**).

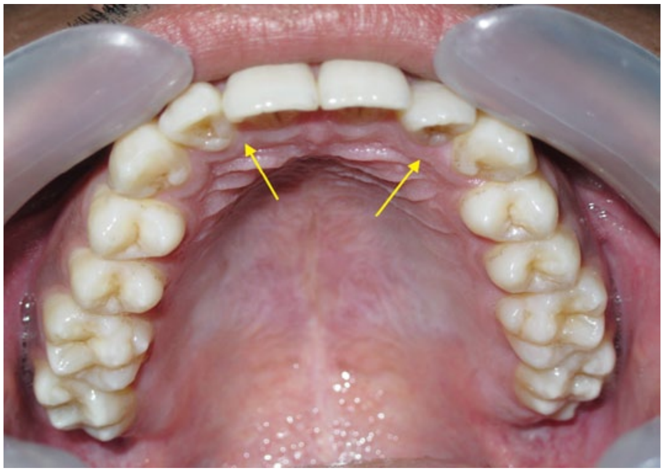
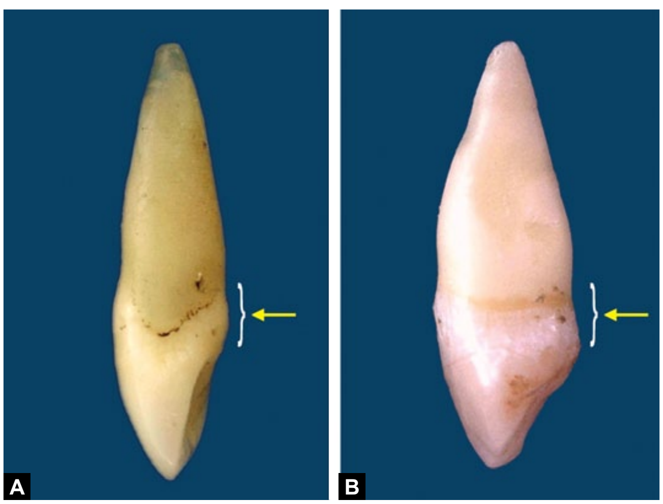


Figure 1.14 Tubercle on lingual surface of the maxillary lateral incisor



Figures 1.15A and B Cingulum is present only in anteriors and is most prominent on maxillary canine: (A) Maxillary central incisor; (B) Maxillary canine

It develops from the lingual lobe of anteriors and makes up the major bulk of cervical third of the crown lingually.

Cingulum resembles a girdle encircling the lingual surface at the cervical third of the crown. It is present in all the anteriors and is most prominent on maxillary permanent canine.

Anatomy

- The cingulum is smooth and convex both mesiodistally and cervicoincisally
- It makes up the bulk of cervical third of the lingual surface
- Marginal ridges extend from cingulum forming the mesial and distal borders of the lingual fossa
- There is a concavity next to the cingulum incisally, called the *lingual fossa*
- Cingulum forms the cervical boundary of the lingual fossa
- Usually two developmental grooves extend from cingulum into the lingual fossa; especially on canines and maxillary incisors.

Ridges

A ridge is any linear elevation on the surface of a tooth. It is named according to its location.

Marginal ridge: All teeth have two marginal ridges; *mesial* and *distal*. These are rounded borders of enamel that form the mesial and distal margins of the occlusal surface of posterior teeth. In case of anteriors, the mesial and distal ridges form the mesial and distal margins of the lingual surfaces (**Fig. 1.16A**).

Buccal cusp ridge: It is a ridge on the buccal surface of a tooth that runs from the tip of a buccal cusp toward the cervical line. There is *labial ridge* in case of canines (**Fig. 1.16B**).

Lingual cusp ridge: It is a ridge on the lingual surface of a lingual cusp of premolar/molar tooth that runs from the cusp tip towards the cervical line. In case of canines, the lingual ridge runs on the lingual surface dividing the lingual fossa into two small fossae.

Mesial and Distal Cusp Ridges

Each cusp has mesial and distal cusp ridges on either side of its tip (**Fig. 1.16C**)

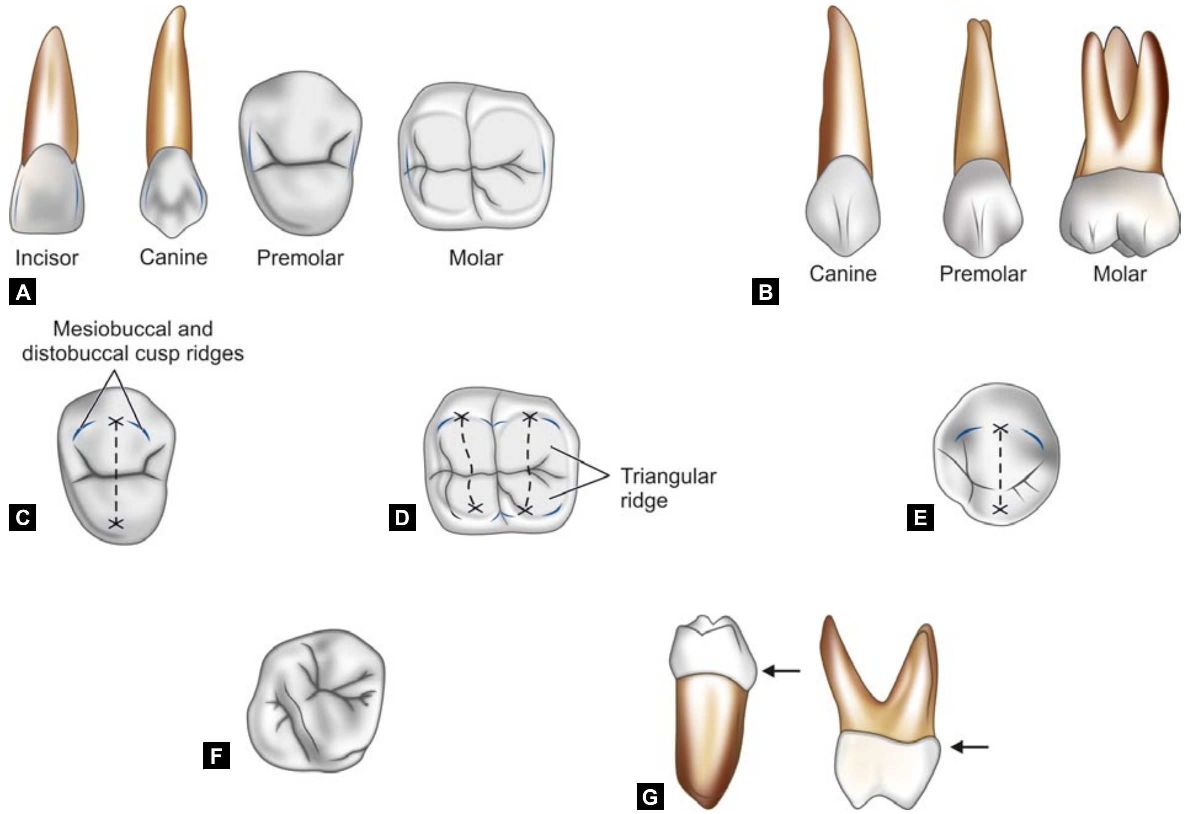
Triangular ridge: Triangular ridge is found on the occlusal surface of premolars and molars. It is the ridge that descends from each cusp tip towards the center of the occlusal surface of a posterior tooth (**Fig. 1.16D**).

Triangular ridges are so named because the inclined planes on either side of the ridge resemble two sides of a triangle. They take the name of the cusp they belong to, e.g. triangular ridge of the buccal cusp of mandibular permanent 1st premolar.

Transverse ridge: A transverse ridge is the union of two triangular ridges crossing the occlusal surface of a posterior tooth in a transverse (buccolingual) direction, e.g. transverse ridge between buccal and lingual cusps on premolar (**Fig. 1.16E**).

Oblique ridge: Oblique ridge is most prominent on permanent maxillary 1st molar (**Fig. 1.16F**). It may be present on maxillary permanent 2nd and 3rd molars. It is also present in deciduous maxillary 2nd molar.

Cervical ridge: It is a ridge that runs mesiodistally on the cervical third of the buccal surface of the crown. Presence of cervical ridge is a characteristic feature of all primary teeth;



Figures 1.16A to G Ridges on teeth: (A) Marginal ridge; (B) Labial buccal ridge; (C) Cusp ridge; (D) Triangular ridge; (E) Transverse ridge; (F) Oblique ridge; (G) Cervical ridge

most prominent on maxillary and mandibular 1st molars (**Fig. 1.16G**). In permanent dentition, the cervical ridge is noticeable on the molar teeth.

Lobe

A lobe is one of the primary sections of formation in the development of the crown. The minimum number of lobes involved in the development of a permanent tooth is four. All anterior teeth develop from four lobes; named as the *mesial, labial, distal* and *lingual lobes* (**Fig. 1.17**). The lingual lobe forms the cingulum in these teeth.

All premolars except for the mandibular 2nd premolar develop from four lobes; named as the *mesial, buccal, distal* and *lingual lobes*. The mandibular 2nd premolar often develops from five lobes; the *mesial, buccal, distal, mesiolingual* and *distolingual lobes*. The lingual lobe forms the lingual cusp in premolars.

The maxillary and mandibular first permanent molars develop from five lobes. All other molars develop from four lobes. Molar lobes are named same as the cusps. The tip of each cusp represents the primary center of formation of each lobe. The number of lobes in different teeth is listed in **Table 1.4**.

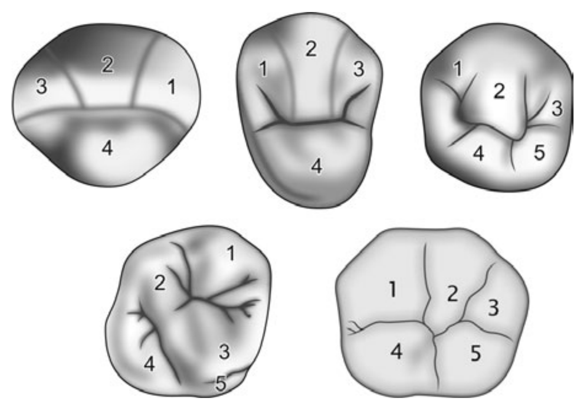


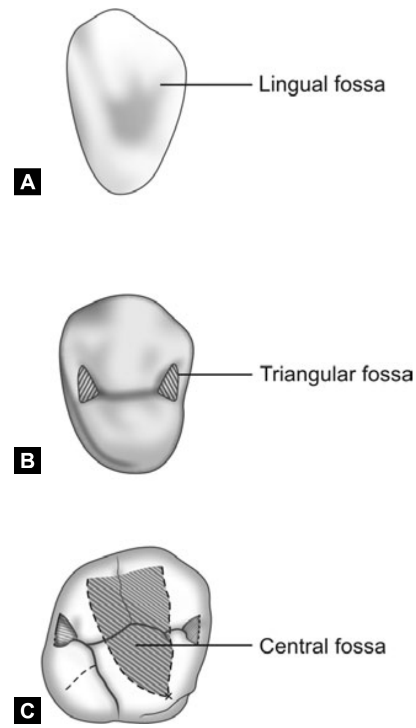
Figure 1.17 All anteriors develop from 4 lobes. All premolars develop from 4 lobes, except mandibular 2nd premolar which often develop from 5 lobes. Maxillary and mandibular 1st molars develop from 5 lobes. Other molar generally develop from 4 lobes

Mamelons

Mamelons are the three rounded protuberances found on the incisal ridges of newly erupted incisor teeth (**Fig. 1.18**). They

Table 1.4 Number of lobes in different teeth

Tooth	*No. of lobes*	*Names of lobes*
Anteriors	4	Mesial, labial, distal and lingual
Premolars		
Maxillary 1st and 2nd premolar mandibular 1st premolar	4	Mesial, labial, distal and lingual
Mandibular 2nd premolar	5	Mesial, labial, distal, mesiolingual and distolingual
Molars		
Maxillary 1st molar	5	Mesiobuccal, distobuccal, mesio-lingual, distolingual and fifth lobe
Maxillary 2nd and 3rd molar	4	Mesiobuccal, distobuccal, mesio-lingual and distolingual
Mandibular 1st molar	5	Mesiobuccal, distobuccal, distal, mesiolingual and distolingual
Mandibular 2nd and 3rd molar	4	Mesiobuccal, distobuccal, mesio-lingual and distolingual (3rd molar can have 5 cusps from 5 lobes)



Figures 1.19A to C Fossae on various teeth: (A) Lingual fossa; (B) Triangular fossa; (C) Central fossa

Figure 1.18 Mamelons on erupting permanent incisor teeth. Primary incisors do not exhibit this feature

represent the mesial, labial and distal lobes of the incisor teeth. Mamelons soon disappear as the incisal ridges get worn away due to mastication. The mamelons are not seen in case of primary incisors.

DEPRESSIONS ON THE TOOTH SURFACE

Fossae

A fossa is a depression or concavity on the lingual surfaces of anteriors and occlusal surface of posterior teeth. A fossa is named according to its location or shape.

Lingual fossa: It is found on the lingual surfaces of anterior teeth (**Fig. 1.19A**). In case of canines, the lingual fossa may be divided into two small lingual fossae by the lingual ridge.

Triangular fossae: Found on the occlusal surface of all posterior teeth, mesial and distal to the marginal ridges (**Fig. 1.19B**). Base of the triangle is at the mesial/distal marginal ridge and the apex is at the mesial/distal pit.

Central fossa: It is found on the occlusal surface of molar teeth (**Fig. 1.19C**).

Sulcus

A sulcus is a long depression or valley on the occlusal surface of the posterior teeth, the inclines of which meet at an angle. *Developmental groove* is present at the bottom of a sulcus where the inclines meet.

Developmental Grooves

A developmental groove is a sharply defined groove or line separating the lobes or the primary parts of the crown or root, e.g. the central developmental groove running mesiodistally

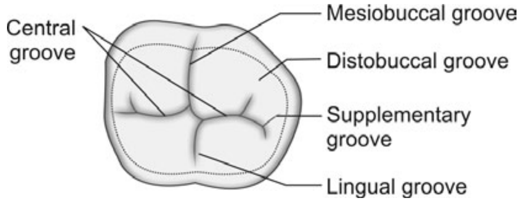


Figure 1.20 Developmental grooves, supplementary grooves, pits on occlusal surface of the teeth

on the occlusal surface of a molar separates the buccal and lingual cusps (**Fig. 1.20**).

A supplemental groove is a small irregular, less distinct line on occlusal surface a tooth. It is supplemental to a developmental groove and does not mark the junction of primary parts of the tooth.

Pit

Pits are small pinpoint depressions located at the junction of two or more developmental grooves or at the terminus of these grooves. They are named according to their location (**Fig. 1.21**).

For example, central pit is a pit in the central fossa of molars where the developmental grooves meet.

Buccal pit: It is a pit on the buccal surface of a molar where the buccal developmental groove terminates. Lingual pit is a pit on the lingual surface of a molar where the lingual developmental groove terminates. Lingual pit can also be seen on lingual surface of maxillary lateral incisors.

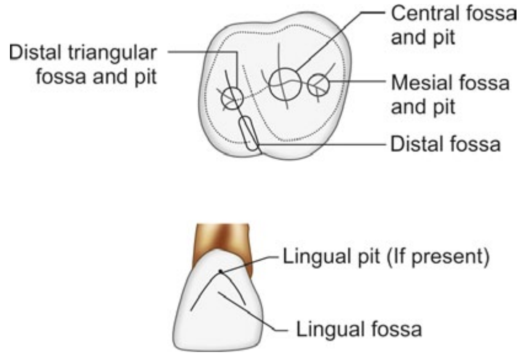


Figure 1.21 Pits on occlusal surface of the teeth

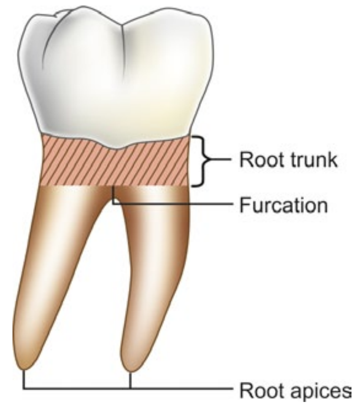


Figure 1.22 Landmarks on root surface

LANDMARKS ON THE ROOT (FIG. 1.22)

Root Trunk

Root trunk is present only in multirooted teeth. It is the undivided part of the root near the cervical line. Root trunk is very short and nearly absent in primary molars.

Furcation

Furcation is the place on multirooted teeth where the root trunk divides into separates roots. Mandibular molars and maxillary 1st premolars are bifurcated while the maxillary molars are trifurcated.

Apex of the Root

The apex of the root is the tip at the end of the root.

Apical Foramen

See Chapter 14 Pulp Morphology.

ARBITRARY DIVISIONS OF CROWN AND ROOT INTO THIRDS (FIG. 1.23)

For descriptive purposes the surfaces of crowns and roots of teeth are arbitrarily divided into thirds. Such a division helps in describing the morphology of tooth.

Divisions of crown: The crown may be divided into thirds in three directions:
1. Mesiodistally
2. Cervico-occlusally/cervicoincisally
3. Faciolingually.

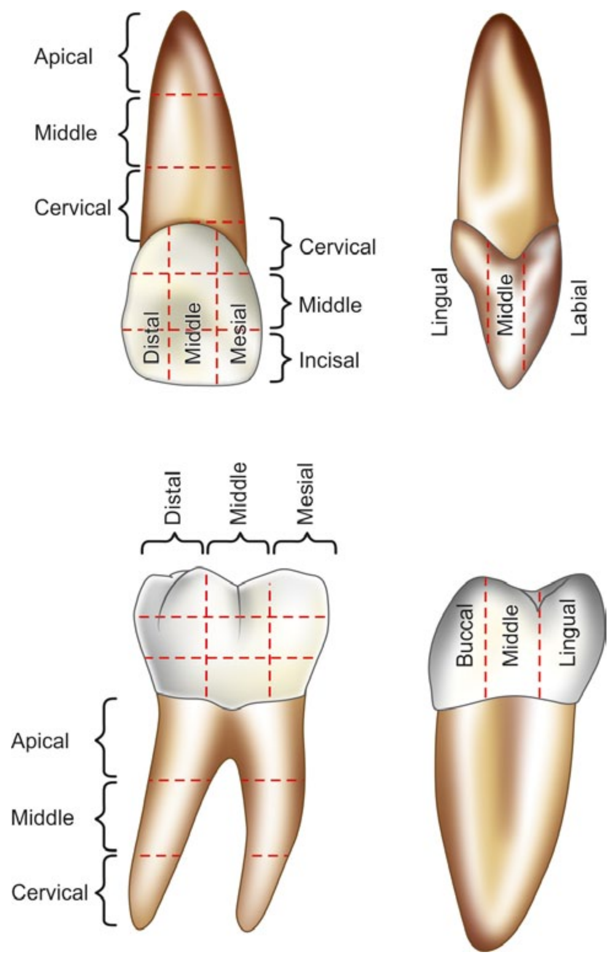


Figure 1.23 Surface of root and crown are traditionally divided into thirds for descriptive purposes. It is a good practice to divide the wax block in thirds during carving exercises

Mesiodistally

Mesiodistally, the crown is divided into:
- Mesial third
- Middle third
- Distal third.

Cervico-occlusally/Cervicoincisally

The crown is divided into:
- Incisal or occlusal third
- Middle third
- Cervical third.

Faciolingually

Faciolingually, the crown is divided into:
- Labial or buccal third
- Middle third
- Lingual third.

DIVISIONS OF THE ROOT

Divisions of the root mesiodistally and faciolingually are exactly similar to that of the crown.

Cervico-occlusally, the root may be divided into:
- Cervical third
- Middle third
- Apical third.

LINE ANGLES AND POINT ANGLES ON THE CROWN

Most surfaces of the crown are spherical and no distinct angles can be made out on the tooth crown. The terms *line angle* and *point angle* are used for descriptive purpose to indicate a location and there are no actual angles on the crown.

Line and point angles can be understood easily by imagining a cube/box or a room. A line angle is formed where two walls meet and a point angle is formed where three walls meet.

Line Angles (Figs 1.24A and B, Table 1.5)

A line angle is formed by the junction of two surfaces. It is named from the combination of the two surfaces that join, e.g. the junction of mesial and buccal walls of a tooth is called the *mesiobuccal line angle*.

There are six line angles on an anterior tooth and eight line angles on a posterior tooth.

Point Angles (Figs 1.25A and B, Table 1.6)

A point angle is formed where three surfaces meet on the crown, and the name is derived from the same.

MEASUREMENTS OF TEETH

The teeth are measured using eight calibrations for each tooth. Boley's gauge is used to measure various dimensions of a tooth such as crown length, root length, labiolingual diameter and mesiodistal diameter of the crown, etc. The methods of measuring various dimensions of anterior and posterior teeth are given in **Boxes 1.1 and 1.2**.

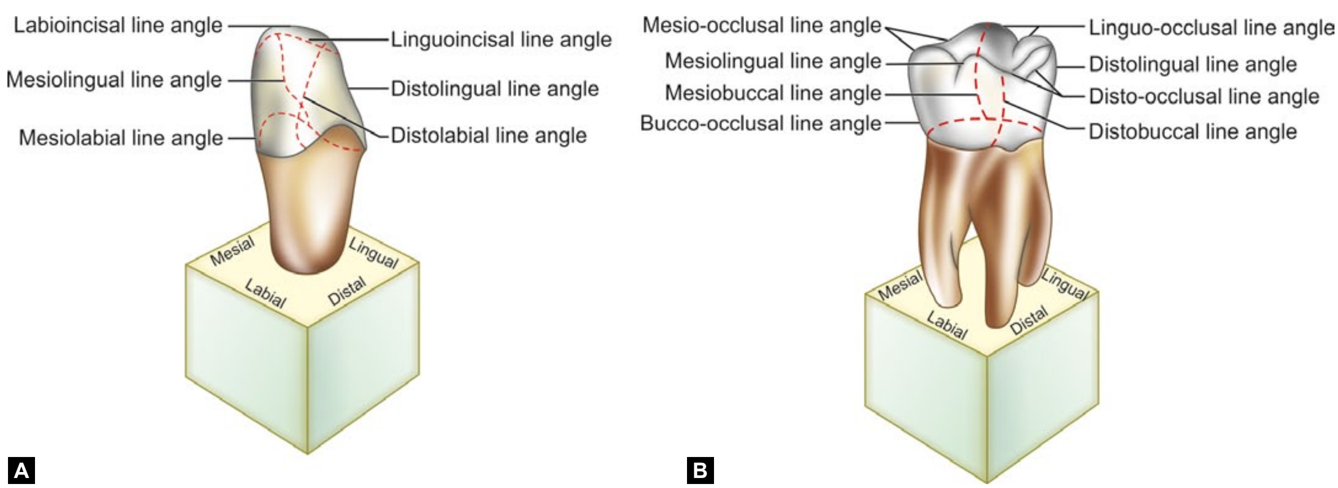
Table 1.5 Line angles

Line angles on anterior teeth	*Line angles on posterior teeth*
Mesiolabial	Mesiobuccal
Mesiolingual	Distobuccal
Labioincisal	Mesiolingual
Distolabial	Distolingual
Distolingual	Mesio-occlusal
Linguoincisal	Disto-occlusal
	Bucco-occlusal
	Linguo-occlusal

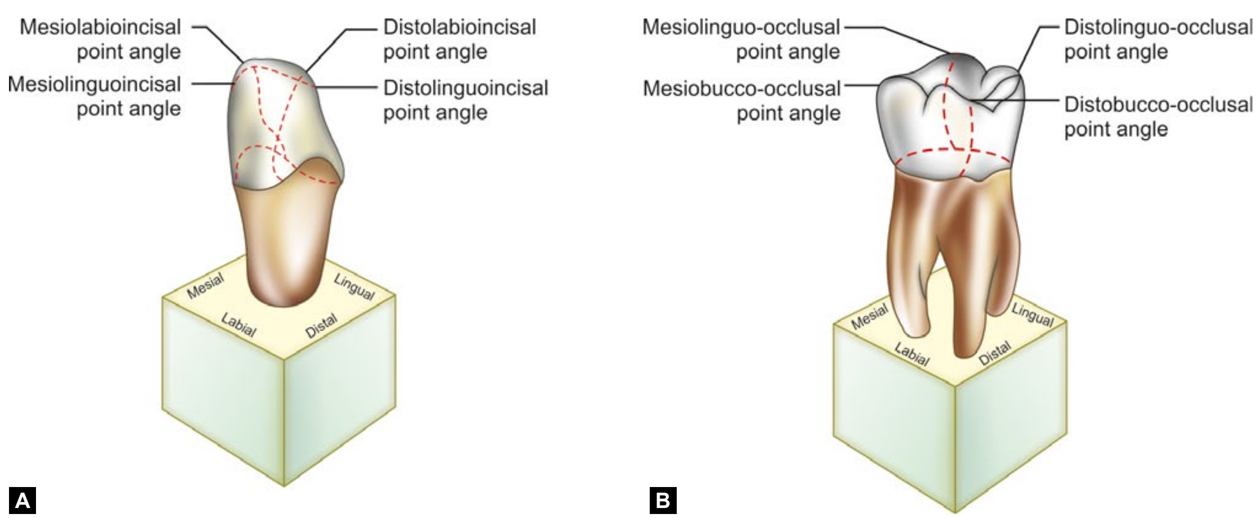
Table 1.7 gives the average dimensions of permanent teeth. These average dimensions are used while carving the teeth.

Table 1.6 Point angles

Point angles on anterior teeth	*Line angles on posterior teeth*
Mesiolabioincisal	Mesiobucco-occlusal
Distolabioincisal	Distobucco-occlusal
Mesiolinguoincisal	Mesiolinguo-occlusal
Distolinguoincisal	Distolinguo-occlusal

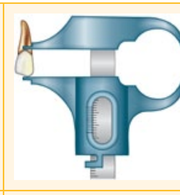
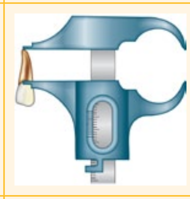
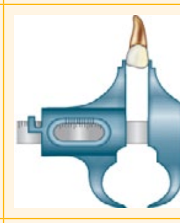
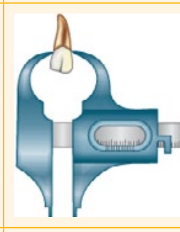
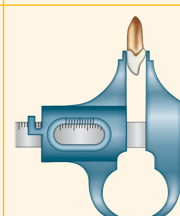
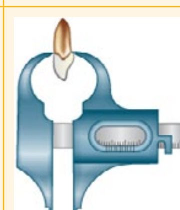
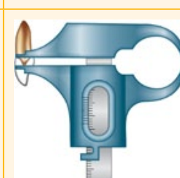


Figures 1.24A and B Line angles in: (A) Anterior; (B) Posterior teeth



Figures 1.25A and B Point angles in: (A) Anterior; (B) Posterior teeth

Box 1.1 Method of measuring anterior teeth

• Length of crown (labial) From – Crest of curvature at cementoenamel junction To – Incisal edge	
• Length of root measurement From – Apex To – Crest of curvature at crown cervix	
• Mesiodistal dimension of crown From – Crest of curvature on the mesial surface (mesial contact area) To – Crest of curvature on distal surface (distal contact area)	
• Mesiodistal diameter of crown at cervix From – Junction of crown and root on mesial surface To – Junction of crown and root on distal surface	
• Labiolingual diameter of crown From – Crest of curvature on the labial surface To – Crest of curvature on the lingual surface	
• Labiolingual diameter of crown at cervix From – Junction of crown and root on the labial surface To – Junction of crown and root on the lingual surface	
• Curvature of cementoenamel junction on mesial From – Crest of curvature on cementoenamel junction an labial and lingual surfaces To – Crest of curvature on cementoenamel junction on mesial surface	
• Curvature of cementoenamel junction on distal From – Crest of curvature on cementoenamel junction on labial and lingual surfaces To – Crest of curvature on cementoenamel junction on distal surface	

Box 1.2 Method of measuring posterior teeth

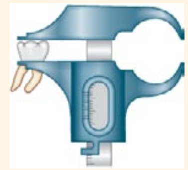
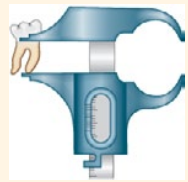
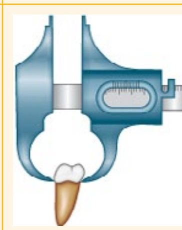
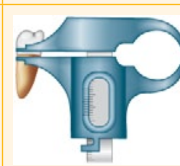
• Length of crown (buccal) From – Crest of buccal cusp or cusps To – Crest of curvature on cementoenamel junction	
• Length of root From – Crest of curvature at crown cervix To – Apex of root	
• Mesiodistal diameter of crown From – Crest of curvature on the mesial surface (mesial contact area) To – Crest of curvature on distal surface (distal contact area)	
• Mesiodistal diameter of crown at cervix From – Junction of crown and root on mesial surface To – Junction of crown and root on distal surface	
• Buccolingual diameter of crown From – Crest of curvature on the buccal surface To – Crest of curvature on the lingual surface	
• Buccolingual diameter of crown at cervix From – Junction of crown of roof on buccal surface To – Junction of crown of roof on lingual surface	
• Curvature of cementoenamel junction on mesial From – Crest of curvature on cementoenamel junction on buccal and lingual surfaces To – Crest of curvature on cementoenamel junction on mesial surface	
• Curvature of cementoenamel junction on distal From – Crest of curvature on cementoenamel junction on labial and lingual surfaces To – Crest of curvature on cementoenamel junction on distal surface	

Table 1.7 Measurements of teeth: Average dimensions for carving of teeth (in millimeters)*

	Cervico-incisal length of crown	*Length of root*	*Mesiodistal diameter of crown*	*Mesiodistal diameter of crown at cervix*	*Labiolingual diameter of crown*	*Labiolingual diameter of crown at cervix*	*Depth of curvature of cervical line on mesial*	*Depth of curvature of cervical line on distal*
Maxillary								
Central incisor	10.5	13.0	8.5	7.0	7.0	6.0	3.5	2.5
Lateral incisor	9.0	13.0	6.5	5.0	6.0	5.0	3.0	2.0
Canine	10.0	17.0	7.5	5.5	8.0	7.0	2.5	1.5
1st premolar	8.5	14.0	7.0	5.0	9.0	8.0	1.0	0.0
2nd premolar	8.5	14.0	7.0	5.0	9.0	8.0	1.0	0.0
1st molar	7.5	B-12 L-13	10.0	8.0	11.0	10.0	1.0	0.0
2nd molar	7.0	B-11 L-12	9.0	7.0	11.0	10.0	1.0	0.0
Mandibular								
Central incisor	9.5	12.5	5.0	3.5	6.0	5.3	3.0	2.0
Lateral incisor	9.5	14.0	5.5	4.0	6.5	5.8	3.0	2.0
Canine	11.0	16.0	7.0	5.5	7.5	7.0	2.5	1.0
1st premolar	8.5	14.0	7.0	5.0	7.5	6.5	1.0	0.0
2nd premolar	8.5	14.5	7.0	5.0	8.0	7.0	1.0	0.0
1st molar	7.5	14.0	11.0	9.0	10.5	9.0	1.0	0.0
2nd molar	7.0	13.0	10.0	8.0	10.0	9.0	1.0	0.0

* Compiled and modified from Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.
2. Brand RW, Isselhard DE. Anatomy of Orofacial Structures, 5th edn. St Louis: CV Mosby; 1994.
3. Kraus B, Jordan R, Abrams L. Dental Anatomy and Occlusion. Baltimore: Williams and Wilkins; 1969.
4. Sicher H, DuBrul EL. Oral Anatomy, 7th edn. St Louis: CV Mosby; 1975.
5. Woelfel JB, Scheid RC. Dental Anatomy: Its Relevance to Dentistry, 5th edn. Baltimore; Williams and Wilkins; 1997.

MULTIPLE CHOICE QUESTIONS

1. The permanent teeth that are not succedaneous teeth in the strict sense are:
   a. Permanent incisors
   b. Permanent premolars
   c. Permanent canines
   d. Permanent molars
2. Dental formula for human deciduous dentition is:
   a. I2/2 C1/1 P2/2 M 3/3
   b. I2/2 C 1/1 M3/3
   c. I2/2 C1/1 M2/2
   d. I2/2 C1/1 P1/1 M2/2
3. The only teeth that have their mesial surfaces facing each other are:
   a. Maxillary and mandibular 3rd molars
   b. Maxillary and mandibular central incisors
   c. Maxillary and mandibular canines
   d. None of the above
4. The minimum number of lobes in the development of permanent tooth is:
   a. 5
   b. 3
   c. 4
   d. 2
5. The buccal cervical ridge is most prominent on:
   a. Permanent 1st molars
   b. Deciduous 1st molars
   c. Permanent 2nd molars
   d. Deciduous 2nd molars
6. The number of line angles and point angles on posterior teeth:
   a. 4 line angles and 4 point angles
   b. 6 line angles and 6 point angles
   c. 4 line angles and 6 point angles
   d. 6 line angles and 4 point angles

7. Which of the maxillary posterior teeth, which has both the cusps are symmetrical and are having same height and width:
   a. Maxillary permanent 1st molar
   b. Maxillary permanent 1st premolar
   c. Maxillary permanent 2nd premolar
   d. Mandibular permanent 3rd molars
8. In maxillary permanent 1st molar, the cusp of Carabelli is located on:
   a. Mesiobuccal cusp
   b. Mesiolingual cusp
   c. Distobuccal cusp
   d. Distolingual cusp
9. Who and when described the cusp of Carabelli
   a. George C Carabelli in 1842
   b. Carabelli Maxwell in 1800
   c. Donald in 1900
   d. Phillip in 1616
10. Cusp of Carabelli is a:
   a. Functional cusp
   b. Non-functional cusp
   c. Fifth cusp
   d. Both b and c

Answers

1. d	2. c	3. b	4. c	5. b	6. d	7. c	8. d	9. a	10. b

CHAPTER

2

Tooth Notation Systems

For more than 130 years, several systems for designating and encoding teeth have been in use. Tooth numbering systems have been developed in order to have a standard way of referring to particular teeth. When identifying a specific tooth, one has to list the dentition, dental arch, quadrant and the tooth name. Listing all these information in words, while referring to each of 52 teeth (20 primary, 32 permanent) becomes cumbersome and time consuming.

For example, speaking, writing or typing permanent maxillary right central incisor (37 letters and 5 words) is more taxing than referring to same tooth as "**8**" in universal system, "**11**" in FDI system. Tooth notation acts like a dental 'short hand' providing a standard and an easy way of communication among dental professionals, students and care providers. It also gives a convenient method of record keeping in dental practice. It is important for anthropologists also to be familiar with the tooth-coding systems.

Although, there have been more than 32 different tooth notation systems, 3 systems are commonly in use and they are discussed in this chapter. It is necessary to be familiar with all the three popular systems so that communication between dental offices is efficient. However, it is important to stick to one notation system in a dental practice so as to avoid confusion. Also, it is important to specify which system is used.

For example, **11** (read as 'eleven') in universal system refers to the permanent maxillary left canine. While 11 (read as 'one one') in FDI system refers to the permanent maxillary right central incisor.

The following are the three tooth notation systems that are in common use.

1. Universal numbering system
2. Zsigmondy-Palmer notation system
3. FDI (Federation Dentaire Internationale) system.

Universal system is widely used in United States. Zsigmondy-Palmer notation is the oldest system in use. Although superseded by the FDI system in most countries it continues to be used in UK and many parts of Asia. Internationally, the two-digit FDI system is widely used.

Some of the other tooth notation systems that were in use are listed here:

- The Dane or Haderup system
- The reverse numeration system
- The Latin numeral system
- The Metcalf system
- The Bosworth system
- The Crow system
- The US army system
- The US navy system
- The Lowlands system
- The Holland system
- The South African system
- The French system
- The Dutch system
- The Cincinnati system.

Most of these numbering systems are of only historical value now. Among these, the Haderup system was popular in Norway, Sweden, Denmark, Finland and Ireland; was practically the only system used in these countries for some decades after its introduction in 1891.

UNIVERSAL NOTATION SYSTEM

Universal numbering system was first proposed by *Parreidt* in 1882. It was officially adopted by the *American Dental Association* (ADA) in 1975. It is still widely used by dentists in USA and also endorsed by the *American Society of Forensic Odontology*. Today the universal system for tooth-coding is an interesting misnomer, because it is only used in the United States.

The universal system uses continuous numbers and letters to denote each tooth. In this system, irrespective of the dentition, numbering always starts from the last tooth in the upper right quadrant and ends with the last tooth in the lower right quadrant. Numbering is done clockwise beginning with the last tooth in the upper right quadrant and ends with the last tooth in the lower right quadrant.

The numbers, 1 to 32 are used to denote the permanent teeth; English alphabets, A to T in upper case are used to denote the primary teeth.

Universal Notation for Permanent Teeth (Figs 2.1A and B)

- Numbers 1 to 32 are used to denote teeth in permanent dentition.
- The numbering begins from the posterior most tooth in the upper right quadrant, i.e. the maxillary 3rd molar, which is designated as tooth #1. Numbering goes in a clockwise direction on right side.
- The count continues along the upper teeth to the left side, so that left maxillary 3rd molar is designated as #16.
- After descending down to mandibular 3rd molar, tooth #17, numbering continuous along the mandibular arch and ends at the last tooth in mandibular right quadrant, the mandibular right 3rd molar as tooth #32.

Numbering for entire permanent dentition is given below. One must remember that notation charts traditionally are printed in *dentist's view*. In other words, patient's right side corresponds to tooth chart's left side. *To put it simply, always visualize a patient's dentition in front of you while designating teeth in any system.*

Right									Left							
1	2	3	4	5	6	7	8	|	9	10	11	12	13	14	15	16
32	31	30	29	28	27	26	25	|	24	23	22	21	20	19	18	17

Teeth 1 to 8 — are of maxillary right quadrant
9 to 16 — are of maxillary left quadrant
17 to 24 — are of mandibular left quadrant
25 to 32 — are of mandibular right quadrant

For example, maxillary right central incisor #8 mandibular left 1st molar #19.

It helps to remember that #1, #16, #17, #32 are third molars and #8, #9, #24 and #25 are central incisors.

Universal Notation for Primary Teeth (Figs 2.2A and B)

- The universal notation system for primary dentition uses upper case English letters for each of primary teeth.
- The maxillary teeth are designated as letters 'A' though 'J', beginning with right maxillary 2nd molar. For mandibular teeth, letters 'K' through 'T' are used, beginning with the left mandibular 2nd molar.

(In the original system, 20 deciduous teeth were designated in the same order as in permanent dentition 1 to 20 followed by small letter 'd' to indicate deciduous teeth. It was later modified to use upper case letters 'A' through 'T' to denote the primary teeth).

The universal notation system for entire primary dentition is as follows:

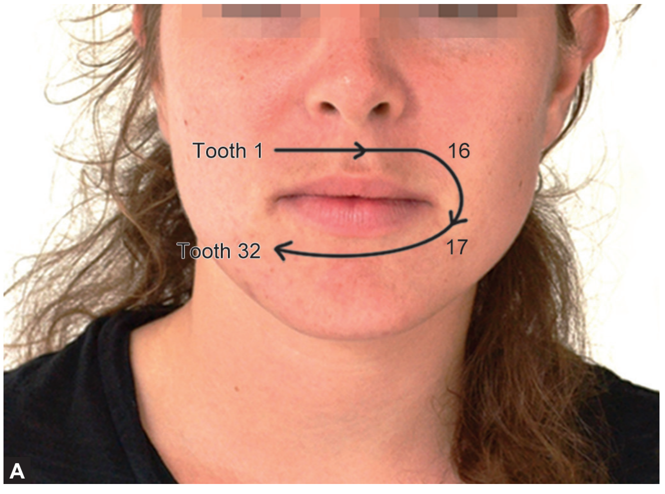
Right						Left				
A	B	C	D	E	|	F	G	H	I	J
T	S	R	Q	P	|	O	N	M	L	K

For example, primary maxillary right central incisor 'E' primary mandibular left 1st molar 'L'.

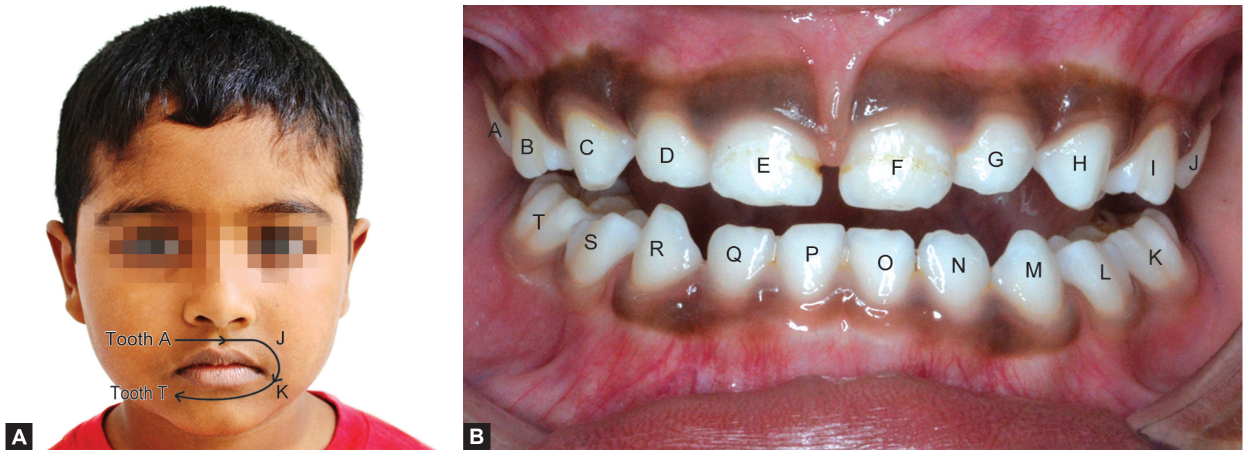
It helps to remember that A, J K, T are 2nd molars (at distal ends quadrants) and E, F, O, P are central incisors.

Advantages of Universal Numbering System

- Concept is very simple
- Each tooth has a unique numerical or an alphabetical code



Figures 2.1A and B Universal notation for permanent teeth. The numbers from 1 to 32 are used in a clockwise manner beginning from upper leftmost tooth



Figures 2.2A and B Universal notation for primary teeth. English alphabets from A to T are used in a clockwise direction

- Left and right teeth of same type have different designations. For example, permanent left maxillary 1st molar is '3' while permanent right maxillary 1st molar is '14'.
- It can be communicated verbally.
- It is compatible with computer keyboard and easy for typing.

Disadvantages

- Difficult to memorize the notation of each tooth. Needs practice.
- Difficult to visualize graphically.

Box 2.1 summarizes the universal tooth notation system.

Box 2.1 Universal tooth notation system

Permanent teeth

Right | Left

1 2 3 4 5 6 7 8 | 9 10 11 12 13 14 15 16

32 31 30 29 28 27 26 25 | 24 23 22 21 20 19 18 17

Primary teeth

Right | Left

A B C D E | F G H I J

T S R Q P | O N M L K

Examples:
Upper right permanent central incisor = # 8
Lower left primary second molar = # K

ZSIGMONDY-PALMER SYSTEM/SYMBOLIC SYSTEM/ QUADRANT SYSTEM/GRID SYSTEM/ANGULAR SYSTEM

The Zsigmondy-Palmer notation system is the oldest method in use and the most popular system for much of the twentieth century. The symbolic notation system was originally termed the Zsigmondy system after the Hungarian (Vienna) dentist *Adolf Zsigmondy*, who developed the idea in 1861, using a *Zsigmondy cross* grid to record quadrants of tooth positions. He then modified the system for denoting primary dentition in 1874. An Ohio dentist Corydon Palmer also invented the system independently in 1870. The system then, came to be known as Zsigmondy-Palmer system. However, it is simply called the Palmer system in most English speaking countries.

The Zsigmondy-Palmer system was recommended as the numbering system of choice by a committee at the *American Dental Association* (ADA) in 1947. However, with the move from written dental notes to electronic/computer records, difficulties were encountered in reproducing the 'symbols' with standard computer keyboard. Thus, in 1968, ADA officially recommended universal notation system, which is still the widely used method in United States.

In Palmer system, the mouth is divided into 4 sections called the *quadrants* (**Fig. 2.3**). The system uses a unique 'L' shaped symbol/grid. (┌, ┐ , └, ┘) to depict in which quadrant the specific tooth is found. The vertical line segment of the 'symbol' indicates the patient's midline and the horizontal line indicates the occlusal plane that separates the upper and lower arches. The counting always begins at the midline and progresses backwards. Numbers 1 through 8 are used to denote the permanent teeth in each quadrant. For primary teeth the upper case English letters 'A' through 'E' are used. The numbers/letters indicate the position of the tooth from the midline.

The symbols used to denote quadrants in Zsigmondy-Palmer system:

- Maxillary right quadrant..................... ┘
- Maxillary left quadrant .... └
- Mandibular right quadrant .... ┐
- Mandibular left quadrant.................... ┌

These four symbols remain same for both permanent and deciduous dentitions.

Table 2.1 gives the quadrant symbols and tooth codes used in Palmer system for both permanent and primary dentitions.

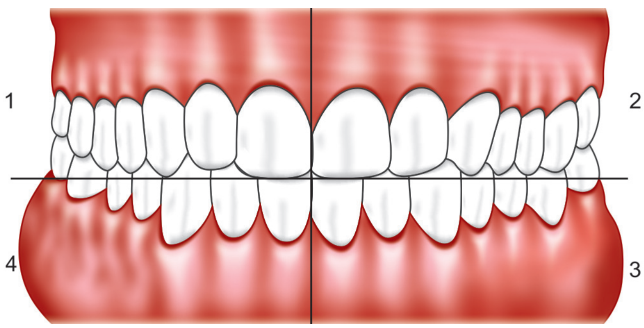


Figure 2.3 Facsimile of a diagram by Palmer 1891 showing the division of the dentition into four quadrants. The patient's quadrants are: 1. Upper right, 2. Upper left, 3. Lower left, 4. Lower right

Table 2.1 Quadrant symbols and tooth codes used in Palmer system for permanent and primary dentitions

Quadrant symbols (same for both dentitions)		*Tooth codes*			
			Permanent teeth		*Primary teeth*
Upper right quadrant	┘	1	Central incisor	A	Central incisor
Upper left quadrant	└	2	Lateral incisor	B	Lateral incisor
Lower right quadrant	┐	3	Canine	C	Canine
Lower left quadrant	┌	4	1st premolar	D	1st molar
		5	2nd premolar	E	2nd molar
		6	1st molar		
		7	2nd molar		
		8	3rd molar		

Zsigmondy-Palmer Notation for Permanent Teeth (Figs 2.4A and B)

- Permanent teeth are numbered 1 to 8 in each quadrant.
- The numbering begins from the midline and moves backwards. Thus, '1' is a central incisor, 3 is a canine, 4 and 5 are premolars and 8 is a 3rd molar.
- The symbol indicates the quadrant in which the specific tooth is found and the number indicates the position of the tooth from the midline.

Zsigmondy-Palmer notation for permanent dentition is as follows:

Upper right	Upper left
8 7 6 5 4 3 2 1	1 2 3 4 5 6 7 8
8 7 6 5 4 3 2 1	1 2 3 4 5 6 7 8
Lower right	Lower left

Individual teeth are represented by writing the specific tooth number inside the symbol of that quadrant.

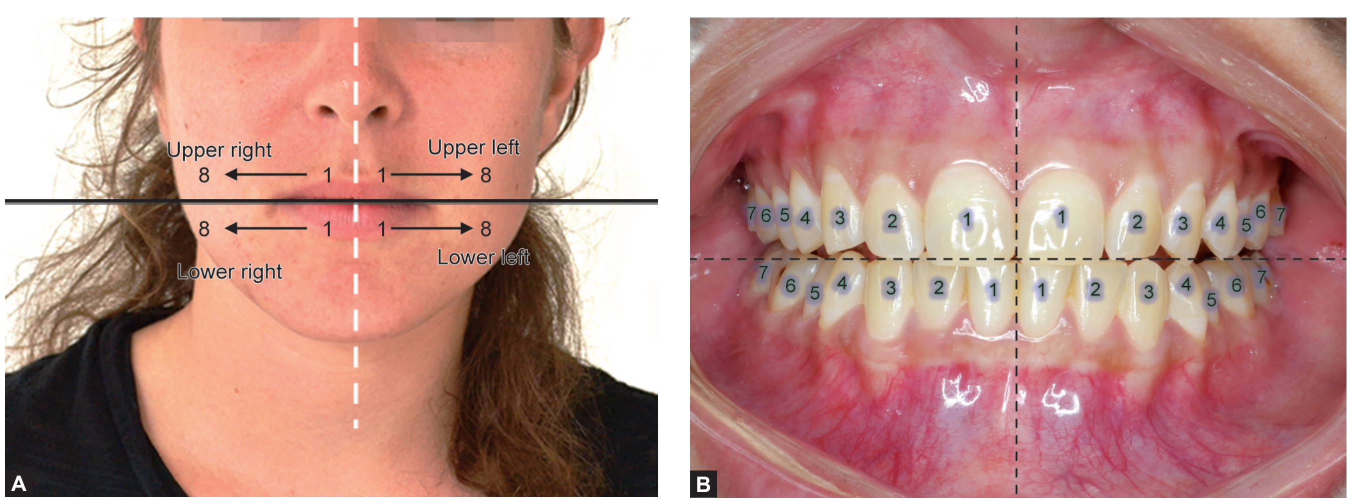
For example, Maxillary right central incisor – 1┘

Mandibular left 1st molar – ┌6

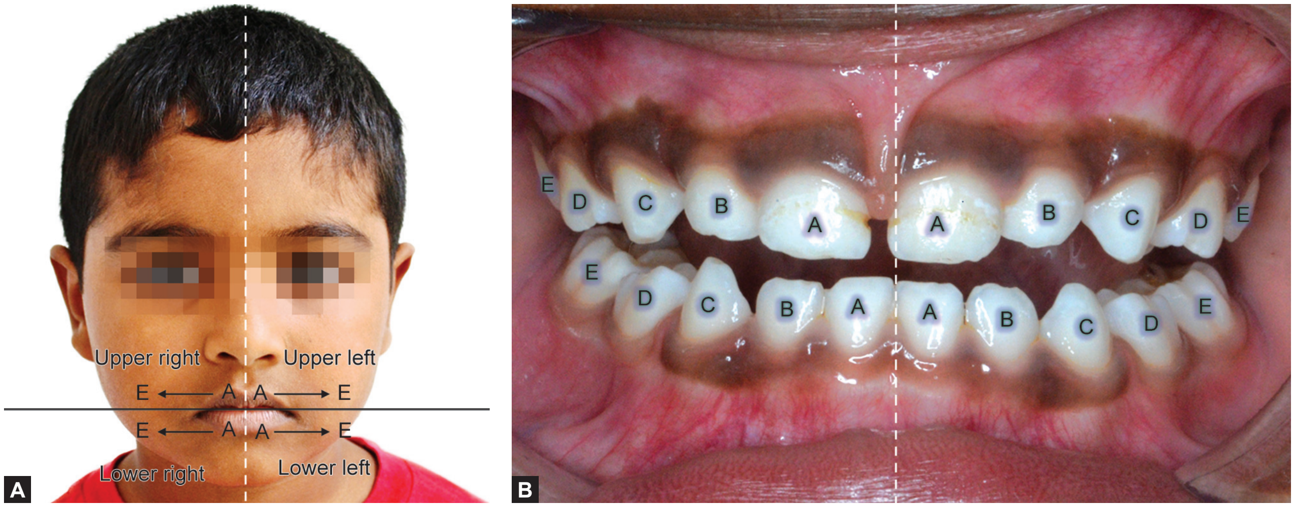
Zsigmondy-Palmer Notation for Primary Teeth (Figs 2.5A and B)

- The quadrant symbols are same as that used for the permanent dentition.
- The upper case English letters A to E are used to represent the primary teeth in each quadrant.
- Numbering begins at midline and progresses backwards so that A is a central incisor, C is a canine, and E is a 2nd molar.

Zsigmondy-Palmer notation for the primary dentition is as follows:



Figures 2.4A and B Zsigmondy-Palmer system for permanent dentition. Mouth is divided into four quadrants. Permanent teeth are numbered 1 to 8 in each quadrant beginning from midline proceeding backwards



Figures 2.5A and B Zsigmondy-Palmer system for primary dentition. Mouth is divided into four quadrants. Primary teeth are given A to E in each quadrant beginning from midline proceeding backwards

E D C B A	A B C D E
E D C B A	A B C D E

Individual teeth are denoted by placing the letter of specific tooth inside the quadrant symbol.

For example, primary maxillary right central incisor –A┘

Primary mandibular left 1st molar – ┌D.

Advantages

- One major advantage of Zsigmondy-Palmer notation is that, it produces a very graphical image, akin to a 'map' of dentition. Thus, any anomalies like tooth transposition, edentulous spaces, can be easily represented using Zsigmondy cross (**Fig. 2.6**).
- It is simple to follow and user friendly.
- Quadrant symbols are same for both the dentitions.

Disadvantages

- The major drawback of symbolic system is that, it is generally incompatible with computers and word processing systems. It is difficult to create the symbol using standard keyboard.
- It is difficult to use this system for verbal communication. For instance, if one has to communicate 'permanent maxillary right central incisor', it is not possible to verbally pronounce the tooth designation 1┘.
- Though the method is simple, there are more chances of error while designating the side of the tooth.

Box 2.2 summarizes the Zsigmondy-Palmer system.

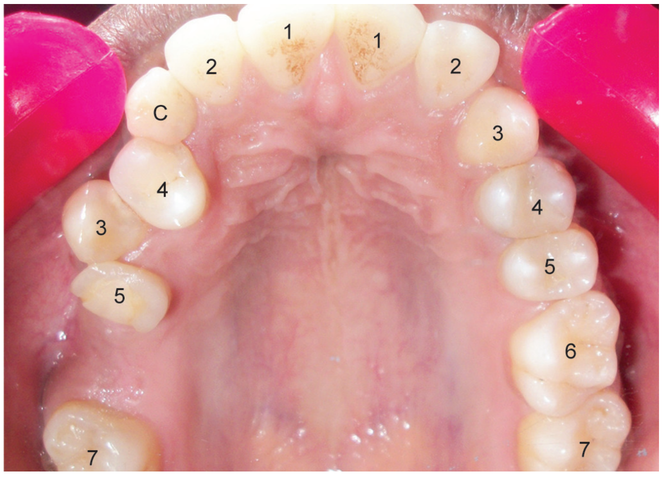


Figure 2.6 A major advantage of Zsigmondy-Palmer system is that it permits graphical representation of any anomalies, missing teeth, etc. For example,

7 5 3 4 C 2 1 | 1 2 3 4 5 6 7

Note: Retained primary canine and buccally erupted permanent canine between premolars

FDI NOTATION SYSTEM/TWO-DIGIT SYSTEM/ISO 3950 NOTATION/INTERNATIONAL NUMBERING SYSTEM

Since the above discussed methods did not comply with the requirements set by Federation Dentaire Internationale (FDI World Dental Federation), the organization introduced its own two-digit system in 1970. This system was developed by a 'Special Committee on Uniform Dental Recording' and passed as a resolution of the FDI General Assembly at its 1970 meeting in Bucharest, Romania. While the FDI labeled, this 'Two-digit system', it became commonly known as the 'FDI system.' According to the FDI committee, five criteria are met by the two-digit system. They are:

1. Simple to understand and teach
2. Easy to pronounce in conversation of dictation
3. Readily communicable in print
4. Easy to translate into computer output
5. Easily adapted to standard charts used in general practice.

The FDI two-digit system is now being used internationally and is the most accepted method.

The two-digit system has been adopted by the World Health Organization (WHO) and accepted by the other organizations such as the International Association for Dental Research (IADR). It is the only method that makes visual, cognitive and computer sense.

The FDI committee combined the Zsigmondy-Palmer's tooth numbering system with the prefix number to denote the quadrant thereby removing the computer non-friendly grid/symbol.

The FDI system uses *two-digit* for each tooth—permanent and primary. The *first-digit* always denotes the quadrant: each quadrant is assigned a number 1 to 4 for the permanent dentition and 5 to 8 for the primary dentition. The quadrant code denotes the dentition, arch and side in which the tooth is present.

The *second digit* denotes the tooth (1 to 8 for permanent teeth and 1 to 5 for deciduous teeth). The teeth are numbered from midline to posterior. The two-digit combination of quadrant code and tooth code gives the notation of a specific tooth.

Table 2.2 gives the quadrant and tooth codes used in FDI system for permanent and primary dentitions.

Box 2.2 Zsigmondy-Palmer tooth notation system

Permanent teeth

Right	Left
8 7 6 5 4 3 2 1	1 2 3 4 5 6 7 8
8 7 6 5 4 3 2 1	1 2 3 4 5 6 7 8

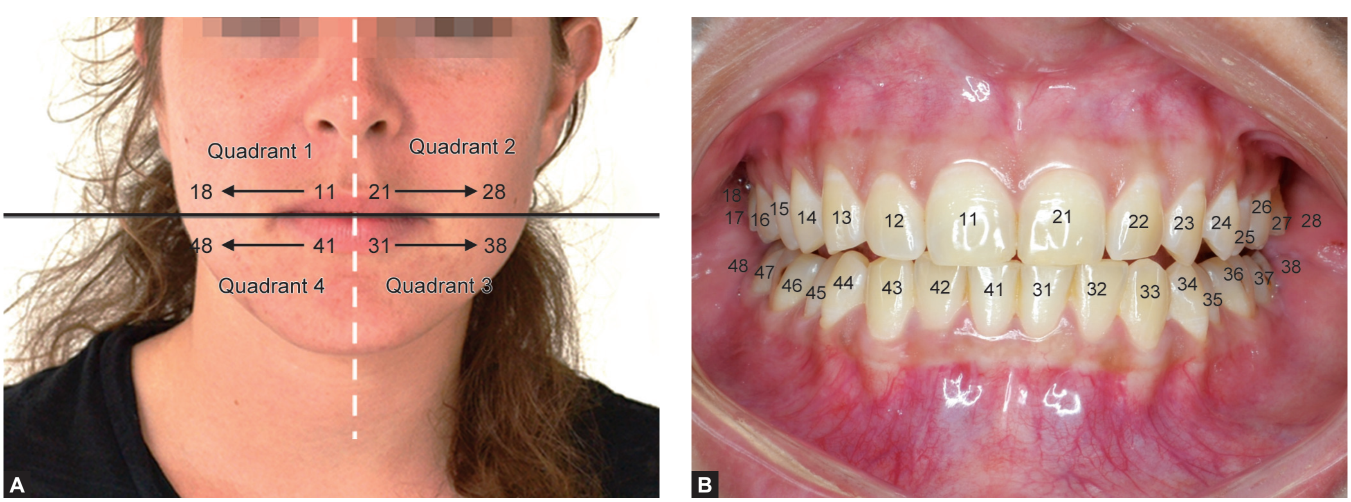
Primary teeth

Right	Left
E D C B A	A B C D E
E D C B A	A B C D E

Examples:
Permanent upper right central incisor = 1|
Primary lower left second molar = |E

FDI Notation for Permanent Dentition (Figs 2.7A and B)

- The mouth is divided into four quadrants.
- The first digit represents the quadrant. The quadrants in permanent dentition are numbered 1 to 4 in a clockwise manner such that, 1 is upper right, 2 is upper left, 3 is lower left, 4 is lower right quadrant.
- The second digit represents the type of the tooth denoted in the quadrant. Each quadrant in permanent dentition has 8 teeth. They are designated with numbers 1 to 8, beginning from the midline such that, 1s are central incisors, 3s are canines, 6s are 1st molars, etc.
- *Note that two digits are always pronounced separately.*



Figures 2.7A and B FDI notation for permanent dentition. The four quadrants are assigned the unique numbers. First digit 1 to 4 represents quadrant; second digit represents specific tooth in quadrant (*Note*: 3rd molars are not visible in the image)

For example, '16' denoting permanent maxillary right 1st molar is spelt as 'one six' and not as 'sixteen' (If spelt as 'sixteen' and notation system is not specified then it would indicate the tooth permanent maxillary left 3rd molar in universal system).

FDI notation for the whole permanent dentition is as follows:

Right	Left
18 17 16 15 14 13 12 11	21 22 23 24 25 26 27 28
48 47 46 45 44 43 42 41	31 32 33 34 35 36 37 38

For example, permanent maxillary right central incisor is '11' (spelt as 'one one').

Permanent mandibular left 1st molar is '36' (spelt as 'three six').

Table 2.2 Quadrant codes and tooth codes used in FDI system for permanent and primary dentitions

Quadrant codes		*Tooth codes*	
Permanent teeth	*Primary teeth*	*Permanent dentition*	*Primary dentition*
1. Upper right	5. Upper right	1. Central incisor	1. Central incisor
2. Upper left	6. Upper left	2. Lateral incisor	2. Lateral incisor
3. Lower left	7. Lower left	3. Canine	3. Canine
4. Lower right	8. Lower right	4. 1st premolar	4. 1st molar
		5. 2nd premolar	5. 2nd molar
		6. 1st molar	
		7. 2nd molar	
		8. 3rd molar	

FDI Notation for Primary Dentition (Figs 2.8A and B)

- The four quadrants of primary dentition are designated as 5 to 8 in a clockwise manner.
- Here, the first digit denoted by number 1 to 5 denotes quadrant. The second digit represents the tooth from midline.

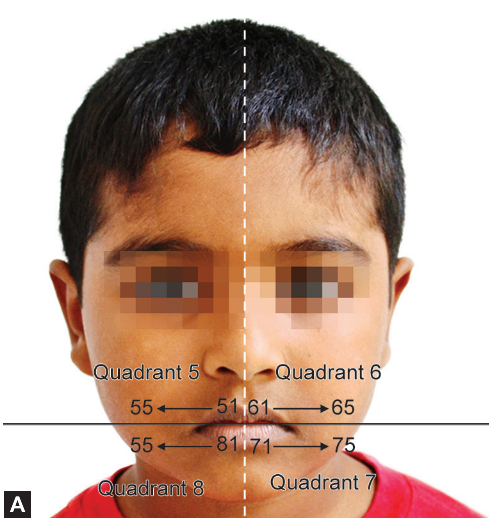
The FDI notation for the entire primary dentition is as follows:

Right	*Left*
55 54 53 52 51	61 62 63 64 65
85 84 83 82 81	71 72 73 74 75

For example, 51 is primary maxillary central incisor; 74 is primary mandibular 1st molar.

Advantages

- Internationally followed system in most parts of the world.
- It is the only method that makes visual, cognitive and computer sense.
- Makes visual sense, can be used for verbal communication.
- Easy to type and print and it is suitable for computer processing and can be incorporated in computer languages.
- It helps to prevent errors when differentiating between right and left sides of mouth or between upper and lower dental arches.



Figures 2.8A and B FDI notation for primary dentition. The four quadrants are assigned the unique numbers. First digit 5 to 8 represents quadrant; Second digit 1 to 5 represents specific tooth in quadrant

Table 2.3 Various tooth identification systems

		Universal			Zsigmondy/Palmer notation		International (FDI)	
		Tooth	Right	Left	Right	Left	Right	Left
Deciduous dentition	Maxillary teeth	Central incisor	E	F	A┘	└A	51	61
		Lateral incisor	D	G	B┘	└B	52	62
		Canine	C	H	C┘	└C	53	63
		1st molar	B	I	D┘	└D	54	64
		2nd molar	A	J	E┘	└E	55	65
	Mandibular teeth	Central incisor	P	O	A┐	┌A	81	71
		Lateral incisor	Q	N	B┐	┌B	82	72
		Canine	R	M	C┐	┌C	83	73
		1st molar	S	L	D┐	┌D	83	74
		2nd molar	T	K	E┐	┌E	85	75
Permanent dentition	Maxillary teeth	Central incisor	8	9	1┘	└1	11	21
		Lateral incisor	7	10	2┘	└2	12	22
		Canine	6	11	3┘	└3	13	23
		1st premolar	5	12	4┘	└4	14	24
		2nd premolar	4	13	5┘	└5	15	25
		1st molar	3	14	6┘	└6	16	26
		2nd molar	2	15	7┘	└7	17	27
		3rd molar	1	16	8┘	└8	18	28
	Mandibular teeth	Central incisor	25	24	1┐	┌1	41	31
		Lateral incisor	26	23	2┐	┌2	42	32
		Canine	27	22	3┐	┌3	43	33
		1st premolar	28	21	4┐	┌4	44	34
		2nd premolar	29	20	5┐	┌5	45	35
		1st molar	30	19	6┐	┌6	46	36
		2nd molar	31	18	7┐	┌7	47	37
		3rd molar	32	17	8┐	┌8	48	38

Box 2.3 FDI tooth notation system

Permanent teeth

Right	Left
18 17 16 15 14 13 12 11	21 22 23 24 25 26 27 28
48 47 46 45 44 43 42 41	31 32 33 34 35 36 37 38

Primary teeth

Right	Left
55 54 53 52 51	61 62 63 64 65
85 84 83 82 81	71 72 73 74 75

Examples:
Permanent upper right central incisor = 11, pronounced "one-one"
Primary lower left second molar = 75, pronounced as "seven-five"

Box 2.3 summarizes FDI tooth notation system.

Table 2.3 campares the tooth designation in all three systems.

BIBLIOGRAPHY

1. American Dental Association, Committee on nomenclature: committee adopts official method for the symbolic designation of teeth. J Am Dent Assoc. 1947;34:647.
2. Federation Dentaire Internationale. Two Digit system of designating teeth. Int Dent J. 1971;34:312.
3. Keiser-Nielsen S. Two-digit system of designating teeth. Br Dent J. 1971;21:104-6.
4. Peck S, Peck L. A time for change of tooth numbering systems. J Dent Educ. 1993;57:643.
5. Zsigmondy A. A practical method for rapidly noting dental observations and operations. Br J Dent Sci. 1874;17:580.

MULTIPLE CHOICE QUESTIONS

1. Who and when was the Universal tooth numbering system reported?
   a. Parridt in 1882
   b. Dane in 1782
   c. Palmar in 1880
   d. Haderup in 1682
2. According to Universal tooth numbering system, the alphabets used to designate teeth in deciduous dentition are:
   a. 1–32
   b. A–T
   c. I–XX
   d. All of the above
3. According to Universal tooth numbering system the tooth 1 denotes:
   a. Maxillary permanent right central incisor
   b. Mandibular permanent right central incisor
   c. Maxillary permanent right third molar
   d. Mandibular permanent right third molar
4. According to Universal tooth numbering system the tooth 27 denotes:
   a. Maxillary permanent left second molar
   b. Mandibular permanent right canine
   c. Maxillary permanent left canine
   d. Mandibular permanent left second molar
5. According to Universal tooth numbering system, F denotes:
   a. Maxillary deciduous left central incisor
   b. Maxillary deciduous second molar
   c. Maxillary deciduous right first molar
   d. Maxillary deciduous right central incisor
6. Who and when Zsigmondy-Palmer notation was reported:
   a. Adolph Zsigmondy in 1861
   b. Zsigmondy in 1850
   c. Palmer in 1870
   d. Both a and b
7. Numerical used for permanent dentition in Zigmondy-Palmer notation are:
   a. 1–8
   b. 9–16
   c. 17–24
   d. 25–32
8. According to Zsigmondy-Palmer notation teeth in deciduous dentition are represented by:
   a. 1–8
   b. A-E
   c. Both of the above
   d. None of the above
9. Which of the following is a major disadvantages of Zsigmondy/Palmer notation system:
   a. Difficult in verbal communication
   b. Tedious to write using computers
   c. More chances of errors
   d. Not commonly used system
10. In FDI system, first and second digit denotes:
   a. Quadrant and tooth
   b. Tooth and quadrant
   c. Both of the above
   d. None of the above

Answers

1. a	2. b	3. c	4. b	5. a	6. d	7. a	8. b	9. b	10. a

SECTION

2

Chronology of Tooth Development and Form and Function

CHAPTER

3 Chronology of Tooth Development

Humans have two sets of teeth namely, the primary/deciduous dentition and the secondary/permanent dentition which contain 20 and 32 teeth respectively. In both the dentitions, not all the teeth are formed and appear in oral cavity at the same time. Some teeth are completed before others are formed, resulting in different times of eruption for different groups of teeth. Groups of teeth develop at specific rates so that the sequence of their appearance into oral cavity is well defined although with few variations.

A thorough knowledge of development of teeth, timing and pattern of their eruption is essential for all clinical fields of dentistry. For example, an understanding of development of teeth, jaws and skull as a whole is essential for orthodontic treatment of malocclusions. It is imperative to know developmental chronology of secondary teeth so as to avoid injury to the developing tooth germs especially during the early surgical treatment of cleft palate.

It is also important to understand the effects of certain diseases and environmental factors on the development of teeth. For example, *Amelogenesis imperfecta* (**Fig. 3.1A**) and *dentinogenesis imperfecta* (**Fig. 3.1B**) are genetic conditions that cause structural defects in teeth; while calcium deficiency (**Fig. 3.1C**) causing enamel hypoplasia and syphilis in expectant mothers causing congenital defects in the child's teeth are examples of environment factors that affect development of teeth.

Ingestion of drinking water that contains excessive fluoride content during the formative years of teeth may lead to defective enamel formation. The affected teeth show yellow/brownish spots on teeth or pitted enamel, and the condition is known as *fluorosis* (**Figs 3.2A to E**).

TOOTH DEVELOPMENT: AN OVERVIEW

A brief discussion of development of tooth is given here.

The primitive oral cavity or stomatodeum is lined by the stratified squamous epithelium called the *oral ectoderm*. The underlying connective tissue is called the *ectomesenchyme*, as these cells are formed by migration of neural crest cells derived from ectoderm of head region. The primitive oral cavity establishes connection with the foregut at 4th week of gestation when *buccopharyngeal membrane*, which is limiting the stomatodium ruptures (**Fig. 3.3**).

The first indication of tooth formation is seen at about 6th week of gestation when oral ectoderm proliferates into the underlying ectomesenchyme to form horseshoe-shaped *primary epithelial band* in the (presumptive) upper and lower jaws. The primary epithelial band in each jaw soon gives rise to two subdivisions: the *dental lamina* that forms teeth and the *vestibular lamina* that proliferates and then degenerates to form the vestibule between the cheek and the tooth bearing area (**Fig. 3.4**).

Development of tooth occurs by a series of epithelial-mesenchymal interactions along the dental lamina. The ectoderm in certain areas of dental lamina proliferates into the underlining ectomesenchyme to form an *enamel organ*. Each enamel organ surrounds a local proliferation of ectomesenchyme called the *dental papilla*. Condensed ectomesenchyme that limits the dental papilla and surrounds the enamel organ is called *dental follicle/dental sac*. The enamel organ forms enamel, the dental papilla forms dentin and pulp and the dental sac forms the supporting tissues—periodontal ligament and alveolar bone.

The enamel organ, dental papilla and dental sac together constitute a *tooth bud or tooth germ*. Ten such tooth germs arise in each dental arch to form the primary dentition (**Fig. 3.5A**).

Tooth germs that give rise to permanent successors (i.e. the permanent incisors, canines and premolars) develop on the lingual aspect of their deciduous predecessors in the same bony crypt (**Fig. 3.5B**), by lingual proliferation of dental lamina called the *successional lamina*. The permanent molar tooth germs, which have no deciduous predecessors, develop from the distal extension of the dental lamina when the jaws grow long enough (**Figs 3.5A and B**).

The tooth germs undergo a series of morphological stages to eventually form the respective teeth.

Figures 3.1A to C (A) Amelogenesis imperfecta; (B) Dentinogenesis imperfecta; (C) Enamel hypoplasia caused due to calcium deficiency

Figures 3.2A to E Enamel mottling caused due to dental fluorosis

STAGES OF TOOTH DEVELOPMENT

Bud Stage (Fig. 3.6A)

The enamel organ at first resembles a small bud, which is surrounded by the condensation of ectomesenchymal cells. During bud stage, the enamel organ consists of peripherally located low columnar cells and centrally located polygonal cells.

Cap Stage (Fig. 3.6B)

The enamel organ then proliferates to form a cap over the central condensation of ectomesenchymal cells—the dental papilla. The dental papilla and the dental sac become well-defined. The enamel organ differentiates to form three layers namely:

1. Inner dental/inner enamel epithelium
2. Stellate reticulum
3. Outer dental/outer enamel epithelium.

Early Bell Stage (Fig. 3.6C)

The enamel organ aquires a bell shape resulting in deepening of the undersurface of the epithelial cap. Another cell layer

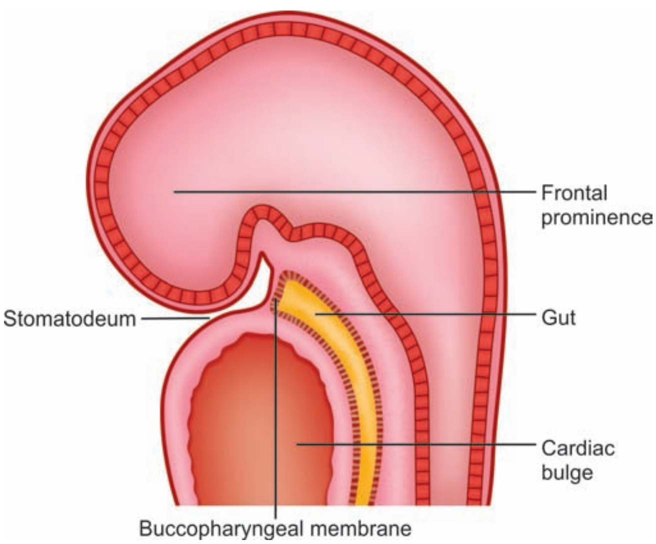


Figure 3.3 Buccopharyngeal membrane ruptures at 4th week of gestation establishing connection between the primitive oral cavity and the foregut

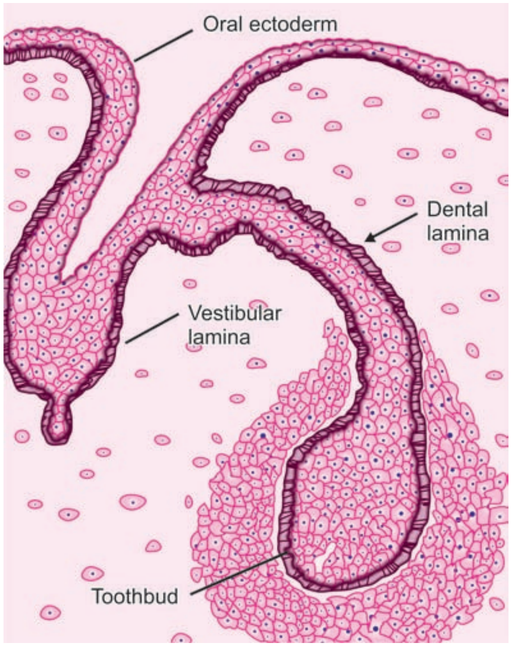
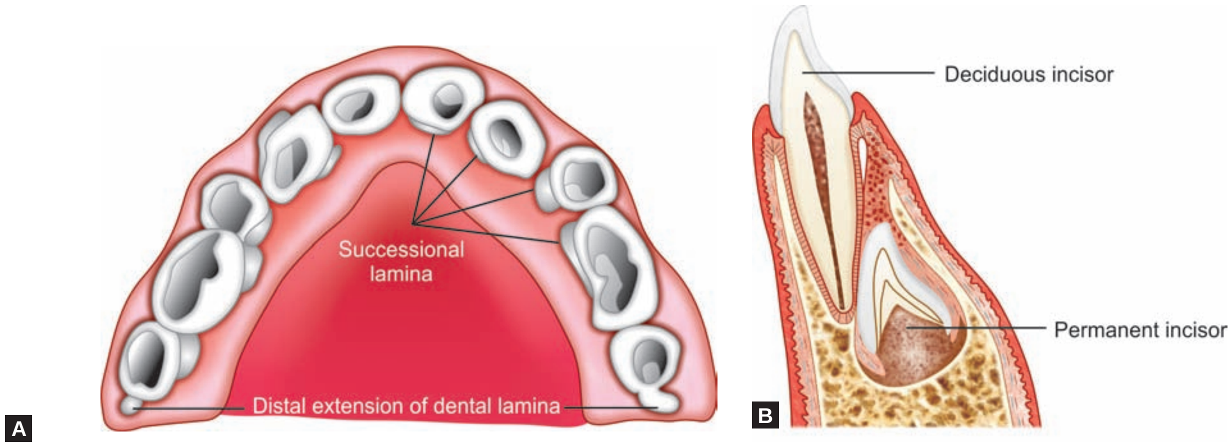


Figure 3.4 Primary epithelial band gives rise to 'dental lamina' that forms teeth and 'vestibular lamina' that forms the vestibular area



Figures 3.5A and B (A) Dental lamina gives rise to 10 teeth in each dental arch to form the primary dentition; (B) Permanent successors develop from successional lamina on lingual aspect of their predecessor teeth

forms in between the inner dental epithelium and stellate reticulum, called the *stratum intermedium*. Thus, the enamel organ at bell stage exhibits four different types of epithelial cells.

The inner dental epithelium differentiates into tall columnar cells called the *ameloblasts*, which are enamel forming cells. The peripheral cells of the dental papilla differentiate into *odontoblasts* under the organizing influence of inner dental epithelium, which form dentin.

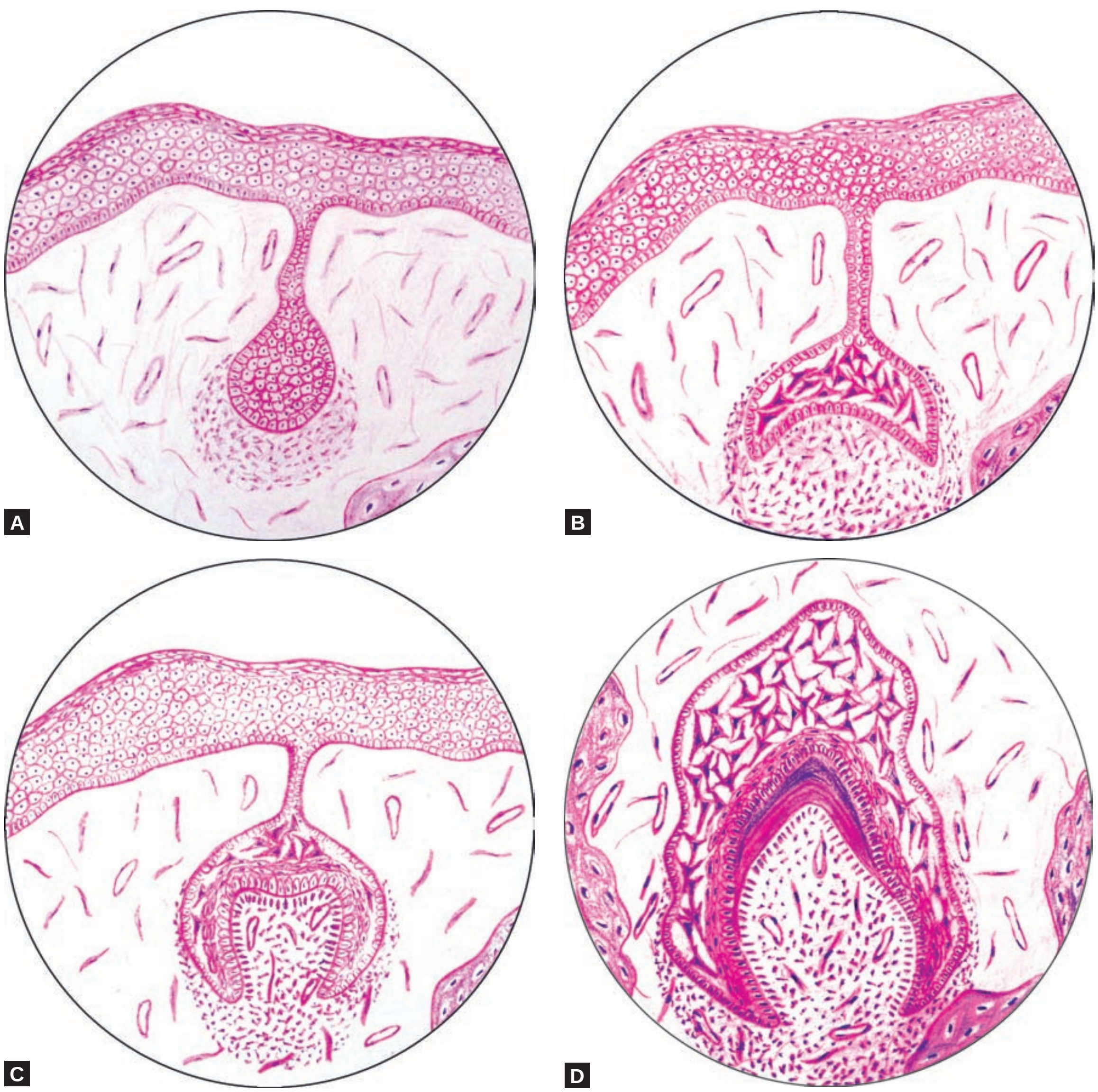
Advance Bell Stage (Fig. 3.6D)

Apposition of dental hard tissues occurs at advanced bell stage. First, a layer of predentin is secreted by the odontoblasts. The ameloblasts begin to form enamel following the reciprocal induction. The deposition of enamel and dentin continues until the crown formation is complete.

Overlapped on these morphological stages of tooth development are a series of physiological processes that occur in a sequential manner.

These physiological processes are:
- *Initiation*: Dental lamina and bud stage
- *Proliferation*: Bud and cap stage
- *Histodifferentiation*: Early bell stage
- *Morphodifferentiation*: Advanced bell stage.

Mineralization begins around 14th week of gestation in primary dentition and occurs first in central incisors. The



Figures 3.6A to D Morphologic stages and tooth development: (A) Bud stage; (B) Cap stage; (C) Early bell stage; (D) Advance bell stage

permanent tooth germ begins to form around 4th to 5th month of intrauterine life and their mineralization commences at birth, beginning in 1st molars.

ROOT FORMATION

Root formation begins once the dentin and enamel reach future *cementoenamel junction*. The cervical portion of enamel organ gives rise to *Hertwig's epithelial root sheath*, which molds the shape of the roots and initiates radicular dentin formation. Hertwig's epithelial root sheath is a double cell-layered structure formed by proliferation of inner and outer enamel epithelium from cervical loop of enamel organ (**Fig. 3.7A**).

The root sheath extends apically between the dental pulp and the dental follicle. The root sheath encloses all of the dental pulp except at apical portion where, the rim of root sheath, the *epithelial diaphragm* surrounds the *primary apical foramen* (**Fig. 3.7B**). The root apex remains wide open until about 2 to 3 years after the eruption of the tooth, when the root development is completed.

In multirooted teeth, two or three tongues of epithelium grow inwards towards each other and fuse near the center of the root (**Fig. 3.7C**). The primary apical foramen is thus subdivided into two or three *secondary apical foramina*. The root sheath then extends around each apical foramen and proliferates apically as in single rooted teeth.

ERUPTION OF TEETH

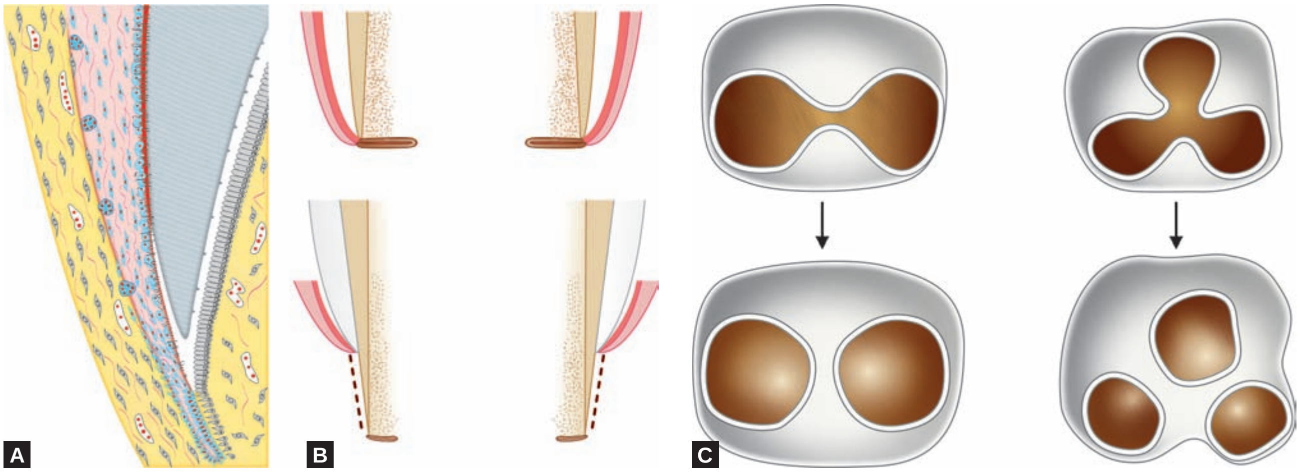
Tooth eruption is considered to be a developmental process where by the tooth moves in an axial direction from its anatomical position within the alveolar crypt of the jaw into its functional position within the oral cavity. The term '*eruption*' has thus come to mean a continuous process of tooth movement from within its socket until it reaches the final functional position. The actual *emergence* of the tooth into oral cavity, when it breaks through the gum, is only one phase of eruption.

Tooth eruption is a continuous process while its emergence through the mucous membrane is a single event. In the chronology charts and in discussions about dental age the term 'eruption' is used interchangeably with the term 'emergence'. The eruptive movement continues after the incidence of emergence, and eventually the tooth comes into occlusion with the teeth in opposite arch. Even then it continues to erupt to compensate for wear (attrition) on its incisal or occlusal surfaces.

Tooth eruption is the result of a number of factors and many theories have been proposed to explain the mechanism of tooth eruption including *bone remodeling, root formation, vascular pressure and periodontal ligament traction theories*. *Periodontal ligament traction theory* is the most accepted one and a lot of evidence suggests that the eruptive movement is brought about by the *dental follicle-periodontal ligament complex*. The contractile force exerted by periodontal ligament fibroblasts is transmitted to the properly oriented collagen fiber bundles. Summation of these contractile forces cause tooth movement. Bone remodeling necessary for forming the eruptive pathway is facilitated by the cells of dental follicle.

Eruption of tooth begins soon after completion of the crown. When the tooth reaches the functional occlusal plane the root development is not yet complete. Root formation is usually completed 1 to 3 years after the eruption of the tooth.

When the tooth crown first emerges into oral cavity through oral mucosa, the epithelium covering of crown, i.e. *the reduced enamel epithelium* rapidly disintegrates and becomes incorporated into the gingival epithelium to form the *junctional/attachment epithelium*. With continued eruption, as more of the crown is exposed, a *gingival crevis* is formed



Figures 3.7A to C Hertwig's epithelial root sheath. Root formation in single and multirooted teeth

around the neck of the tooth. The junctional epithelium provides a means of attachment between the enamel (hard surface) and the sulcular epithelium which lines the gingival sulcus (**Fig. 3.8**).

DENTITION STAGES IN HUMANS

Humans have three stages of dentition—primary, mixed/transitional and permanent.

Figures 3.9A and B graphically depict the development of primary and permanent human dentitions.

PRIMARY DENTITION STAGE (6 MONTHS TO 6 YEARS)

Primary dentition stage begins at around 6 months of age when the first primary teeth, generally the mandibular central incisors erupt into oral cavity (**Fig. 3.10**). Primary dentition stage lasts until the eruption of first permanent tooth around 6 years of age.

Development of Primary Dentition

Table 3.1 gives the chronology of primary teeth. The important developmental events that are recorded in the chronology chart are:

- First evidence of calcification
- Crown completion
- Emergence (eruption) through mucosa into oral cavity
- Root completion.

It must be remembered that the times given in chronology table reflect approximate values since no two individuals will chronologically develop in precisely the same manner. Thus, considerable variation exists. Nonetheless, these tables are of immense value in diagnosing any abnormal development.

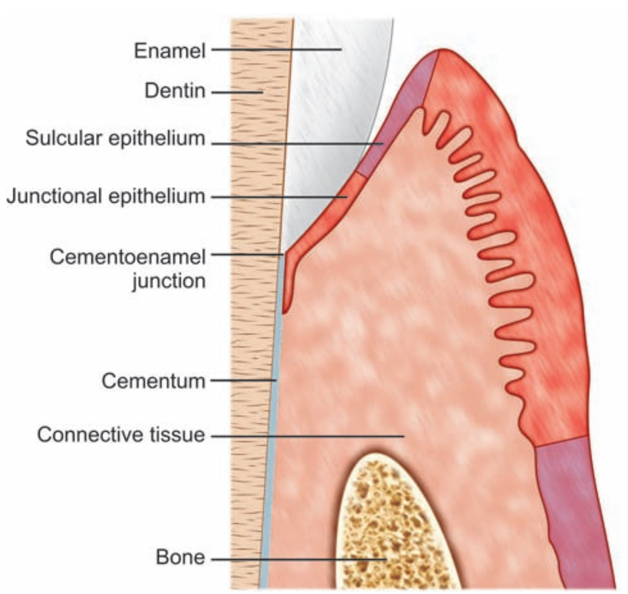


Figure 3.8 Junctional epithelium provides attachment between tooth enamel and gingival epithelium

The following points may be noted from the chronology of primary dentition:

- Development of primary teeth occurs both prenatally and postnatally; whereas the development of permanent teeth is entirely postnatal
- Crowns of primary teeth begin to calcify between 4 to 6 months of intrauterine life
- Primary teeth take an average of 10 months for crown completion
- Primary teeth emerge into oral cavity some 6 to 8 months after the completion of their crown
- On an average, root completion occurs 1 to 2 years after the emergence of the crown
- Formation of primary teeth from initial calcification to root completion occurs in only 2 to 3 years (However, mineralization of permanent dentition takes about some 8 to 12 years, and is entirely postnatal).

Emergence of Primary Teeth

Usually there are no teeth present in the mouth at birth. However, occationally infants may be born with erupted mandibular incisors, which are called the *natal teeth*. **Figure 3.11 and Table 3.1** give average eruption time of the primary teeth. Considerable variation does exist among different races and ethnic groups and from one individual to the other.

- Emergence of primary dentition into oral cavity occurs between 6th and 30th month of age (postnatal)
- The mandibular central incisors are usually the first primary teeth to appear in mouth about 6 months of age
- It is followed by other incisors, so that by about 9 to 12 months, all the primary incisors have exposed
- Then the first primary molars emerge by about 12 to 16 months and establish contact with antagonistic teeth several months later, before the canines are fully erupted
- The primary canines emerge around at 16 to 20 months of age
- The last teeth to emerge are the maxillary 2nd molars at the age of 20 to 30 months.

Sequence of Emergence of Primary Teeth

Although some variation can occur, the predominant sequence of eruption of the primary teeth in each jaw is as follows:

- Central incisor (A)
- Lateral incisor (B)
- 1st molar (D)
- Canine (C)
- 2nd molars (E).

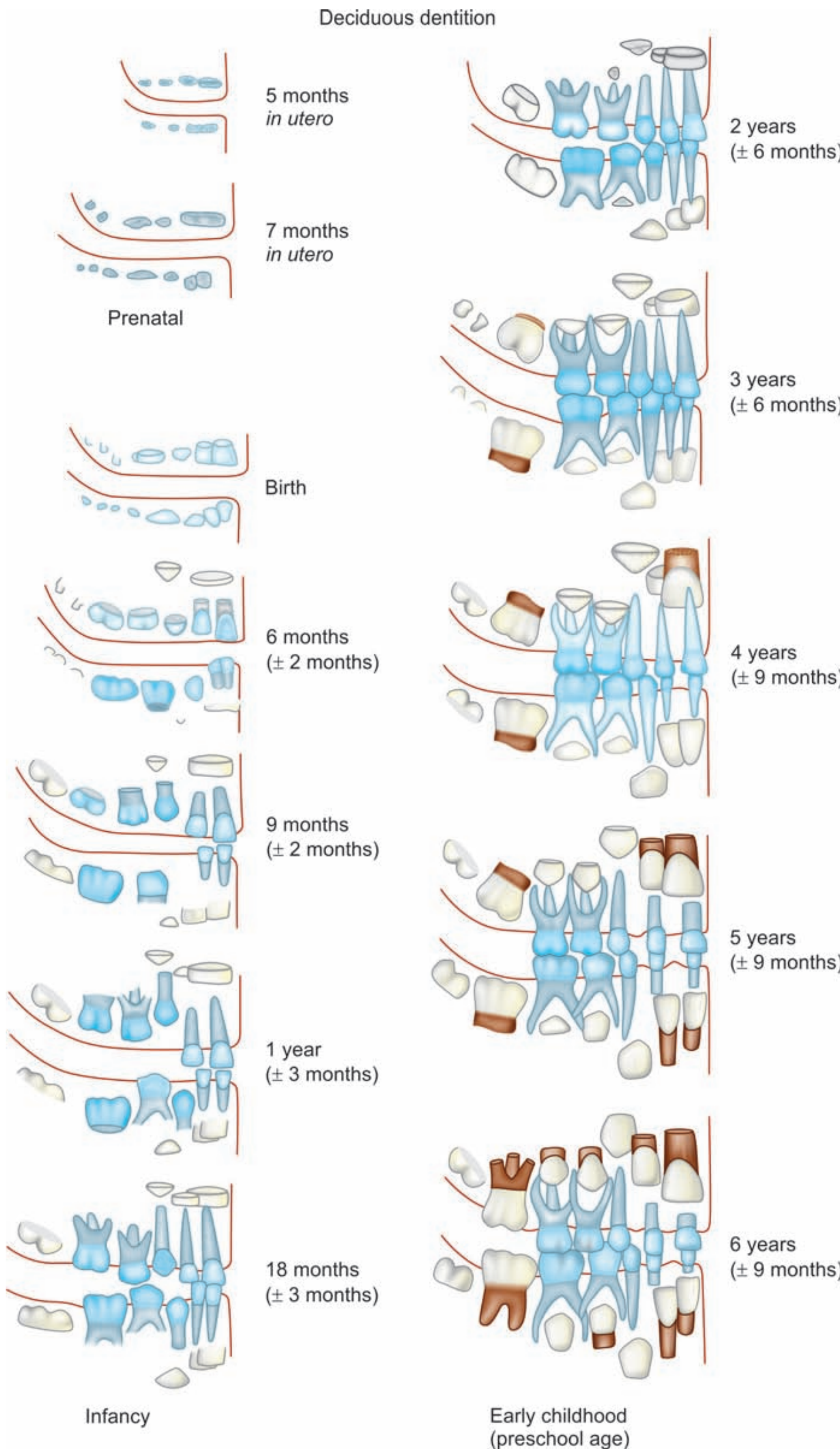


Figure 3.9A Development of human dentitions—primary dentition stage (From Schour L, Massler M. The development of the human dentition. J Am Dent Assoc. 1941;28:1153)

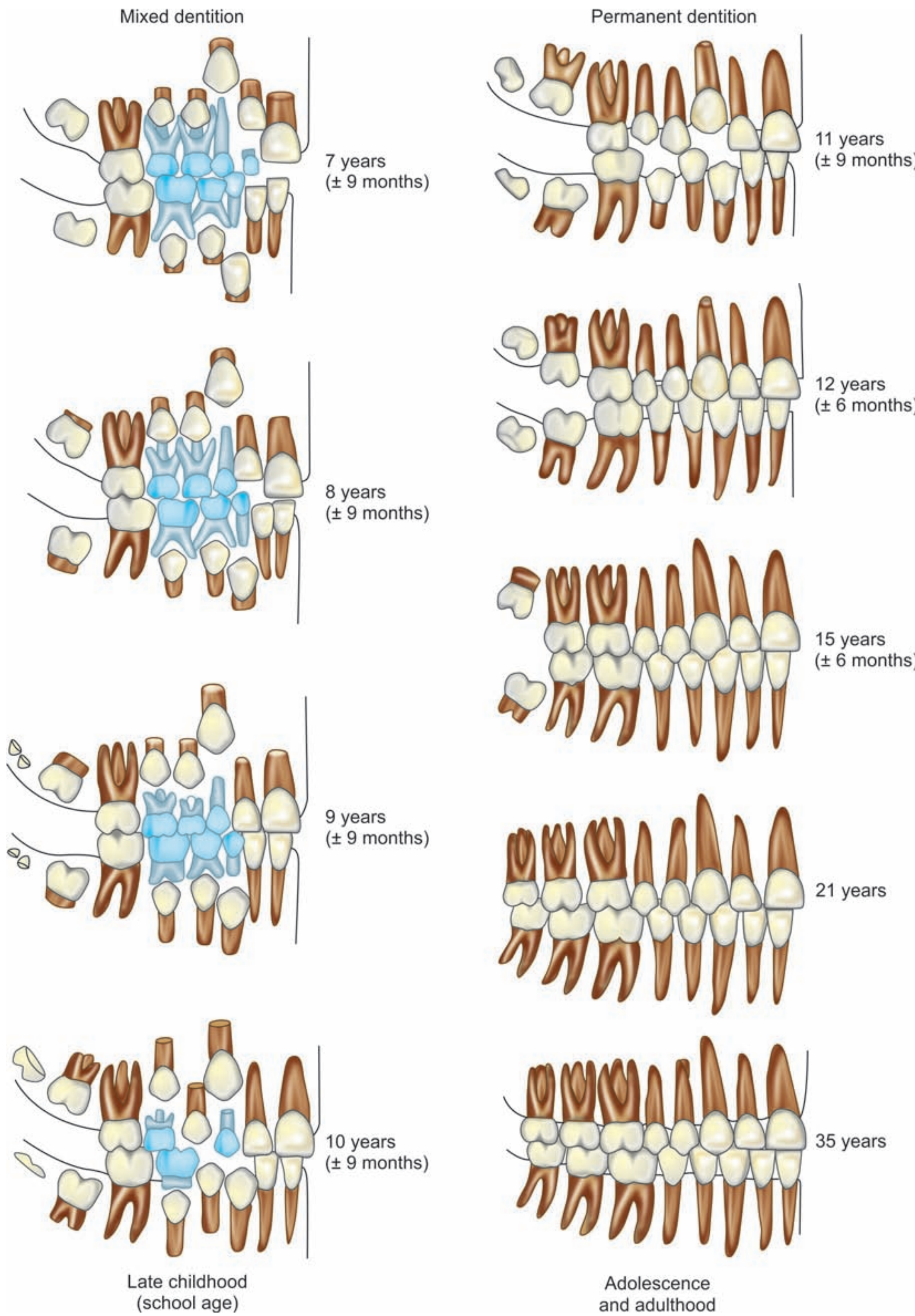


Figure 3.9B Mixed and permanent dentition stages (From Schour L, Massler M. The development of the human dentition. J Am Dent Assoc. 1941;28:1153)

The lateral incisors, 1st molars and canines tend to erupt earlier in the maxilla than the mandible. The eruption sequence of primary dentition can be represented as follows:

$$\frac{AB \quad D \quad C \quad E}{A \quad B \quad D \quad CE}$$

Figure 3.10 Primary dentition stage generally begins at 6 months with emergence of mandibular central incisors

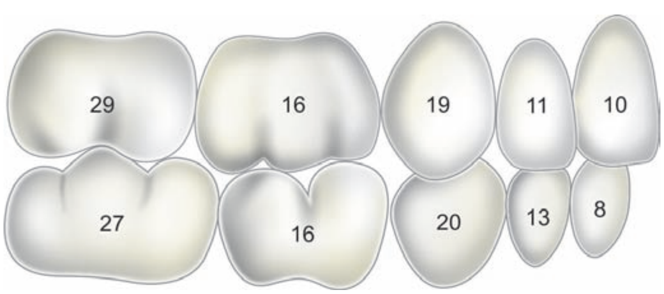


Figure 3.11 Average eruption time of primary teeth in months

Primary Dentition Period

The primary dentition is considered to be completely established by about 30 months of age or when the primary molars are in occlusion (**Fig. 3.12A**). All the teeth are in use from about 2 to 2½ years until the age of 6 to 7 years, a total of up to 5 years. The primary molars and maxillary canines stay in the oral cavity up to 11 to 12 years. Premature loss or prolonged retention of primary teeth, especially that of the molars and canines often leads to development of malocclusion in the permanent dentition stage (**Fig. 3.12B**).

Once the primary dentition is established, no significant changes occur intraorally during the primary dentition period. The form of the dental arches remains relatively constant without significant changes in depth or width. Primary occlusion is discussed in Chapter 21.

Although the primary teeth seem to serve for a relatively short period of time in one's life, they nevertheless are as important as the permanent teeth. Major physiological, psychological, cognitive and neuromuscular development, acquisition of masticatory skills including complex mandibular and tongue movements occur during the primary dentition stage. Thus, it is equally important to care for primary teeth that play an important role in the maintenance of child's welfare during his/her first years of growth and development both physically and mentally.

Shedding of Primary Teeth

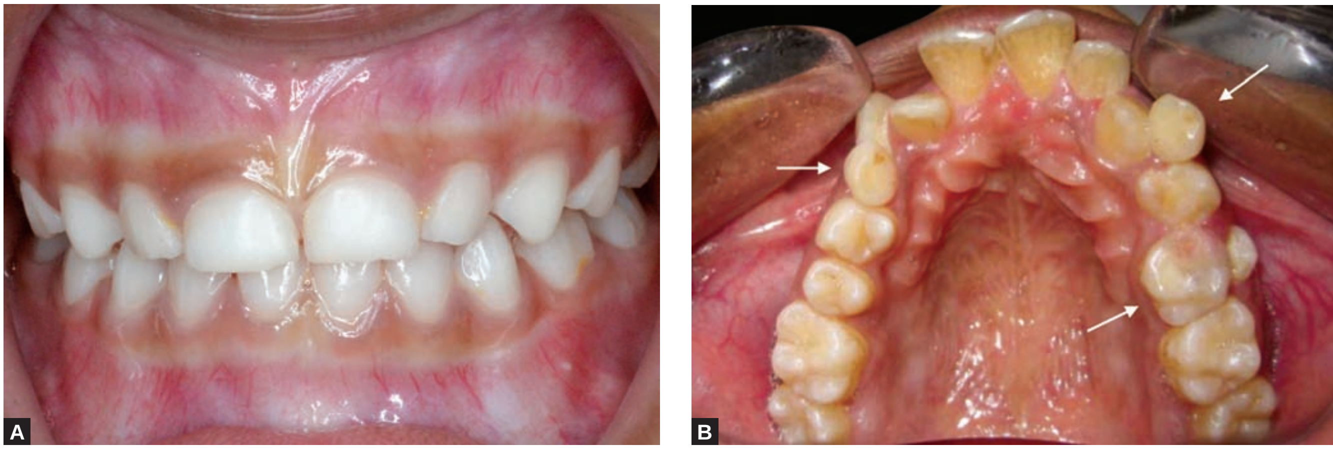
Primary teeth are shed naturally when their permanent successor teeth are ready to erupt. Not all the primary teeth are lost at the same time; central incisors are lost early at 6 to 7 years while the canines and 2nd molars are lost at around 12 years of age.

Exfoliation of primary teeth occurs due to physiologic resorption of their roots (**Fig. 3.13A**). Only 3 years after the

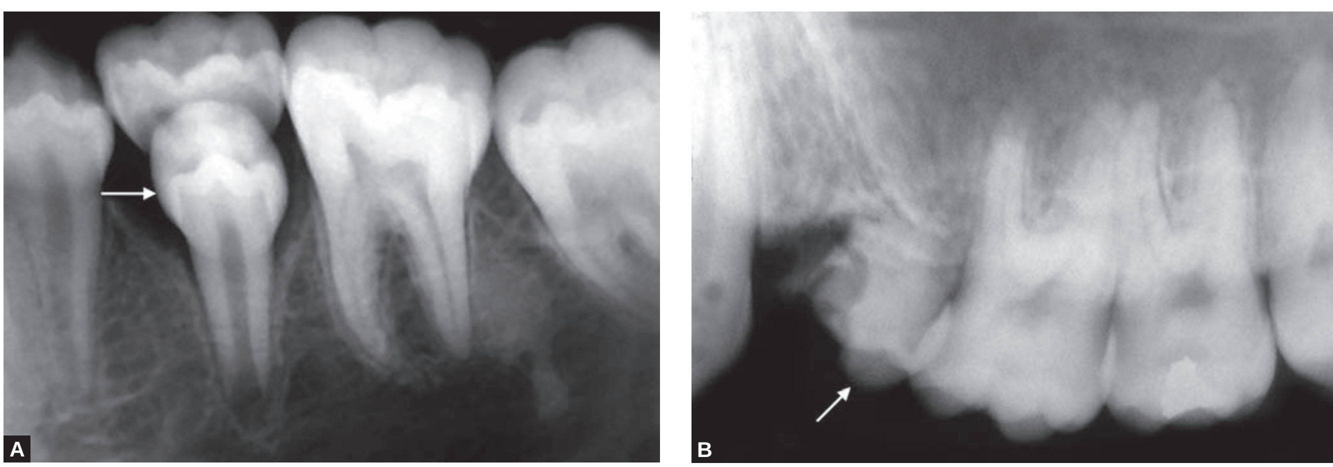
Table 3.1 Chronology of primary dentition*

Tooth	*First evidence of calification weeks in utero*	*Amount of enamel formed at birth*	*Crown completed*	*Eruption*	*Root completed*
Maxillary teeth					
Central incisor	14	Five-sixths	1½ months	7½ months	1½ years
Lateral incisor	16	Two-thirds	2½ months	9 months	2 years
Cuspid	17	One-third	9 months	18 months	3¼ years
1st molar	15½	Cusps united	6 months	14 months	2½ years
2nd molar	19	Cusp tips still isolated	11 months	24 months	3 years
Mandibular teeth					
Central incisor	14	Three-fifths	2½ months	6 months	1½ years
Lateral incisor	16	Three-fifths	3 months	7 months	1½ years
Cuspid	17	One-third	9 months	16 months	3¼ years
1st molar	15½	Cusps united	5½ months	12 months	2¼ years
2nd molar	18	Cusp tips still isolated	10 months	20 months	3 years

* Chronology of teeth. Schour and Massler (1940); Logan and Kronfeld sightly modified by McCall and Schour (1933).



Figures 3.12A and B (A) Primary dentition is completely established when primary molars are in occlusion, generally by 30 months of age; (B) Retained primary canines and 2nd molars leading to malocclusion development



Figures 3.13A and B (A) Primary 2nd molars root completely resorbed. It is at the verge of exfoliation; (B) Shedding of primary 2nd molar delayed due to congenital absence of permanent 2nd premolar

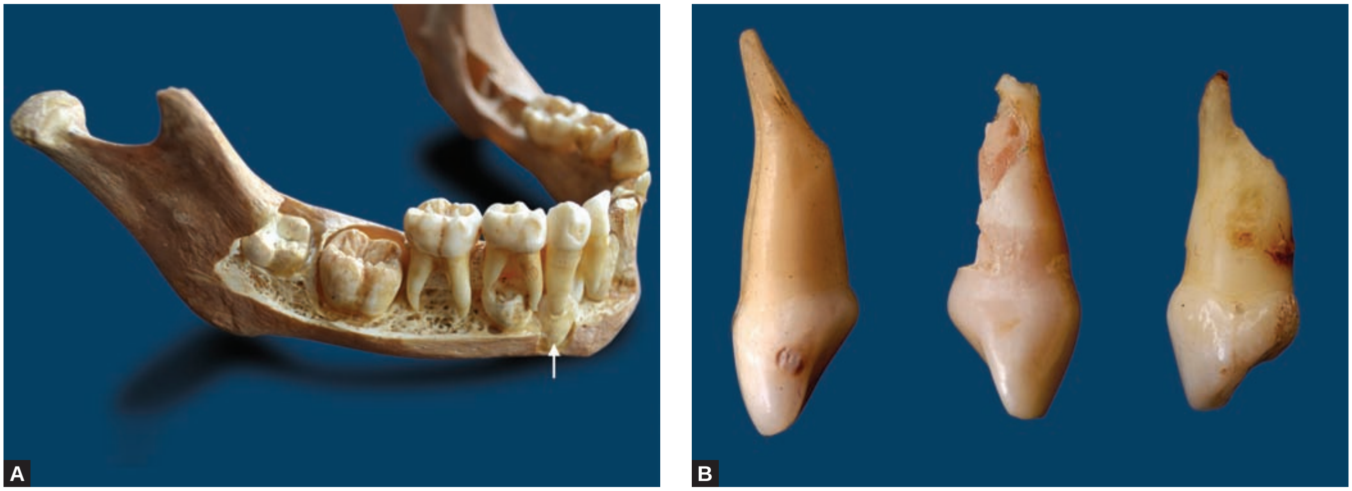
roots are complete they begin to resorb as the permanent successor teeth begin their occlusal migration. Pressure from erupting successional teeth plays a key role in shedding of the deciduous dentition. When a successional tooth germ is missing congenitally, shedding of its deciduous predecessor tooth is delayed (**Fig. 3.13B**). However, the tooth is shed eventually.

Pattern of resorption is influenced by the position of the permanent tooth germ. For example, permanent anteriors develop lingually to the deciduous teeth and erupt in an occlusal and vestibular direction (**Fig. 3.14A**). Thus, the resorption occurs on the lingual surface of roots in case of deciduous anteriors and these teeth are shed with much of their pulp chamber intact (**Fig. 3.14B**).

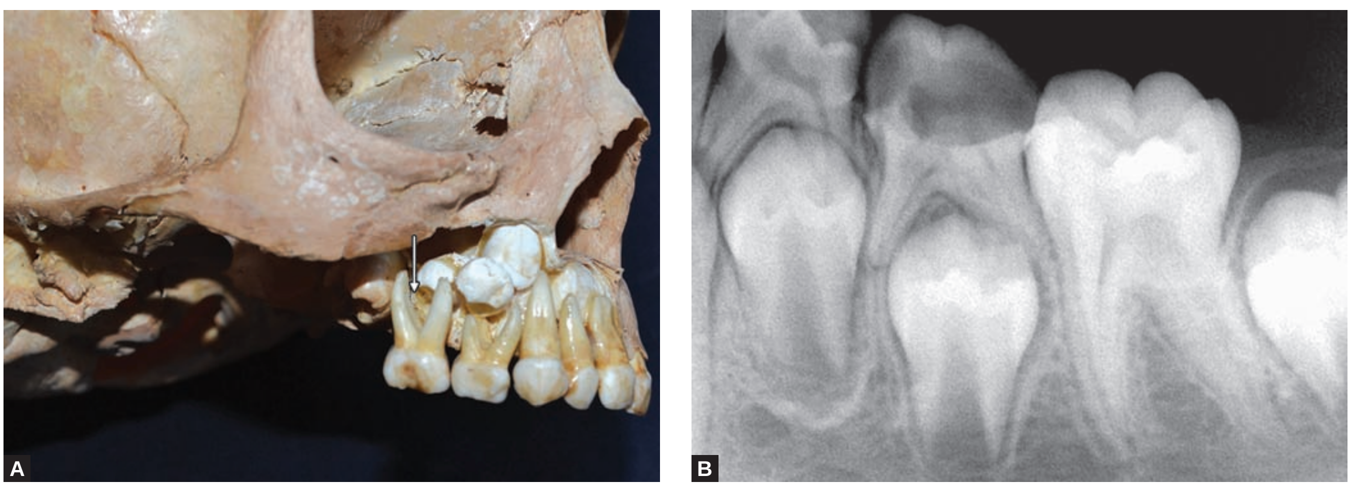
Permanent premolars on the other hand, develop between the divergent roots of the primary molars and erupt in an occlusal direction (**Fig. 3.15A**). Hence, resorption begins at inter-radicular area. Some resorption of pulp chamber, coronal dentin, and sometimes even enamel may occur (**Fig. 3.15B**).

Pattern of Shedding

The pattern of shedding is symmetrical for the right and left sides of the mouth. There should not be a discrepancy of more than 3 months between exfoliation of left and right deciduous teeth. Generally, the mandibular primary teeth are shed before their maxillary counterparts, except for the 2nd molars. All four primary 2nd molars are shed simultaneously.



Figures 3.14A and B (A) Permanent anteriors develop lingual to their deciduous tridecessors; (B) Pattern of root resorption on primary anteriors on lingual surface of root



Figures 3.15A and B (A) Premolars develop between the roots of primary molar; (B) Root resorption in primary molars begins at inter-radicular area

Shedding pattern of primary teeth reflects the eruption pattern of secondary (permanent) teeth.

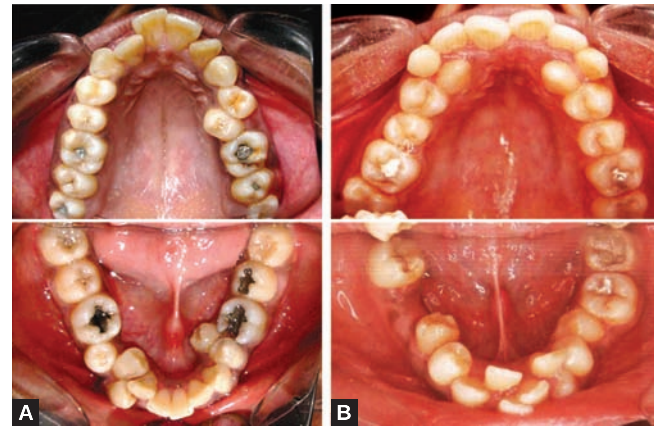
Primary teeth shedding time table should be closely monitored to prevent abnormal developments. If a deciduous tooth has not exfoliated when its permanent successor erupts into oral cavity, the primary tooth should be promptly extracted. This usually occurs with incisor teeth (**Fig. 3.16**).

When primary teeth, especially the canines and molars are lost prematurely due to caries, trauma, etc. the space should be maintained by way of space maintainers so that there is enough space in the arch when their permanent successor teeth are ready to erupt (**Fig. 3.17**). Premature loss of primary teeth and/or unrestored proximal caries resulting in loss of arch length (**Fig. 3.18A**), prolonged retention of primary teeth are important causes of malocclusion development in the permanent dentition (**Fig. 3.18B**).

MIXED DENTITION STAGE (6–12 YEARS)

It is a transition stage when primary teeth are exfoliated in a sequential manner, followed by the eruption of their permanent successors. In the *first transitional period*, eruption of permanent 1st molars and replacement of primary incisors by the permanent incisors occur. The *second transitional period* involves replacement of the primary molars and canines by the permanent premolars and canines respectively, and emergence of second permanent molars. **Figure 3.9B** shows mixed dentition period.

Figure 3.16 Primary mandibular central incisor not yet shed when permanent successors are erupting-leading to their lingual eruption. Primary tooth should be extracted to facilitate proper alignment of the erupting successor tooth



Figures 3.18A and B Development of malocclusion due to: (A) Premature loss of primary teeth and failure to maintain space; (B) Prolonged retention of primary teeth

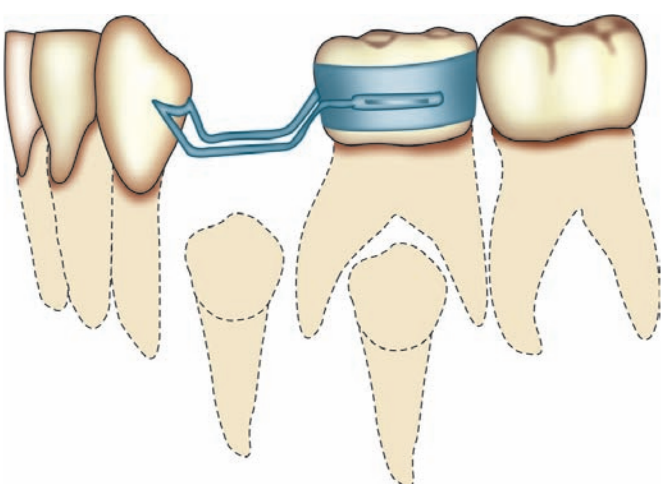


Figure 3.17 A space maintainer designed to maintain space for the eruption of the permanent successor tooth at a later stage

PERMANENT DENTITION STAGE (12 YEARS AND BEYOND)

Permanent dentition stage is established by about 12 to 13 years excluding the 3rd molars. Occlusion of permanent dentition is considered in the Chapter 21.

Development of Permanent Teeth

Permanent successor teeth, i.e. the permanent incisors, canines and premolars develop from the lingual proliferation of the dental lamina (successional lamina). The permanent molars, which are not succedaneous teeth, develop from posterior extension of the dental lamina.

Chronology of permanent dentition is given in the **Table 3.2**. The following observations can be made from the chronology table:

- The permanent dentition begins to form at birth, at which time, initial calcification of permanent 1st molars become evident. Their crowns are completed by 3 years of age
- Most of the anteriors begin to calcify between 3 and 5 months and their crowns are completely formed by 5 to 7 years
- The premolars begin to calcify by 11/2 to 2½ years. Crown completion occurs by 7 years of age
- The 2nd molars begin to form by 21/2 to 3 years and their crowns are completed by 7 to 8 years
- The last teeth to develop, the 3rd molars begin to calcify by 7 to 10 years, and crowns are not completed until 12 to 16 years.

Eruption Sequence

In general, the teeth erupt earlier in females than in males. The mandibular permanent teeth tend to erupt before their maxillary counterparts. The sequence of eruption of permanent dentition is more variable than that of the primary dentition. In addition, there are significant differences in the eruption sequences between the maxillary and the mandibular arches (**Fig. 3.19**).

Most common eruption sequence in maxillary arch:

6-1-2-4-3-5-7-8

or

6-1-2-4-5-3-7-8

Most common eruption sequence for mandibular arch:

(6-1)-2-3-4-5-7-8

or

(6-1)-2-4-3-5-7-8

Table 3.2 Chronology of permanent dentition*

Tooth	*First evidence of calcification*	*Amount of enamel formed at birth*	*Crown completed*	*Eruption*	*Root completed*
Maxillary					
Central incisor	3–4 months	–	4–5 years	7–8 years	10 years
Lateral incisor	10–12 months	–	4–5 years	8–9 years	11 years
Cuspid	4–5 months	–	6–7 years	11–12 years	13–15 years
First bicuspid	1½–1¾ years	–	5–6 years	10–11 years	12–13 years
Second bicuspid	2–2¼ years	–	6–7 years	10–12 years	12–14 years
1st molar	At birth	Sometimes a trace	2½–3 years	6–7 years	9–10 years
2nd molar	2½–3 years	–	7–8 years	12–13 years	14–16 years
3rd molar	7–9 years	–	12–16 years	17–21 years	18–25 years
Mandibular					
Central incisor	3–4 months	–	4–5 years	6–7 years	9 years
Lateral incisor	3–4 months	–	4–5 years	7–8 years	10 years
Cuspid	4–5 months	–	6–7 years	9–10 years	12–14 years
First bicuspid	1¾–2 years	–	5–6 years	10–12 years	12–13 years
Second bicuspid	2¼–2½ years	–	6–7 years	11–12 years	13–14 years
1st molar	At birth	Sometimes a trace	2½–3 years	6–7 years	9–10 years
2nd molar	2½–3 years	–	7–8 years	11–13 years	14–15 years
3rd molar	8–10 years	–	12–16 years	17–21 years	18–25 years

* Chronology of teeth. Schour and Massler (1940); Logan and Kronfeld sightly modified by McCall and Schour (1933).

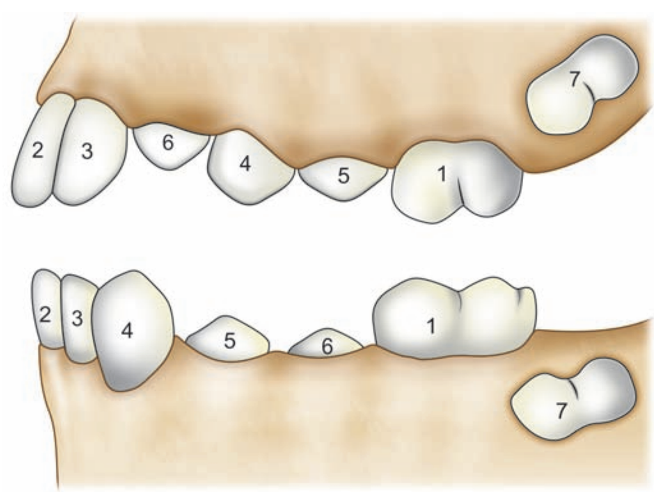


Figure 3.19 Eruption sequence of permanent teeth

Figure 3.20 Maxillary canine erupts after the eruption of premolars. Thus anterior crowding is a common problem in maxillary arch due to buccal/palatal eruption of maxillary canine

It must be noted that, there is a difference in the eruption timing of the canine teeth. In the mandibular arch, the canines erupt before the premolars; whereas in the maxillary arch, the canines generally erupt after the premolars. Thus, the maxillary canine often erupts buccally or palatally when the space is lost due to mesial migration of the already erupted premolars leading to crowding of teeth (**Fig. 3.20**).

The following observations can be made from the chronology table of permanent dentition (**Table 3.2**):

- Usually, the first permanent teeth to emerge are the 1st molars at around 6 years of age. They are thus also referred to as 6-year molars
- The mandibular central incisors emerge next around 6 to 7 years, which are closely followed by the mandibular lateral incisors
- The maxillary central incisors emerge next in the order about 7 to 8 years. The maxillary lateral incisors emerge about 1 year later

- The mandibular canine follows next at 9 to 10 years. However, the maxillary canine erupt late after one or both the maxillary premolars erupt around 11 to 12 years
- The premolars emerge between 10 and 12 years
- The 2nd molars erupt next, around 12 years of age; they are also called the 12-year molars
- The 3rd molars do not erupt until 17 to 21 years. In many individuals, the 3rd molars remain impacted or may even be completely absent.

DENTAL AGE

Estimation of age is an important requisite in forensic, judicial and criminal proceedings. Circumstances where age assessment is required include; asylum seeker of unknown age, young people accused of criminal activities, convicted criminals whose age is claimed to be less than 18 years prior to sentencing and identification of subjects from mass disasters.

Apart from forensics and anthropology, dental age assessment has an important role in pediatric dentistry and orthodontics. Orthodontists use such knowledge to predict the timing of particular treatments and pediatricians may be interested in knowing whether the dental maturity of a child with a certain disease has been delayed or advanced.

The chronological age (actual age from date of birth) of an unknown person with uncertain birth record can be predicted by correlating his/her physical, skeletal and dental development. Dental age is considered a better indicator of biologic maturity than physical, skeletal or sexual age since tooth formation is least affected by nutritional status and endocrinal disturbances. **Box 3.1** lists various biologic maturity in dicators.

Dental age can be assessed mainly by two methods: tooth eruption status and tooth formation.

Based on the Status of Tooth Emergence (Eruption) in the Oral Cavity

This method takes into account the number of teeth that have emerged into the oral cavity and the last tooth to erupt. This method is rather rough since tooth emergence through the mucous membrane is a single event for each tooth. Furthermore, local factors such as caries, tooth loss, ankylosis, lack of space in the dental arch may affect emergence of teeth through gingiva.

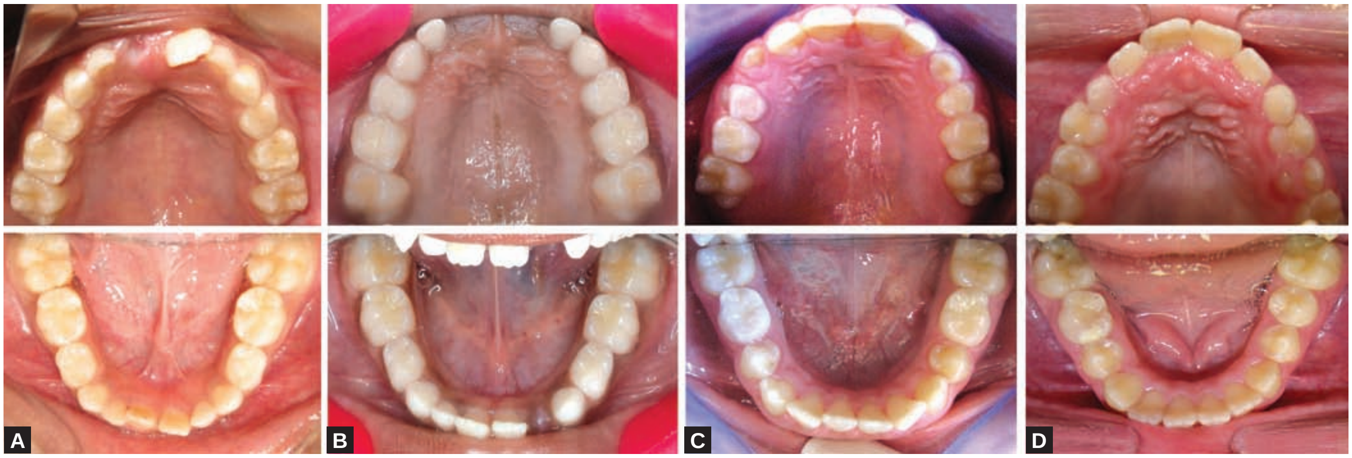
Thus, chronologies of eruption of teeth are less satisfactory for dental age assessment than those based on tooth formation. However eruption status can be used in mixed dentition period to get a rough idea about the dental age. **Figures 3.21 and 3.22** give examples of dental age assessment using eruption status of teeth in mixed dentition period.

Box 3.1 Maturity indicators

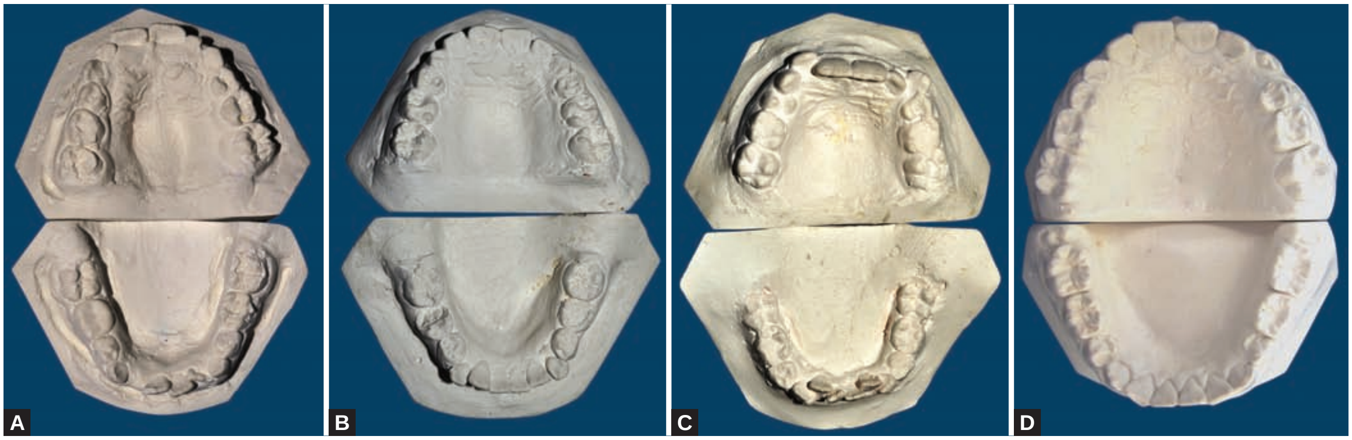
- *Morphologic age*: It is based on height gained. Height or morphological age is useful as a maturity indicator from late infancy to early adulthood.
- *Dental age*: Dental age can be assessed by two methods
  - By eruption status of primary and permanent dentition
  - By radiologic assessment of calcification of crowns and root formation of unerupted and developing teeth.

Dental age maturity indicator is useful from birth to early adolescence.

- *Sexual age*: It refers to the development of secondary sexual characteristics. Sexual age as a maturity indicator is useful only for adolescent growth.
- *Skeletal age*: It is determined by assessing the development of bones of the hand and wrist or by evaluating the development of cervical vertebrae on lateral cephalogram. It is useful through the postnatal growth period



Figures 3.21A to D Dental age assessment using eruption status of teeth in mixed dentition period (Tooth notation in FDI system): (A) Last erupted tooth—21; approximate dental age = 7–8 years; (B) Last erupted tooth—31, 41; approximate dental age = 6–7 years; (C) Erupting teeth—13; approximate dental age = 11–12 years; (D) Erupting teeth—25 and 13; approximate dental age = 10–12 years



Figures 3.22A to D Dental age assessment using eruption status of teeth in mixed dentition period—cast specimen (Tooth notation in FDI system): (A) Erupted teeth-all first permanent molars, erupting teeth—32, 11, 21, 12, 22; approximate dental age 7–9 years; (B) Last erupted teeth—12 and 22; approximate dental age 8–9 years; (C) Erupting tooth—14; approximate dental age 10–11 years; (D) Erupting tooth—23; approximate dental age 11–12 years

The permanent teeth tend to erupt in groups and it is important to know the expected timing of these eruption stages. These eruption stages are used to calculate dental age, particularly during the mixed dentition period.

Dental Age 6 (Fig. 3.23A)

The first stage of eruption of the permanent teeth at age 6 is characterized by the near simultaneous eruption of the mandibular central incisors, maxillary 1st molars and mandibular 1st molars. The onset of eruption of this group of teeth characterizes dental age 6.

Dental Age 7 (Fig. 3.23B)

In the second stage of eruption at dental age 7, the maxillary central incisors and the mandibular lateral incisors erupt.

Dental Age 8 (Fig. 3.23C)

It is characterized by the eruption of the maxillary lateral incisors. After these teeth erupt there is a delay of 2 to 3 years before any further permanent teeth appear.

Dental Ages 9 and 10 (Fig. 3.23D)

Since no teeth are erupting at that time, dental ages 9 and 10 must be distinguished by the extent of resorption of the primary canines and molars and the extent of root development of their permanent successors.

Dental Age 11 (Fig. 3.23E)

It is characterized by eruption of another group of teeth: the mandibular canine, mandibular 1st premolars and maxillary 1st premolar, which all erupt more or less simultaneously.

At dental age 11, the only remaining primary teeth in oral cavity are the maxillary canine and 2nd molar and mandibular 2nd molar.

Dental Age 12 (Fig. 3.23F)

At dental age 12, the remaining succedaneous permanent teeth erupt, i.e. the maxillary canine; the maxillary and mandibular 2nd premolars.

In addition, the 2nd permanent molars in both the arches are nearing eruption.

Dental Ages 13 to 15 (Fig. 3.23G)

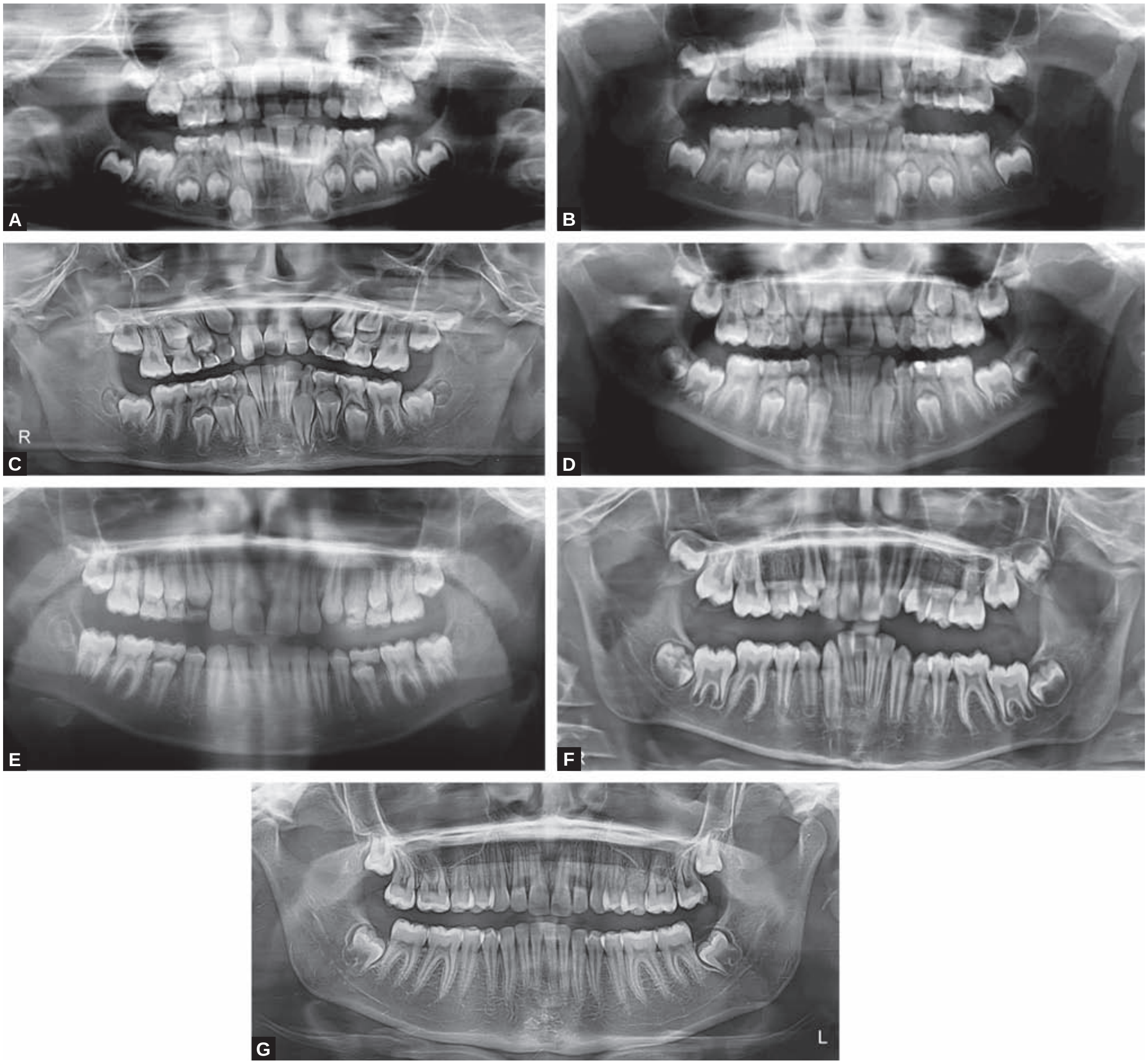
They are characterized by the extent of completion of the roots of permanent teeth. By dental age 15, if the 3rd molar is going to form, it will be apparent on the radiographs and the roots of all other permanent teeth should be complete.

Based on the Stages of Tooth Formation Observed on Radiographs

Tooth formation (calcification) is a continuous process occurring throughout the growth period from birth to adolescence, and can be divided into various stages that can be defined.

Dental age based on tooth formation is superior to that based on tooth emergence because emergence of a tooth is a fleeting single event and its precise time is difficult to determine. Whereas tooth calcification is a continuous process that can be assessed on permanent records such as radiographs.

Dental age is estimated by comparing the tooth development status in a person of unknown age with published reference dental development dataset prepared from a similar or a different population group.



Figures 3.23A to G (A) Dental age 6; (B) Dental age 7; (C) Dental age 8; (D) Dental ages 9 and 10; (E) Dental age 11; (F) Dental age 12; (G) Dental ages 13 to 15

Demirjian in 1973 proposed dental maturity scored from a French-Canadian population and this has served as a reference dataset for evaluation of age for various population groups.

Radiographic studies of tooth formation have used three basic stages:
1. First evidence of calcification
2. Crown completion
3. Root completion.

Nolla expanded the number of stages to 11 and Gleiser and Hunt to 13.

Morrees et al defined 14 stages of permanent tooth formation (**Fig. 3.24**). The 14 stages are designated by abbreviations. Morrees et al studied the development of mandibular canines and provided normative data.

Abbreviations

- C: Cusp
- Cr: Crown
- R: Root

- Cl: Cleft
- A: Apex

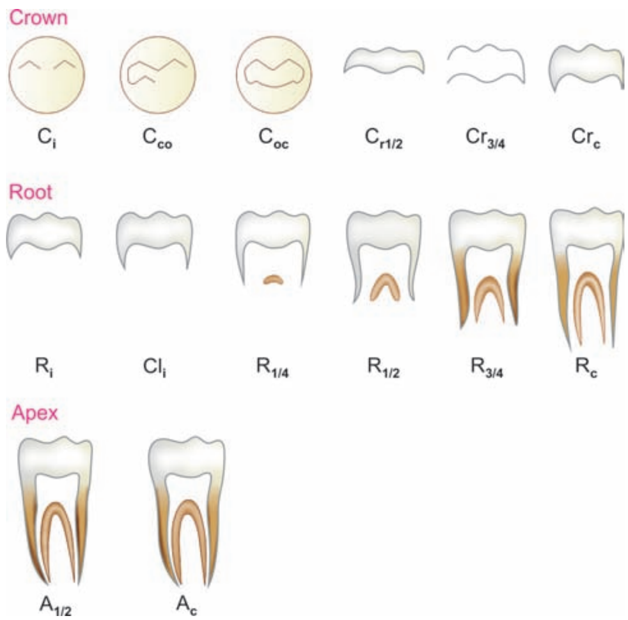


Figure 3.24 14 stages of permanent teeth

Subscripts

- i: initiated
- co: coalescence
- oc: outline complete
- c: complete

The 14 stages would be:

1. C_i: Cusp initiated
2. C_{co}: Cusp coalescence
3. C_{oc}: Cusp outline completed
4. $C_{r1/2}$: Crown half formed
5. $C_{r3/4}$: Crown three-fourth formed
6. C_{rc}: Crown completed
7. R_i: Root initiated
8. C_{li}: Cleft initiated
9. $R_{1/4}$: Root one-fourth formed
10. $R_{1/2}$: Root half formed
11. $R_{3/4}$: Root three-fourth formed
12. R_c: Root complete
13. $A_{1/2}$: Apex half formed
14. A_c: Apex complete

As an example, values for predicting age in females based on Morrees' developmental stages are presented in **Table 3.3**.

Clinicians can use such chronologies to avoid treatment that can damage developing teeth (age of attainment schedules), to assess an unknown age of a patient (e.g. age prediction in forensics), and to assess growth (maturity).

Table 3.3 Values for predicting age from stages of permanent mandibular tooth formation—females*

Developmental stage	*I1*	*I2*	*C*	*P1*	*P2*	*M1*	*M2*	*M3*
C_1	—	—	0.6	2.0	3.3	0.2	3.6	9.9
C_{CD}	—	—	1.0	2.5	3.9	0.5	4.0	10.4
C_{DC}	—	—	1.6	3.2	4.5	0.9	4.5	11.0
$Cr_{1/2}$	—	—	2.5	4.0	5.1	1.3	5.1	11.5
$Cr_{3/4}$	—	—	3.5	4.7	5.8	1.8	5.8	12.0
Cr_c	—	—	4.3	5.4	6.5	2.4	6.6	12.6
R_1	—	—	5.0	6.1	7.2	3.1	7.3	13.2
Cl	—	—	—	—	—	4.0	8.4	14.1
$R_{1/4}$	4.8	5.0	6.2	7.4	8.2	4.8	9.5	15.2
$R_{1/2}$	5.4	5.6	7.7	8.7	9.4	5.4	10.3	16.2
$R_{2/3}$	5.9	6.2	—	—	—	—	—	—
$R_{1/4}$	6.4	7.0	8.6	9.6	10.3	5.8	11.0	19.9
Rc	7.0	7.9	9.4	10.5	11.3	6.5	11.8	17.7
$A_{1/2}$	7.5	8.3	10.6	11.6	12.8	7.9	13.5	19.5
A_c	—	—	—	—	—	—	—	—

* Values from Morrees et al (1963); all ages in years

BIBLIOGRAPHY

1. Demirjian A, et al. A new system of dental age assessment. Human Biol. 1970;45:211.
2. Friel S. The development of ideal occlusion of gum pads and teeth. Am J Orthod.1954;40:196.
3. Hughes TE, et al. Strong genetic control of emergence of human primary incisors. JDR. 2007;86(12):1160-65.
4. Massler M, et al. Developmental pattern of the child as reflected in the calcification pattern of the teeth. Am J Dis Child. 194;63:33.
5. Morrees CFA, Kent RL. A step function model using tooth counts to assess the developmental timing of the dentition. Am Hum Biol. 1978;5:55.
6. Morrees CFA, et al. Age variation of formation stagtes for ten permanent teeth. J Dent Res. 1963;42;1490.
7. Nolla CM. The development of permanent teeth. J Dent Child. 1960;27:254.
8. Schour L, Massler M. The development of human dentition. J Am Dent Assoc. 1941;28:1153.

MULTIPLE CHOICE QUESTIONS

1. Development of teeth in human begin:
   a. At birth
   b. Prenatally
   c. At 6 months
   d. At 1 years
2. Primary teeth begin to calcify at:
   a. Birth
   b. 6 months
   c. 6 weeks *in utero*
   d. 14 weeks *in utero*
3. First primary tooth to show its evidence of calcification (begin its development):
   a. Primary maxillary 1st molar
   b. Primary mandibular 1st molar
   c. Primary mandibular central incisor
   d. Primary mandibular lateral incisor
4. All primary teeth would have begun to calcify by:
   a. 14 weeks of intrauterine life
   b. 18–20 weeks of intrauterine life
   c. 6 months of gestation
   d. 6 months of age
5. The duration of time each primary tooth takes for its formation, from first evidence of calcification to root completion is:
   a. 3–4 months
   b. 2–3 years
   c. 5–6 years
   d. 1–2 years
6. The duration of time each permanent tooth takes for its complete formation is:
   a. 3–4 months
   b. 2–3 years
   c. 5–6 years
   d. 8–12 years
7. Mineralization of permanent teeth is:
   a. Entirely prenatal
   b. Entirely postnatal
   c. Occurs both prenatally and postnatally
   d. None of the above
8. Eruption of all the primary teeth would be completed by:
   a. 6 months
   b. 12 months
   c. 12 years
   d. 2½ years
9. Development of primary dentition is considered to be completed:
   a. At 6 months
   b. 30 months
   c. When second primary molars in occlusion
   d. Both b and c
10. Transitional (mixed) dentition period begins at:
    a. 6 months
    b. 6–7 years
    c. When first permanent teeth erupts
    d. Both b and c

Answers

1. b	2. d	3. c	4. b	5. b	6. d	7. b	8. d	9. d	10. d

CHAPTER

4

Form and Function of Orofacial Complex

The phrase *form and function* is often used in the context of evolutionary science. Biologists often say *form follows function* meaning that, due to the evolutionary process the morphological features (e.g. teeth) of an organism's body are fitted to the activities of an organism. The concept of form and function explains the inter-relation of the shape of some part and its function. In the context of dentistry, this phrase is applied to the entire masticatory system, which acts as a highly coordinated functional unit. Form of each component of the masticatory system is closely related to its individual functions and to that of the whole system including mastication, deglutition, phonetics, esthetics and maintenance. The idea that the form and function are inter-related has to be borne in mind in clinical practice, for instance while restoring teeth, treating malocclusion, etc.

The primary function of teeth is to prepare food for swallowing and to facilitate digestion. Different types of teeth with their respective form are adapted to incise, shear and grind food. The teeth with their proper form and alignment protect the supporting periodontal tissues against trauma during mastication, facilitate the jaw movements, speech and enhance esthetic appearance of face.

In order to understand the form and function of teeth, the following aspects must be considered:

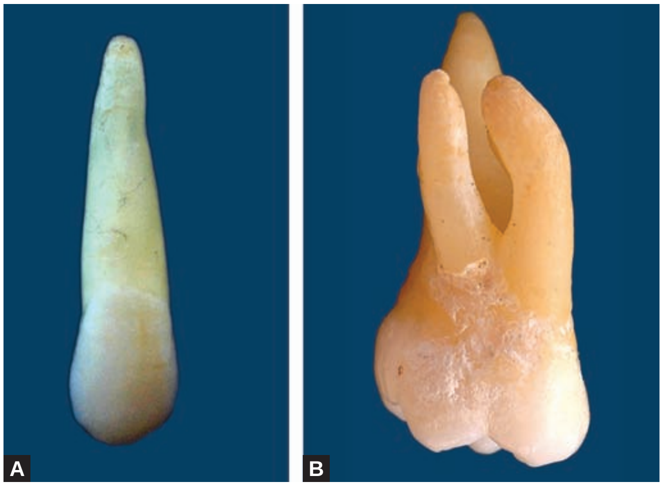
- Size of crown and root, root form
- Tooth form and jaw movements
- Proximal contact areas
- Interproximal spaces
- Embrasures (Spillways)
- Facial and lingual contours of teeth: mesial and distal
- Curvature of the cervical line (CEJ)
- Occlusal curvatures.

SIZE OF CROWN AND ROOT

- The crown and root should be proportional to each other and to the jaw size. Size and shape of roots reflect the function of respective teeth, e.g. the canine teeth located at the corners of the mouth have longest roots (**Fig. 4.1A**). The extra size and length of the root ensures enough anchorage and support for canine teeth that bear shear forces.
- Maxillary and mandibular molars that perform the most part of trituration of food require multiple roots to withstand the masticatory forces. Trifurcated roots of maxillary molars give a tripod arrangement in the alveolar bone that provides excellent anchorage (**Fig. 4.1B**).
- Developmental depressions on the lateral surfaces of the roots also enhance anchorage in the alveolar bone.

TOOTH FORM AND JAW MOVEMENTS

Apart from communition of food, the incisal and occlusal forms of the teeth have a direct influence on the jaw movements. The relation of tooth form and jaw relation can be understood by comparing human jaw movements with



Figures 4.1A and B (A) Canine teeth has longest roots to withstand shear forces at corners of the mouth; (B) Tripod arrangement of maxillary molar roots provides excellent anchorage in the alveolar bone

that of animals. In many animals only simple opening and closing type of jaw movements is possible without lateral excursion. This is because of their interlocking conical form of teeth, temporomandibular joint (TMJ) morphology, isognathic jaws (equal sized jaws) and lack of muscles to carryout lateral movements. Conical form of teeth and equal sized jaws permit limited lateral jaw movement. For example, crocodiles have interlocking conical teeth of different size (**Fig. 4.2**).

Carnivores (wild boars, pigs, dogs), and primates have conical shaped cusps (*bunodont*), equal sized jaws, and very prominent canine teeth that limit lateral jaw movements. Extreme lateral movements are seen in cattle (herbivores) and may be attributed to their elongated flattened condyles, selenodont molars (molars with crescent–shaped cusps) and unequal jaw size.

In humans, however, maxillary and mandibular jaws are not perfectly equal sized. The maxillary arch overlaps the mandibular arch labially and buccally in horizontal plane (**Fig. 4.3**). The TMJ is specialized in humans and the occlusal anatomy of teeth is complex. It can be observed that, increasing complexity of jaw movement is associated with increasing complexity of occlusal anatomy of teeth.

INTERPROXIMAL SPACES AND PROTECTION OF INTERDENTAL GINGIVA

When viewed from facial and lingual aspects, it can be appreciated that the teeth are narrower at the cervix mesiodistally than they are towards the occlusal surfaces. This arrangement creates a triangular/pyramidal shaped space between the approximating teeth just cervical to the contact area (**Fig. 4.4**). The base of the triangle is at the alveolar process between the adjacent teeth; the sides of the triangle are formed by the proximal surfaces of the teeth and the apex of the triangle is at the contact area of the two teeth. These spaces accommodate and protect interproximal gingival tissue and are referred to as the *interproximal spaces*. The gingival tissue that fills the interproximal space is called the *gingival papilla/interdental papilla*.

The gingiva covers the alveolar process of jaw bones (*attached gingiva*), extends around the neck of tooth to form gingival crevice (*free/marginal gingiva*) and fills the interdental spaces (*gingival/interdental papilla*) (**Fig. 4.5**). *Mucogingival line* marks the junction between attached gingiva and the alveolar mucosa. The part of interdental gingival tissue that lies below the contact area and extends

Figure 4.3 Unequal sized jaws with maxillary arch overlapping the mandibular arch and specialized TMJ allow complex lateral jaw movements in humans

Figure 4.2 Interlocking conical teeth in crocodile limit lateral jaw movements

Figure 4.4 Triangular-shaped interproximal spaces between adjoining teeth accommodate interproximal gingival tissue

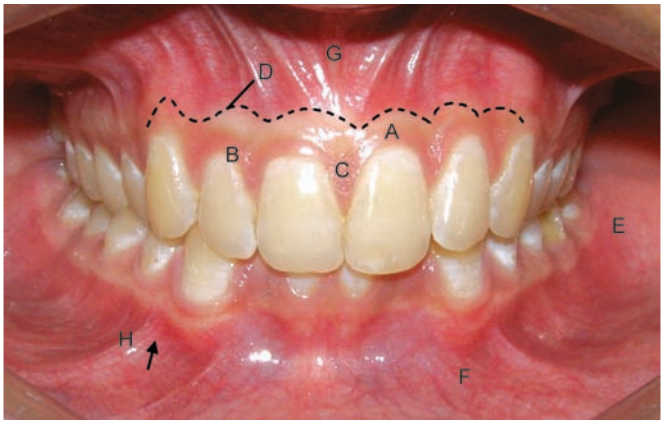


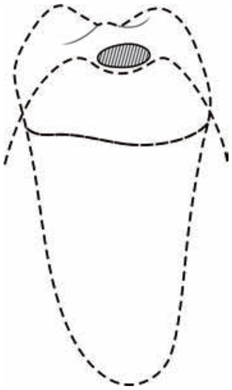
Figure 4.5 Gingiva: A. Attached gingival, B. Free marginal gingival, C. Interdental gingival/papilla, D. Mucogingival junction, E. Buccal corridor/postvestibular fornix, F. Anterior vestibular fornix/ mucobuccal fold, G. Labial frenum, H. Buccal frenum

faciolingually is called the *col*. Col is non-keratinized and vulnerable to trauma during mastication and invasion by bacteria. Tight contacts and proper interproximal spaces between adjacent teeth help to protect the col and interproximal gingival tissue (**Figs 4.6A and B**).

When viewed buccally/lingually, the roots of teeth taper from cervix to apices creating enough space between the roots of adjacent teeth. This allows sufficient alveolar bone between one tooth to another, so that the teeth are securely anchored in the jaws. The arrangement also ensures adequate space for blood and nerve supply to the supporting and investing tissues of teeth (**Fig. 4.7**).

The form of interproximal space will vary with the proximal contours of adjacent teeth and their alignment. Proper contact and alignment of adjacent teeth is essential to provide enough interproximal space between them for normal bulk of the gingival tissue to be attached to the bone and teeth.

A



B

Figures 4.6A and B Form of interproximal gingiva col in relation to contact area. Tight contact between adjacent teeth help to protect the col and interproximal gingival tissue

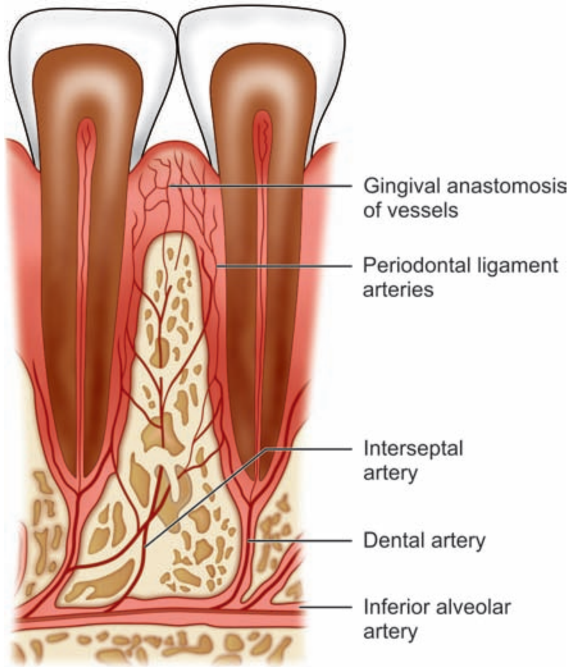


Figure 4.7 Conical tapering form of root allows sufficient alveolar bone and them for anchorage and provides adequate space for blood and nerve supply to the supporting and investing tissues of teeth

Figure 4.8 Each tooth has two contact areas: Mesial and distal, except last molar which does not have distal contact

Figure 4.9 The maxillary and mandibular central incisors are the only teeth which have their mesial surfaces facing each other

PROXIMAL CONTACT AREAS

When a tooth erupts and takes its position in the dental arch, it comes in contact with two adjacent teeth of the same arch—one mesial and one distal to it. Although the contact between newly erupted teeth may be very small and circumscribed, soon the contact becomes broader due to proximal wear. Thus, the term *contact area* is preferred to *contact point*. Each tooth in dental arches except the last molars has two contact areas—the mesial and the distal. The 3rd molar or the 2nd molar when 3rd molar is absent, is in contact only with the tooth mesial to it (**Fig. 4.8**).

Except for the maxillary and mandibular central incisors, the mesial contact area of one tooth faces the distal contact area of the adjoining tooth located mesial to it. The maxillary and mandibular central incisors are the only teeth that have their mesial surfaces facing each other (**Fig. 4.9**).

Adjacent teeth should have tight contact with each other (**Fig. 4.10**). Proper contact relation between adjoining teeth is important due to the following reasons:

- Since adjacent teeth are in contact with each other, the whole dental arch functions as a single unit and masticatory forces are well-distributed
- The combined anchorage of all teeth ensures occlusal stability
- Proper contact prevents food impaction, which can lead to decay and periodontal problems
- Tight contact between adjacent teeth helps to protect the interproximal gingival tissue by diverting/shunting food toward the buccal and lingual areas.

Clinical Significance of Contact Areas

If the contact between adjacent teeth is lost due to some reason (e.g. proximal caries, loss of a tooth, malocclusion, etc.), food is forced between the teeth and pathologic changes occur in interdental gingival tissue, leading to gingivitis. If unresolved, the inflammation may reach deeper periodontal structures with loss of interdental alveolar bone causing

Figure 4.10 Proper contact relation between the adjacent teeth

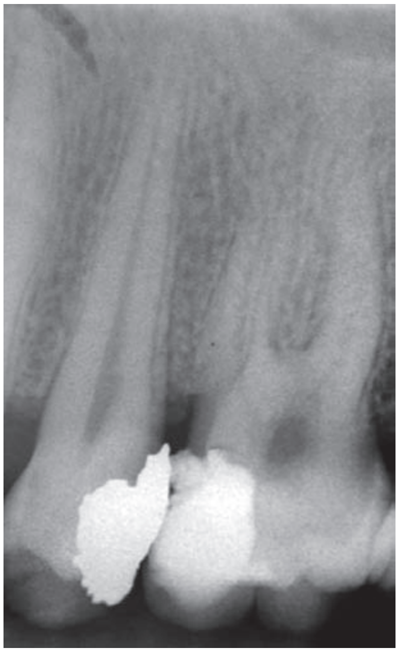


Figure 4.12 Improper proximal restoration causing interdental bone loss

Figure 4.11 Crown prosthesis with proper proximal contacts

periodontitis. For these reasons, it is important to establish proper proximal contact during crown prosthesis (**Fig. 4.11**), proximal restoration of teeth (**Fig. 4.12**) and treatment of malocclusion.

Position of Contact Areas

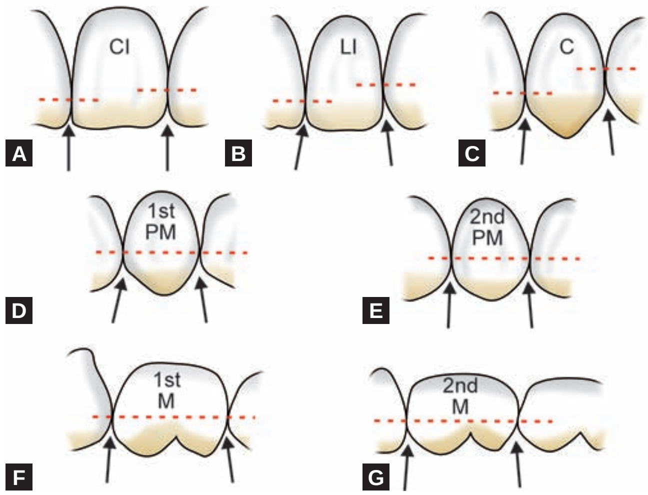
Position of contact areas depend on the type and form of the crown and alignment of teeth. Position of contact areas can be examined from two views:

1. *Facial (labial/buccal) view:* It gives the relative position of the contact areas cervicoincisally/cervico-occlusally.
2. *Incisal/Occlusal view:* It shows the relative position of the contact areas labiolingually/buccolingually.

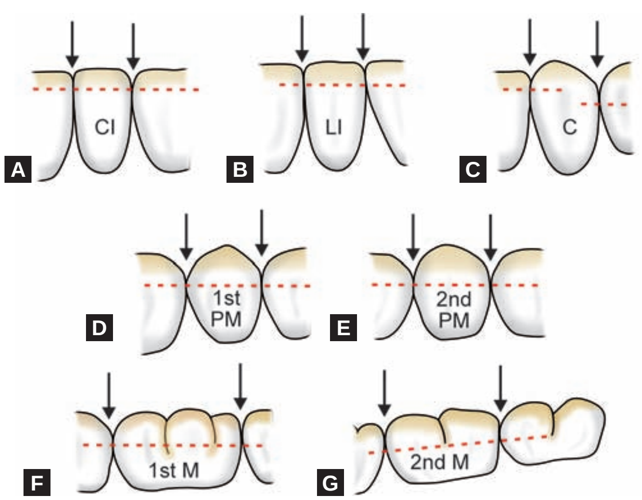
Contact Area Location as Viewed Facially (Figs 4.13 and 4.14)

Generally, in all the teeth:

- The height of the crown decreases as one moves from the central incisor to the last molar. Thus, the contact areas become more cervically positioned when moving away from the midline (**Fig. 4.15**).
- Distal contact area is more cervically placed than the mesial contact area in all the teeth except:
  - In mandibular permanent 1st premolars where the mesial contact area is cervically located than the distal contact area.
  - In mandibular permanent central incisors where both mesial and distal contact areas are at the same level. This is because the mandibular central incisors are bilaterally symmetrical (**Fig. 4.14**).



Figures 4.13A to G Cervico-occlusal location of contact areas as viewed facially in maxillary teeth



Figures 4.14A to G Cervico-occlusal location and contact areas as viewed facially in mandibular teeth

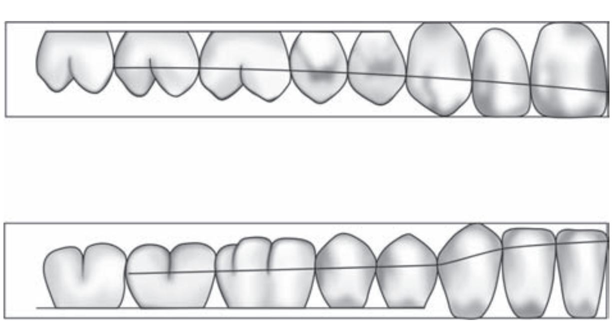


Figure 4.15 Location of contact areas become more cervically placed as moved away from the midline. Distal contact area is more cervically placed than the mesial contact area

In anteriors:
- The mesial and distal contact areas are at dissimilar levels when compared to posterior teeth.
- The contacts become more cervical when moving from incisors to distal of canines.
- Mesial contacts of the incisors are in the incisal third. The distal contacts are at or near the junction of incisal and middle thirds.
- The contacts are more incisally placed in mandibular incisors than the maxillary incisors.
- Canines are the teeth in which the mesial and distal contacts are markedly at different levels. Their mesial contacts are at or near the junction of incisal and middle thirds. The distal contacts are in the middle thirds.

In posteriors:
- The mesial and distal contacts of posteriors are more nearly at the same level than for anterior teeth.
- The mesial and distal contacts of premolars are at/cervical to the junction of middle and occlusal thirds.
- The location of contacts in molars is more regular. Mesial and distal contacts are usually at the middle third of the crown. The contact areas become more cervical toward the distal of the arch (the 3rd molars).

Location of Proximal Contacts as Viewed Occlusally (Figs 4.16 and 4.17)

In anterior teeth: The contact areas are nearly centered labiolingually and are smaller.

In posterior teeth:
- The contact areas are broader than that of the anterior teeth.
- The contact areas on posterior teeth tend to be placed buccal to the line bisecting the crown mesiodistally into buccal and lingual halves. (The contacts areas on posterior teeth are placed buccal to the center of the crown buccolingually).
- Compared to maxillary teeth, the contact areas in mandibular teeth are more centered buccolingually.

Box 4.1 gives the location of contact areas of different teeth both cervico-occlusally and buccolingually.

EMBRASURES (SPILLWAYS)

When two adjacent teeth of the same dental arch come in contact, their curvatures adjacent to the contact areas form "V" shaped spaces called the *embrasures/spillway spaces*. An embrasure is a "V" shaped space adjacent to the contact area of two adjacent teeth. Narrowest part of "V" shaped space is at the contact area. From here the space widens facially to form the *labial/buccal embrasure,* lingually to form the *lingual embrasure* and occlusally to form the *incisal/occlusal embrasure* (**Fig. 4.18**).

Box 4.1 Location of contact areas of teeth

CONTACT AREAS AS VIEWED FACIALLY

Maxillary teeth C I L I C 1st PM 2nd PM 1st M 2nd M 3rd M

M D M D M D M D M D M D M D M D

Incisal 3rd | Junction of incisal and middle 3rd | middle 3rd | Junction incisal and middle 3rd | Center of middle 3rd | Cervical to the junction of occlusal and middle 3rd | Center of middle 3rd of the crown

Mandibular teeth C I L I C 1st PM 2nd PM 1st M 2nd M 3rd M

M D M D M D M D M D M D M D M D

Both at incisal 3rd near incisal ridge | Incisal 3rd | Cervical to the junction of occlusal and middle 3rd | Center of middle 3rd of the crown

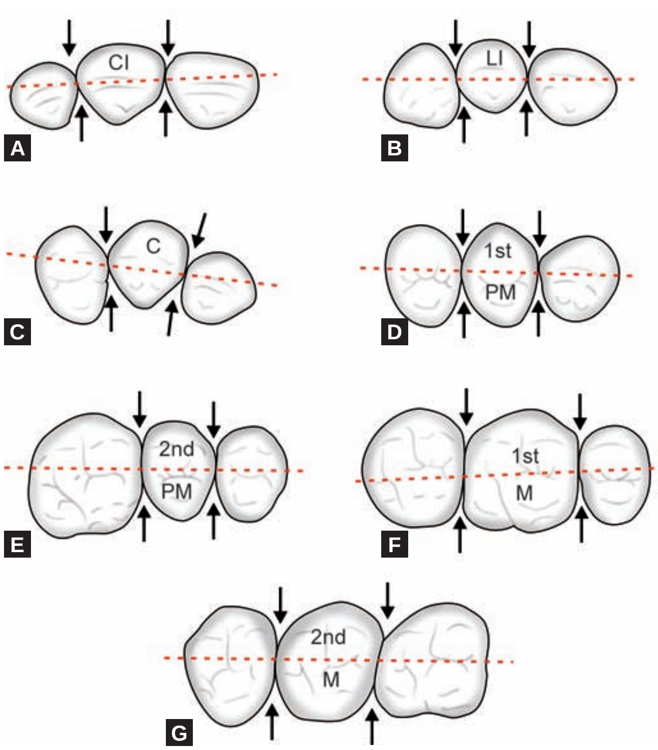
CONTACT AREAS AS VIEWED OCCLUSALLY

Anteriors:

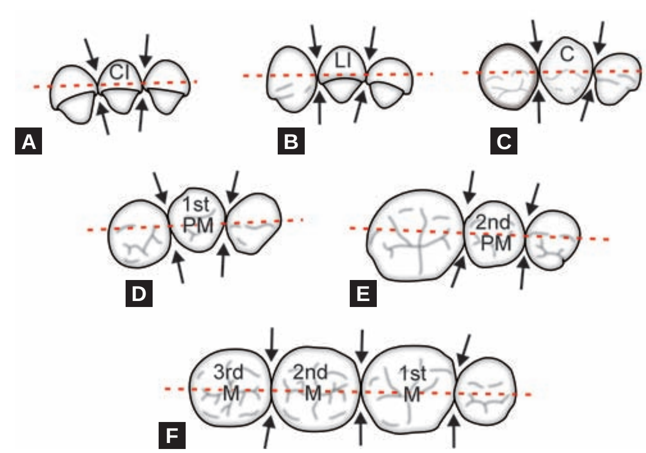
- Contact areas are nearly centered labiolingually, and are small.

Posteriors:

- Contact areas are broader than those of the anteriors.
- The contacts areas on posterior teeth are placed buccal to the center of the crown buccolingually.



Figures 4.16A to G Buccolingual location of contact areas as viewed occlusally in maxillary teeth



Figures 4.17A to F Buccolingual location of contact areas as viewed occlusally in mandibular teeth

The fourth triangular space that is cervical to the contact area is filled by interdental/gingival papilla and is appropriately called as the *interproximal space* though it is sometimes referred to as *gingival/cervical embrasure*.

The incisal/occlusal embrasures are observed when teeth are viewed from facial aspect (**Fig. 4.19A**). The facial and lingual embrasures are seen from incisal/occlusal view (**Fig. 4.19B**). The facial, lingual and occlusal embrasures are

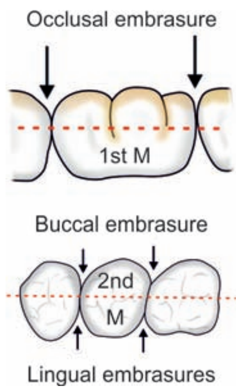
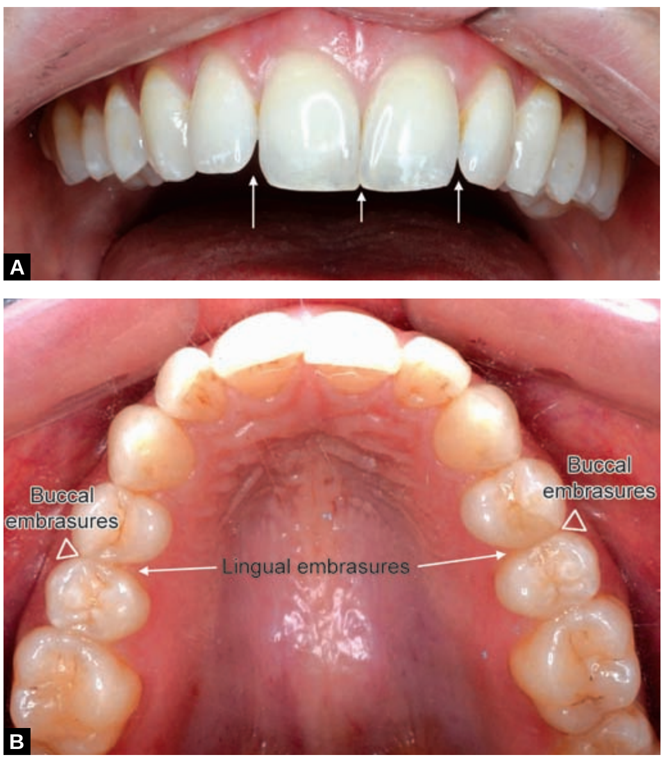


Figure 4.18 Embrasures/spillway spaces



Figures 4.19A and B (A) Incisal/occlusal embrasures are seen from facial view; (B) Buccal/lingual embrasures are seen from occlusal view

continuous as they surround the area of contact. The occlusal (incisal) embrasures are bounded by the marginal ridges as they join cusps and incisal ridges.

Functions of Embrasures

The embrasures serve the following purposes:

- The embrasures provide a spillway for the escape of food during mastication
- They reduce forces imparted on teeth during reduction of any hard food material
- They prevent food from being forced through the contact area. When the occlusal embrasure is lost due to attrition (e.g. in incisors), food is pushed into contact area between the teeth
- They make the tooth self cleansing as the rounded smooth surfaces of the crown are exposed to the cleaning action of fibrous foods and friction of cheeks and lips
- Embrasures and contact areas protect the gingiva from undue trauma.

An ideal embrasure should have the following characteristics (**Figs 4.20A to C**):

- The embrasure should be symmetrical, thus the proximal surfaces of adjacent teeth should be mirror images of each other
- Adjacent marginal ridges and cementoenamel junctions (cervical lines) should be of same height
- The teeth should have tight proximal contacts.

The form of embrasures tends to be constant or uniform in sectional areas/segments of the dental arch; for example, maxillary anterior segment, maxillary posterior segment, mandibular anterior segment and mandibular posterior segment.

In general, in all teeth:

- Occlusal embrasure tend to be widened as one moves away from midline towards the distal of the arch (increases from incisors to molars)
- Crowns of most teeth show lingual convergence. Therefore, usually the lingual embrasures are wider than the facial (labial/buccal) embrasures.

In anterior teeth:

- Incisal embrasures get widened from mesial of central incisor to distal of the canine
- Incisal embrasure is very minimal in mandibular incisors as their contact areas are more incisally located (nearer to the incisal edge)
- Lingual embrasures in anteriors are much wider than the labial embrasures. This is due to marked lingual convergences seen in anterior teeth.

In posterior teeth:

- Embrasures are more regular and uniform in posteriors
- Occlusal embrasures are wider than those seen in anteriors (incisal embrasures).
- Facial and lingual embrasures tend to be similar in form, though lingual embrasure may be slightly bigger.

Applied aspect: During proximal restoration of teeth or when crown prosthesis is given, over/under contouring of proximal surface should be avoided. Over-contouring of the proximal surface at the expense of embrasure space results in food impaction.

Figures 4.20A to C Ideal embrasures should be symmetrical and teeth should have tight proximal contacts

FACIAL AND LINGUAL PHYSIOLOGIC CONTOURS OF TEETH (FIGS 4.21A TO C)

- When teeth are viewed from proximal aspects, the facial (labial/buccal) and lingual surfaces of the crowns show some bulge above the cervical line.
- The crests of curvature of buccal and lingual surfaces are at the cervical/middle third of their crowns. Such a form protects and stimulates gingiva by deflecting the food away from gingival tissue during mastication.
- These convexities when optimal deflect food away from the gingival sulcus and prevent accumulation of food debris
- If buccal and lingual surfaces are under-contoured, there is possibility of food impaction.

In Anterior Teeth (Fig. 4.22A)

- In anteriors teeth the crests of curvature/heights of contours labially and lingually are in cervical third of the crown.
  - The crests of curvatures are at the same level and are opposite to each other labiolingually.
  - The curvatures extend up to 0.5 mm beyond the cervical line
  - Lingually, the crest of curvature is on the cingulum.

In Posterior Teeth

Maxillary Posteriors (Fig. 4.22B)

- Buccal and lingual curvatures extend about 0.5 mm beyond the cervical line.
- Crest of curvature buccally is at the cervical third
- Crest of curvature lingually is at the middle third.

Mandibular Posteriors (Fig. 4.22C)

- Buccal curvature extends about 0.5 mm from the cervical line
- Lingual curvature extends about 1.0 mm from the cervical line. Extent of lingual curvature is accentuated by lingual inclination of mandibular posteriors.
- Crest of curvature buccally is at cervical third
- Crest of curvature lingually is at the middle third.

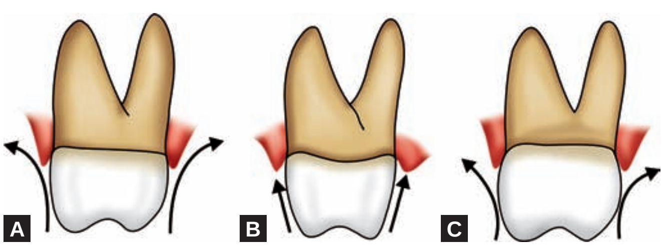
Table 4.1 summarizes the position of height of facial and lingual contours of teeth.

CURVATURES OF CERVICAL LINE (CEJ): MESIALLY AND DISTALLY

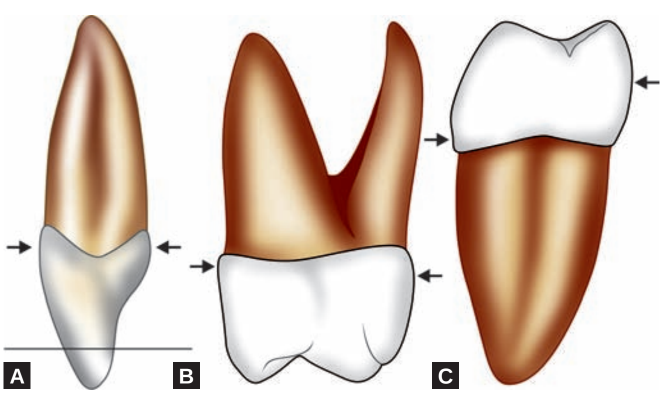
The curvature of cervical line signifies the cementoenamel junction. The epithelial attachment (soft tissue attachment at the neck of the tooth) and contour of alveolar crest follows the curvature of cementoenamel junction of the tooth. Epithelial attachment is vulnerable to physical injuries. Thus, it is important to know the level of epithelial attachment proximally, so as to prevent injury during dental procedures like scaling, restorations, impression making, crown preparation, etc. Inadvertent probing should also be avoided.

The following observations can be made regarding the curvature of cervical line:

- The curvature of cervical line on proximal surfaces of adjoining teeth is nearly at the same level (**Fig. 4.23**). This produces symmetrical interproximal space which is ideal.
- In all teeth, the extent of the curvature is greater mesially than distally.
- In general, the curvature of cervical line on distal surface is 1 mm less than that of the mesial surface of the tooth. For instance, the extent of cervical line curvature on mesial surface of central incisor is 3.5 mm and while it is 2.5 mm on the distal surface (**Fig. 4.24**).
- The extent of cervical line curvature dictates the level of contact areas.
- The height of tooth crowns decreases as one moves away from midline towards distal of arch and the contact areas shift more cervically.
- Incisors have long crowns with incisally placed contact areas. Therefore, the cervical line curvature is greater in incisors and tends to decrease towards the molars. The cervical line curvature is maximum at mesial of central incisor 3.5 mm, from here it diminishes gradually to 0.0 mm at the molars, where there is no curvature at all (**Fig. 4.25**).
- In both the arches, the anterior teeth exhibit greater curvature than the posteriors.



Figures 4.21A to C Facial and lingual contours of teeth: (A) Ideal contours; (B) Under contoured buccal and lingual surfaces may cause food impaction; (C) One-contoured buccal and lingual surfaces—no gingival stimulation



Figures 4.22A to C (A) Crest of labial and lingual contours in anterior teeth at cervical third, facing each other; (B and C) Crest of curvature of buccal and lingual contours in maxillary and mandibular posteriors: Crest of buccal curvature—cervical 3rd; Crest of lingual curvature—middle 3rd

IMAGINARY OCCLUSAL OF PLANES AND CURVES

Curve of Spee (Anteroposterior Curve/the Curve Occlusal Plane)

When viewed from the buccal aspect, the cusp tips of posterior teeth follow a gradual concave curve anteroposteriorly (**Fig. 4.26A**). The curve of the maxillary arch is convex; that of the mandibular arch is concave.

Table 4.1 Facial and lingual contours of teeth

Segment of teeth	*Crest of curvature*	*Extent of convexity beyond cervical line*
Maxillary and mandibular anteriors	Labially } at the cervical third Lingually	0.5 mm
Maxillary posteriors	Buccally—at cervical third	0.5 mm
	Lingually—at middle third	0.5 mm
Mandibular posteriors	Buccally—at cervical third	0.5 mm
	Lingually—at middle third	1.0 mm

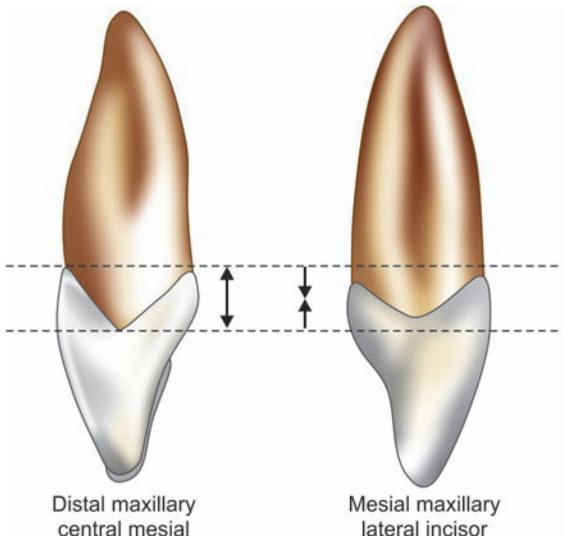


Figure 4.23 Extent of cervical line curvature on proximal surface of adjoining teeth is at same level. Distal of maxillary central incisor and mesial surface of maxillary lateral incisor

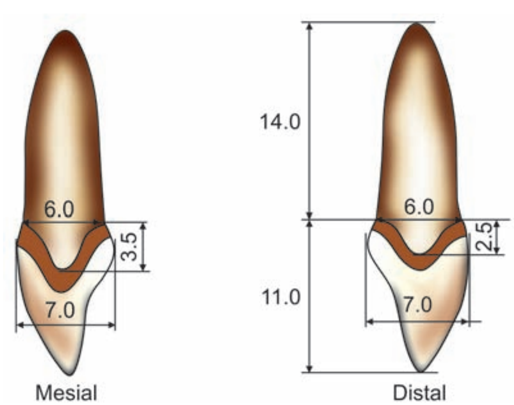


Figure 4.24 Generally, curvature of cervical line on distal surface of teeth is 1 mm less than that of mesial surface

Curve of Wilson (Side-to-Side Curve)

When viewed from anterior aspect with the mouth slightly open, the cusp tips of the posterior teeth follow a gradual curve from the left side to the right side (**Fig. 4.26B**). The curve of the maxillary arch is convex; that of the mandibular arch is concave. Thus, the lingual cusps of the posterior teeth are aligned at a lower level, then the buccal cusps on both sides and in both arches.

GEOMETRIES OF CROWN OUTLINES

Although outlines of tooth crowns are curved, they can be generally included within geometric figures. All the aspects of tooth crowns except the incisal/occlusal aspects can be outlined schematically within three geometric figures namely—a triangle, trapezoid, and rhomboid. Occlusal crown outline differs from one tooth to the other. Geometric shape/form of tooth crowns appears to conform to a general plan. Correct anatomy of tooth crowns can be understood better through the medium of schematic drawings.

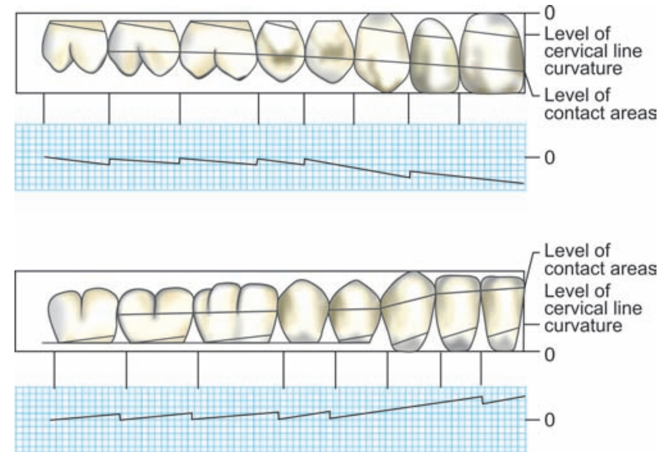


Figure 4.25 The cervical line curvature is maximum at midline on mesial surface of central incisor (3.5 mm) and decrease gradually and become flat (0.0 mm) at the molars

Facial and Lingual Aspects of all Teeth

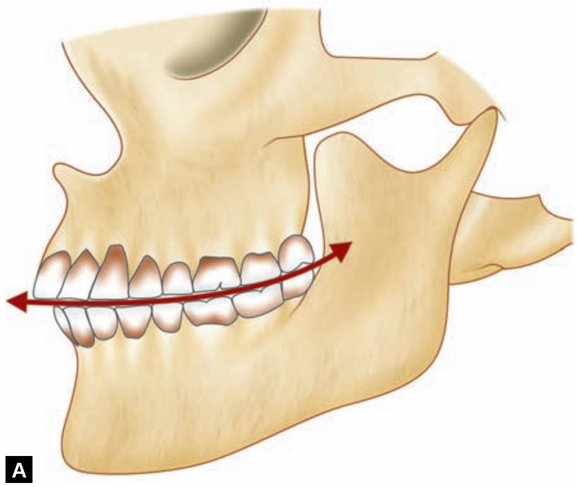
When viewed from facial and lingual aspects, the crown outlines of all the teeth may be represented as trapezoids of various dimensions by disregarding the cuspal forms of cusped teeth, i.e. canines and posteriors (**Fig. 4.27**).

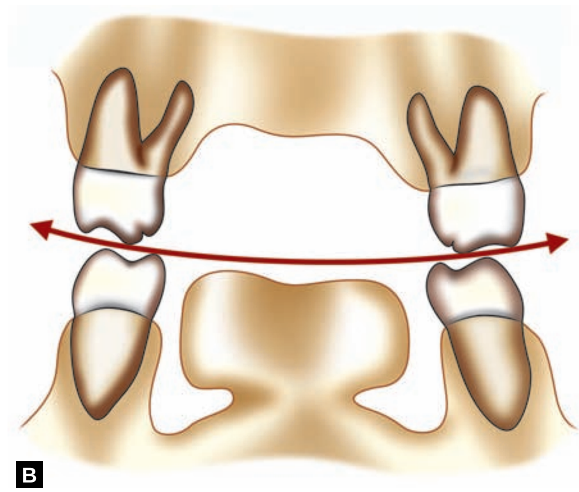
A trapezium has two even sides (of equal length) and two uneven sides. The shortest uneven side of the trapezoid represents the cervical area of the crown while the longest uneven side represents the working (incisal/occlusal) surface.

The schematic diagram (**Fig. 4.27**), drawn by disregarding the overlap of anterior teeth and cuspal forms helps in visualizing the fundamental plan in form and arrangement of the teeth from facial aspect. The occlusal line that is drawn along the longest uneven side of each of the trapezoid represents the approximate line of occlusion of opposing teeth when the jaws are closed.

The trapezoid form of crowns and the arrangement portrays the following fundamentals of form:

- Trapezoid crown form with narrow cervix creates interproximal spaces that can accommodate interproximal tissue.
- Spacing between the roots of adjacent teeth allows sufficient bulk of investing and supporting tissues (alveolar bone, periodontal ligament) for proper investment and maintenance of nutrition and function of adjacent teeth.





Figures 4.26A and B (A) Curve of Spee; (B) Curve of Wilson

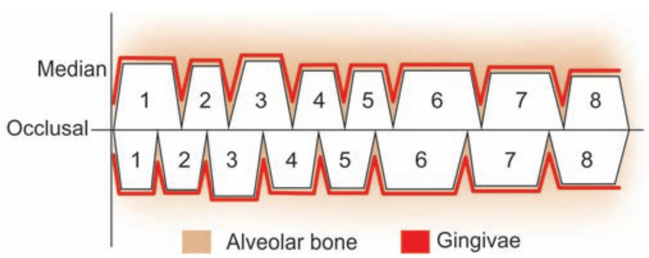


Figure 4.27 The general form of all crowns from facial and lingual aspect is trapezoid with narrow cervical area. This arrangement creates interproximal spaces than can accommodate interproximal gingival tissue

- Each tooth crown in the dental arches makes contact with adjoining tooth/teeth. This arrangement provides mutual support and occlusal stability. It also helps protect the interproximal gingival tissue from trauma during mastication.
- Each tooth in a dental arch occludes with two teeth of the opposing arch when in occlusion. In other words, each tooth has two antagonists in the opposing arch except for the mandibular central incisor and maxillary 3rd molar. When a tooth is lost, this arrangement helps to prevent extrusion of the antagonistic teeth and stabilize the remaining teeth.

Mesial and Distal Aspects of Anterior Teeth

The proximal aspects of all anterior teeth (both maxillary and mandibular) can be included within triangles. The base of the triangle is formed by the cervical portion of crown while the apex is represented by the incisal ridge (**Fig. 4.28A**).

Triangular shape of the anterior teeth when viewed from proximal aspects portrays the following fundamentals of form:

- Base of the crown is wide providing strength
- Tapering labial and lingual outlines converge into a thin incisal ridge. This gives a wedge-shaped cutting edge to the anteriors that facilitates the penetration of food material.

Mesial and Distal Aspects of Maxillary Posterior Teeth

The proximal aspects of maxillary posterior teeth also appear trapezoidal like their facial and lingual aspects. The difference however is that, the longest uneven side of the trapezoidal figure is towards the base of the crown (**Figs 4.28B to D**), i.e. cervical portion, rather than towards the occlusal surface which is true case of facial and lingual aspects (**Figs 4.28E and F**). It must be noted that the tooth crowns are not most narrow at the cervix from all the aspects as it is often perceived to be.

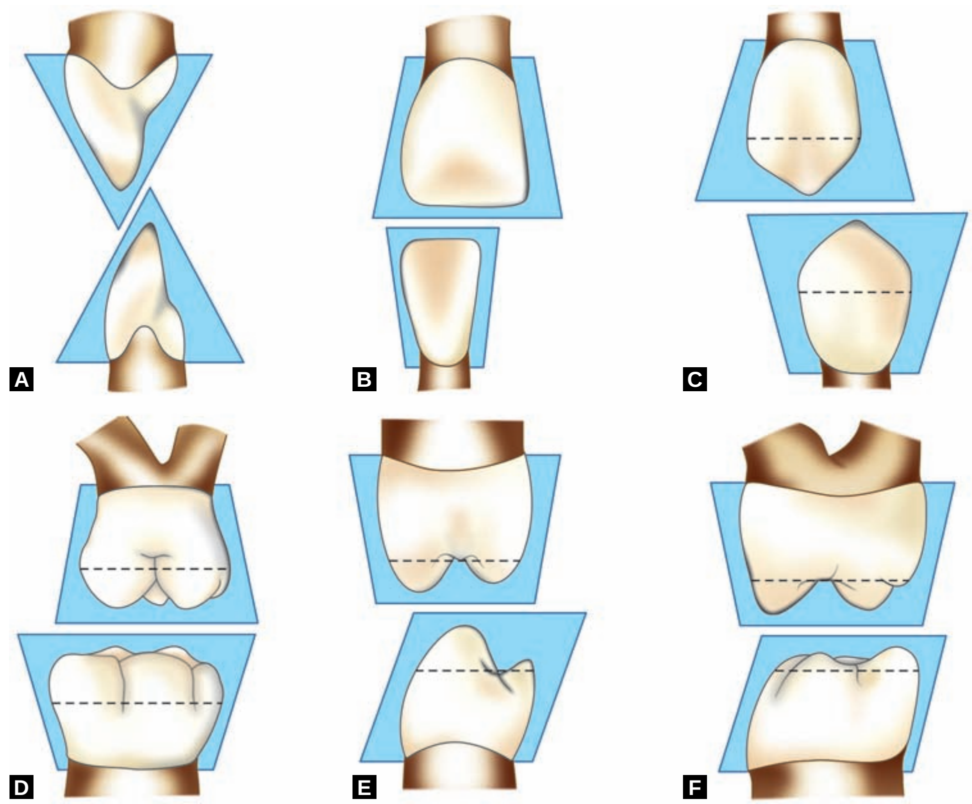
The proximal aspects of maxillary posteriors bring about the following fundamentals of form:

- Since the crown is narrow occlusally, the tooth can be forced into food material more easily during mastication.
- If the occlusal surface were as wide as the base of the crown, the additional chewing surface would have increases the forces of mastication by many folds.

Mesial and Distal Aspects of Mandibular Posterior Teeth

Contrary to maxillary posteriors, the outline of proximal aspects of mandibular posterior teeth is rhomboidal (**Figs 4.28E and F**). However, their occlusal surfaces are constricted in comparison to the bases, similar to the maxillary posteriors.

- The rhomboidal outline obtained is due to the fact that the tooth crowns are inclined lingual to the root bases in case of mandibular posteriors. This ensures proper



Figures 4.28A to F Geometrics of crown outline: (A) Triangular outline—proximal aspect of anteriors; (B to D) Trapezoid outline with narrow cervix—facial and lingual aspect of all teeth; (E and F) Trapezoidal outline with narrow occlusal surface—proximal surface of all maxillary posteriors; Rhomboid outline—proximal aspect of mandibular posteriors

Box 4.2 Geometric crown outlines of teeth

Triangular outline
- All maxillary and mandibular anterior teeth
  - Mesial aspect
  - Distal aspect

Trapezoid outline
- Trapezoid with longest uneven side towards incisal/occlusal surface
  - Facial and lingual aspects of all the teeth (anteriors and posteriors of both the jaws)
- Trapezoid with shortest uneven side towards incisal/occlusal surface
  - Proximal (mesial and distal) aspects of maxillary posterior teeth

Rhomboid outline
- Proximal (mesial and distal) aspects of mandibular posterior teeth

intercuspation of mandibular teeth with their maxillary antagonistics. If mandibular posterior crowns were upright on their root bases, upper and lower cusps would clash and proper intercuspation would not be possible.
- The maxillary posterior teeth have a slight buccal inclination while the mandibular posterior teeth have a slight lingual inclination. Lingual inclination of

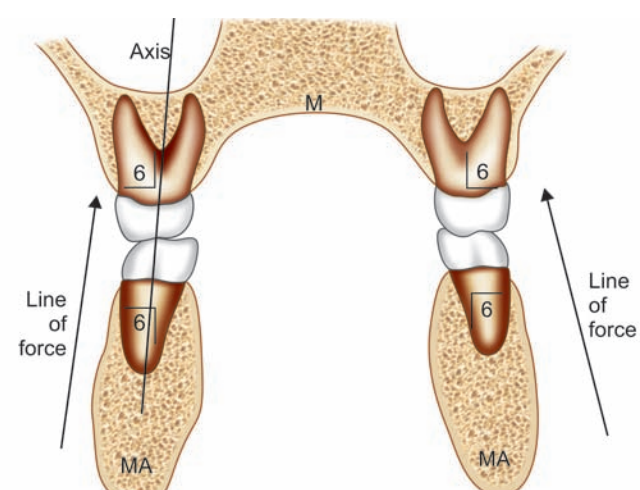


Figure 4.29 Lingual inclination of mandibular teeth and slight buccal inclination of maxillary teeth ensures that the axes of maxillary and mandibular teeth are kept parallel in the jaws. This will be parallel to the line of force

mandibular teeth also ensures that the axes of maxillary and mandibular teeth are kept parallel in the jaws (**Fig. 4.29**).

Box 4.2 summarizes the geometries of crown outlines.

BIBLIOGRAPHY

1. Perel ML. Periodontal consideration of crown contour. J Prosthet Dent. 1971;26:627.
2. Russell ES. Form and function. New York: Dutton; 1917.
3. Shaw DM. Form and function of teeth: A theory of maximum shear. J Anat Physiol. 1917;13:97.
4. Wheeler RC. Complete crown form and periodontium. J Prosthet Dent. 1961;11:722.
5. Youdelis RA, Weaver JD, Sapkos S. Facial and lingual contours of artificial complete crown restoration and their effect on the periodontium. J Prosthet Dent. 1973;19:61.

MULTIPLE CHOICE QUESTIONS

1. Each tooth in permanent dentition is in contact with two adjacent teeth except:
   a. Maxillary central incisors
   b. Maxillary lateral incisors
   c. Maxillary and mandibular 1st molars
   d. Maxillary and mandibular 3rd molars
2. Which of the following statement is false regarding the location of contact areas?
   a. Contact more cervically placed on posterior than in anteriors
   b. Mesial and distal contact areas are nearly at same level in posterior than in anteriors
   c. The contact areas are broader in posteriors than that of anteriors
   d. Mesial contact area is already cervically located than the distal contact area
3. The distal contact area is more cervically placed than the mesial contact area in all teeth except in:
   a. Maxillary canine
   b. Mandibular 1st premolar
   c. Mandibular 1st molar
   d. Mandibular canine
4. Among anteriors both mesial and distal contact areas at the same level in:
   a. Maxillary central incisors
   b. Mandibular central incisors
   c. Mandibular lateral incisors
   d. Mandibular canine
5. Which of the following statements is false about the embrasures?
   a. Lingual embrasures are wider than facial embrasures
   b. They are 'V' shaped spaces between adjacent teeth
   c. Embrasures are more uniform in anteriors than posteriors
   d. Embrasures should be ideally symmetrical
6. In posterior teeth, the crest of curvature buccally is at:
   a. Occlusal 3rd
   b. Middle 3rd
   c. Cervical 3rd
   d. None of above
7. In posterior teeth, the crest and curvature is at:
   a. Occlusal 3rd
   b. Middle 3rd
   c. Cervical 3rd
   d. None of above
8. The curvature of cervical line is maximum on:
   a. Mesial surface of maxillary central incisor
   b. Mesial surfaces of maxillary 2nd molar
   c. Distal surface of mandibular 3rd molar
   d. Distal surface of maxillary 3rd molar
9. The geometric form of proximal aspect of anterior is:
   a. Triangular
   b. Rhomboid
   c. Trapezoid
   d. Quadrilateral
10. The geometric form of maxillary molar is:
    a. Trapezoid
    b. Rhomboid
    c. Quadrilateral
    d. Circular

Answers

1. d	2. d	3. b	4. b	5. c	6. c	7. b	8. a	9. a	10. b

SECTION

3

Deciduous Dentition

CHAPTER 5

Primary (Deciduous) Dentition

Humans are diphyodonts having two sets of dentitions in their life time. The first set of teeth is termed as the '*primary dentition*' or '*deciduous dentition*'. The term '*deciduous*' comes from Latin word meaning 'to fall off'. The deciduous teeth are called so since they fall off or shed naturally similar to the leaves of deciduous trees. Both the terms are accepted and are used interchangeably to describe the first set of dentition in this book.

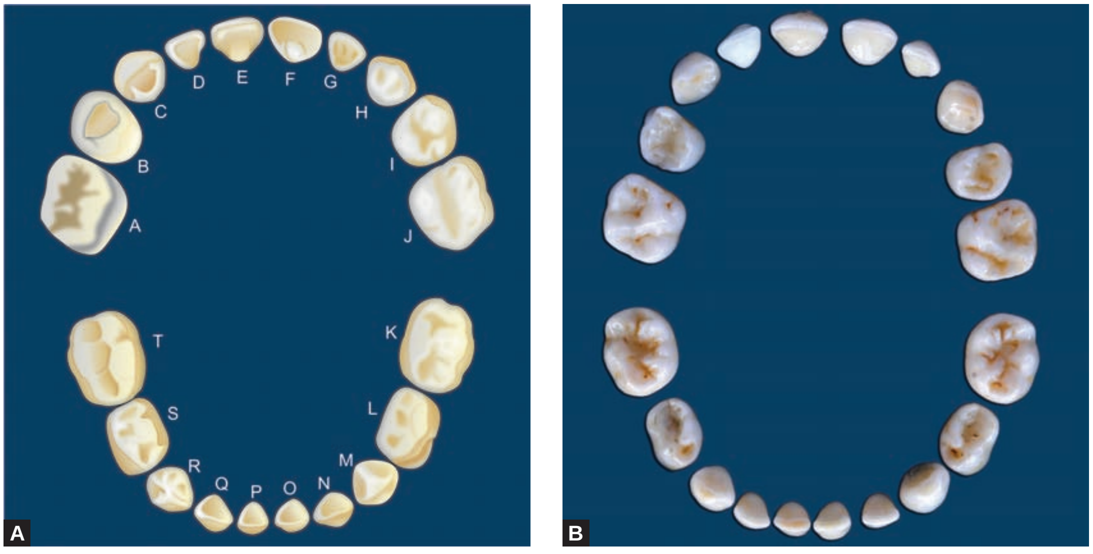
Sometimes, the deciduous teeth are also referred to as '*temporary teeth*', '*milk teeth*', '*baby teeth*' or '*lacteal teeth*'. However, these terms are improper and should be discouraged since they erroneously imply that these teeth are useful for a short period only and thus denote a lack of importance.

DENTAL FORMULA FOR PRIMARY DENTITION

There are a total of 20 teeth in the primary dentition, 10 in each jaw (**Fig. 5.1A**). Each jaw has 4 incisors, 2 canines and 4 molars. Each quadrant has 5 teeth namely—central incisor, lateral incisor, canine, 1st molar and 2nd molar, beginning from the midline. *There are no premolars in primary dentition*.

In mixed dentition period, when the permanent teeth (succedaneous teeth) replace their predecessors (primary teeth)—the primary incisors are replaced by the permanent incisors; the primary canines are replaced by the permanent canines. However, the *primary molars are replaced by the permanent premolars*. The permanent molars do not replace any teeth but erupt distal to the primary molars. In other words, *the permanent molars are not succedaneous teeth as they do not have predecessors in primary dentition* (**Fig. 5.2**). It is also important to note that, there are *no 3rd molars in primary dentition*. Thus, the premolars and the 3rd molars are the teeth which are present only in the permanent dentition.

Primary anteriors resemble their respective permanent anteriors. The primary maxillary 1st molars resemble the permanent premolars in crown form. However, they have



Figures 5.1A and B (A) Primary dentition has 20 teeth, 10 in each jaw (4 incisors, 2 canines, 4 molars); and no premolars (Tooth notation in universal system) and graphic illustration; (B) Teeth specimen arranged in their respective position in the dental arches

three roots like maxillary molars. The primary mandibular 1st molars have unique crown form that does not resemble any permanent tooth. The primary 2nd molars closely resemble and appear like miniature permanent 1st molars of the respective dental archers (**Fig. 5.1B**).

The dental formula (representing each half of mouth) for primary dentition in humans is as follows:

Figure 5.2 OPG of a 6-year-old boy showing replacement of primary teeth by their respective successors—primary incisors by permanent incisors, primary canines by permanent canines and primary molars by the permanent premolars. Note that the permanent molars are not succedaneous teeth and do not replace any primary teeth. (Note that 31 and 41 have already erupted, permanent 1st and 2nd molars are developing distal to the primary molars. The 3rd molar germs are not yet seen)

$I\frac{2}{2}, C\frac{1}{1}, M\frac{2}{2}$ (10 per one side of mouth)

On the other hand, the dental formula for human permanent dentition is:

$I\frac{2}{2}, C\frac{1}{1}, P\frac{2}{2}, M\frac{3}{3}$ (16 per one side of mouth)

Life Cycle

Development of the primary teeth begins prenatally about 11 weeks *in utero*, with the appearance of first evidence of calcification of primary central incisors, and is completed postnatally at about 3 years of age. **Figure 5.3** illustrates the development of primary teeth.

Crown formation of all primary teeth is completed at about 12 months of age. Eruption of primary teeth into oral cavity usually begins with the emergence of mandibular central incisors at around 6 months (**Fig. 5.4A**) and is completed with the eruption of maxillary 2nd molars around 2.5 years (24 ± 4 months). The roots of primary teeth are completely formed in just 1 year after eruption the crown into oral cavity; root formation of all the primary teeth is completed by 3 years of age (**Fig. 5.4B**). The complete primary dentition is functional in the mouth from 2 to 6 years of age, after which the primary teeth are gradually replaced by the permanent teeth. Thus, primary dentition period lasts from 6 months to 6 years of age.

The roots of deciduous teeth begin to resorb just 2 to 3 years after their completion. Resorption begins at the apices

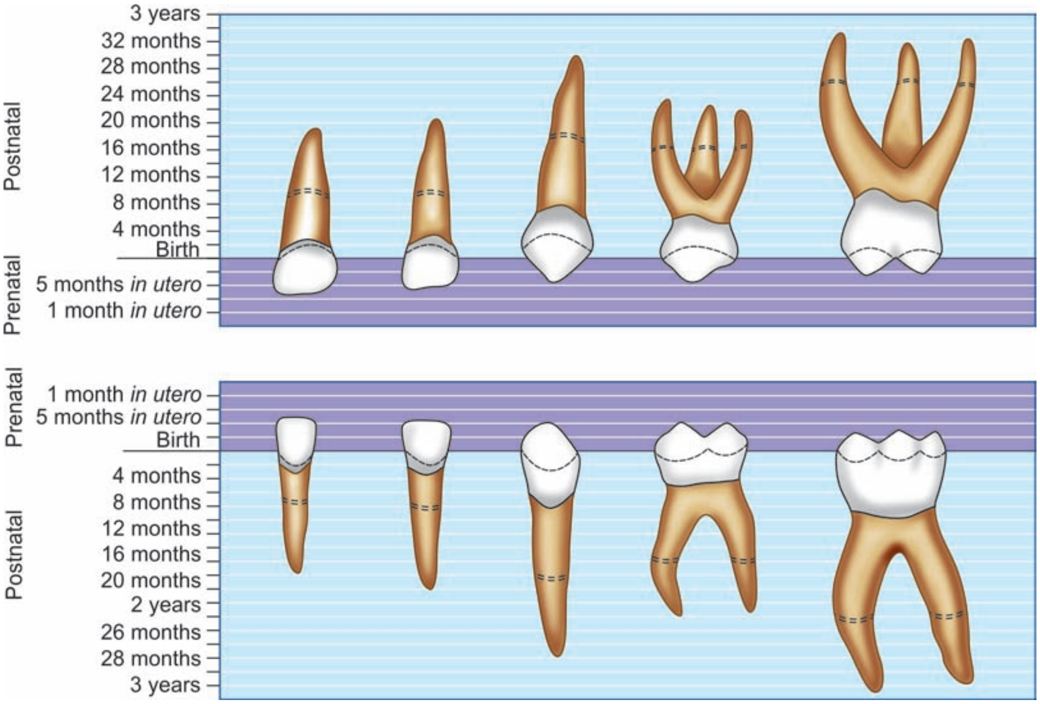


Figure 5.3 Diagrammatic illustration of chronology of primary teeth. Eruption is completed at the time indicated by the dotted area on the root of teeth. Dotted line on crowns of teeth indicates the portion formed prenatally

Figures 5.4A and B (A) Eruption of primary teeth usually begins with emergence of mandibular central incisors at around 6 months of age; (B) OPG of a 3-year-old boy showing root completion of all the primary teeth

of roots and continues gradually towards the crown. When most of the root is resorbed, the crown is shed naturally making way for eruption of the permanent successor tooth (**Fig. 5.5**). The deciduous teeth are exfoliated between 7 and 12 years of age.

Transitional/mixed dentition period begins with the emergence of permanent 1st molars (**Fig. 5.6**). The permanent 1st molars erupt distal to deciduous 2nd molars before any of the deciduous teeth are lost. The transitional period lasts from 6 to 12 years of age, or ends when all the deciduous teeth have been shed. Permanent dentition stage begins at that time.

Chronology of deciduous teeth is given in **Table 5.1**.

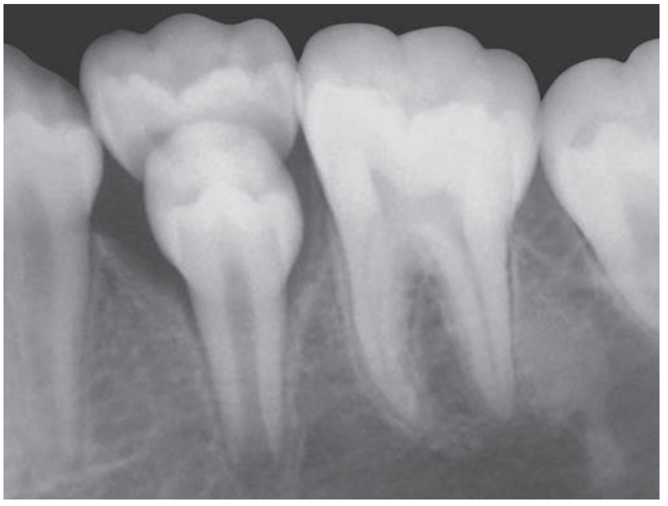


Figure 5.5 A permanent successor tooth replaces its predecessor when most part of latter's root is resorbed and is shed naturally

SIGNIFICANCE OF DECIDUOUS DENTITION

A person with average life expectancy of 70 years would spend only 6 percent of his/her life masticating solely with primary teeth. Despite this small proportion of time they serve, care of deciduous dentition is very much essential for the normal growth and development of the jaws and establishment of normal occlusion of permanent dentition. Well cared primary teeth ensure proper alignment of the permanent teeth by 'preserving' space for the latter until they erupt. Malocclusion with severe crowding can occur when primary teeth are lost prematurely.

Importance of primary teeth can be listed as follows:

- *Efficient mastication of food*: With the establishment of primary occlusion, child learns to masticate the food efficiently. Neuromuscular coordination required for masticatory process is established at primary dentition stage itself.
- *Maintenance of a proper diet and good nutrition:* Primary teeth are the only teeth present until six years of age and thus it is important to provide the child with a comfortable functional occlusion of primary teeth. A child with missing/grossly decayed primary teeth may reject food that is difficult to chew.
- *Maintenance of normal facial appearance*: A well-cared set of deciduous dentition contributes to establishment and maintenance of the normal facial appearance during the tender age of childhood (**Fig. 5.7A**). It contributes to normal psychological and cognitive development of the child. Prematurely lost or rampantly carious front teeth may hamper a child's self-confidence due to mocking from their peers (**Fig. 5.7B**).
- *Development of clear speech*: Teeth, especially the anteriors are essential for normal pronunciation of consonants. Speech is developed in early childhood and congenital absence or premature loss of anterior primary teeth can hamper the development of clear speech.

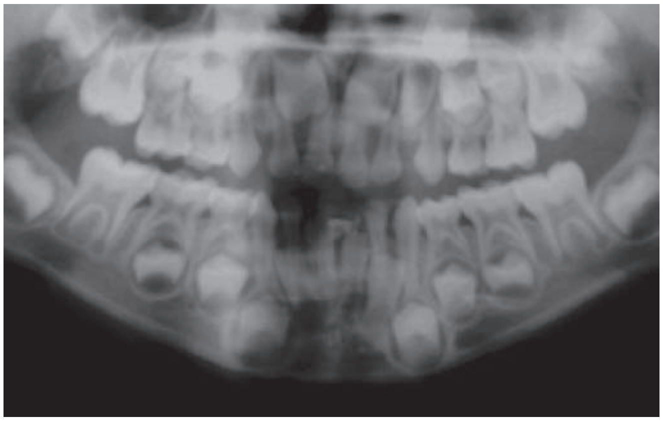
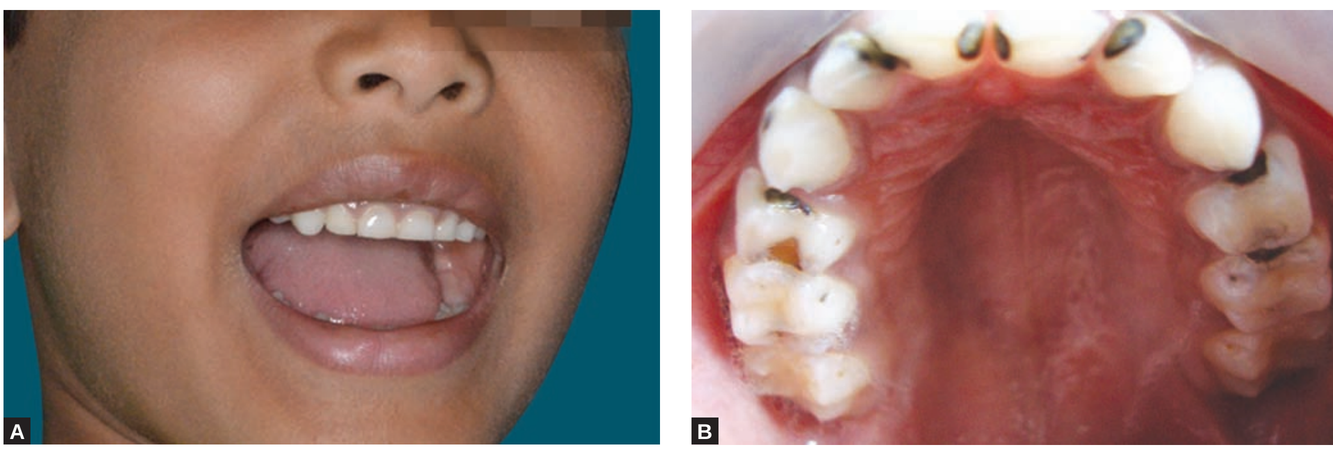


Figure 5.6 The transitional/mixed dentition period begins with emergence of the permanent 1st molars usually before any of the primary teeth are lost

- *Avoidance of infection and possible sequelae:* It is important to prevent and treat dental caries of primary teeth so as to prevent abscess formation and pain. Spread of infection from periapical abscess (especially in primary molars) may reach the underlying permanent tooth germs and can cause brown spots of their crowns (Turner's hypoplasia).
- *Maintenance of normal eruption schedule of permanent successors:* Timing and pattern of primary teeth shedding reflects the eruption schedule of permanent successors. In natural process, a primary tooth is shed when its successor permanent tooth is ready to erupt. Generally, successor tooth erupts within three months of exfoliation of its predecessor tooth. However, this normal eruption schedule of permanent teeth is disturbed when primary teeth are lost prematurely due to caries or trauma. As a consequence malocclusion may develop.



Figures 5.7A and B (A) Well-cared deciduous dentition contributes to normal facial appearance and boosts psychological and cognitive development of the child; (B) Carious/prematurely lost front teeth may hamper child's self-confidence

Table 5.1 Chronology of primary teeth*

Tooth	*First evidence of calcification (Weeks in utero)*	*Amount of enamel formed at birth*	*Crown completed*	*Eruption*	*Root completed*
Maxillary teeth					
Central incisor	14	Five-sixths	1½ months	7½ months	1½ years
Lateral incisor	16½	Two-thirds	2½ months	9 months	2 years
Cuspid	17	One-third	9 months	18 months	3¼ years
1st molar	15½	Cusps united	6 months	14 months	2½ years
2nd molar	19	Cusp tips still isolated	11 months	24 months	3 years
Mandibular teeth					
Central incisor	14½	Three-fifths	2½ months	6 months	1½ years
Lateral incisor	16½	Three-fifths	3 months	7 months	1½ years
Cuspid	17	One-third	9 months	16 months	3¼ years
1st molar	15½	Cusps united	5½ months	12 months	2¼ years
2nd molar	18	Cusp tips still isolated	10 months	20 months	3 years

* Chronology of teeth. Schour and Massler (1940); Logan and Kronfeld sightly modified by McCall and Schour (1933).

- *Maintenance of space for eruption of permanent successor teeth*: Primary teeth serve a very important function of 'preserving' the space for eruption of their permanent successor teeth. Presence of adequate physiologic spacing in primary dentition is conductive to the development of normal occlusal relations in permanent dentition (**Fig. 5.8**). Maintenance of space is especially important in canine and molar regions since their successors, the permanent canines and premolars erupt relatively late in life. When primary teeth are lost prematurely, the adjacent teeth migrate into the available space leading to a decrease in the arch length. This causes a lack of space in the arch for the erupting permanent successors and results in the development of malocclusion. A lack of space associated with premature loss of primary teeth is a common cause of malocclusion development (**Fig. 5.9A**).

When a primary tooth is lost prematurely due to trauma, caries, etc. the space occupied by the lost tooth should be maintained using appliances known as 'space maintainers' until the permanent successor erupts (**Fig. 5.9B**).

DETAILED DESCRIPTION OF EACH PRIMARY TOOTH

DECIDUOUS INCISORS

Deciduous incisors are the first teeth to erupt into oral cavity. The mandibular central incisors erupt at around 6 to 8 months of age, followed by mandibular lateral, maxillary central and maxillary lateral incisors. Deciduous incisors are morphologically similar to permanent incisors. However, they do not exhibit mamelons on the incisal margin. All deciduous incisors have single conical roots.

DECIDUOUS MAXILLARY CENTRAL INCISOR

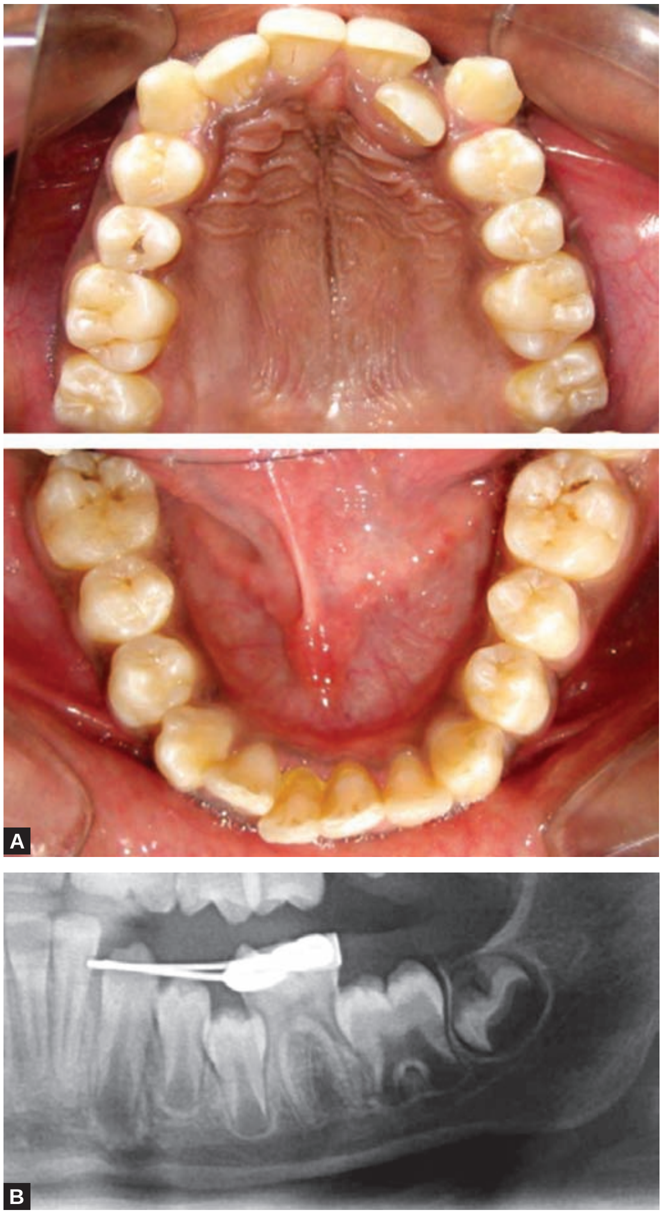
Figures 5.10 and 5.11 show various aspects of deciduous maxillary central incisor.

Figure 5.8 Adequate physiologic spacing between the primary teeth in a 5-year-old child

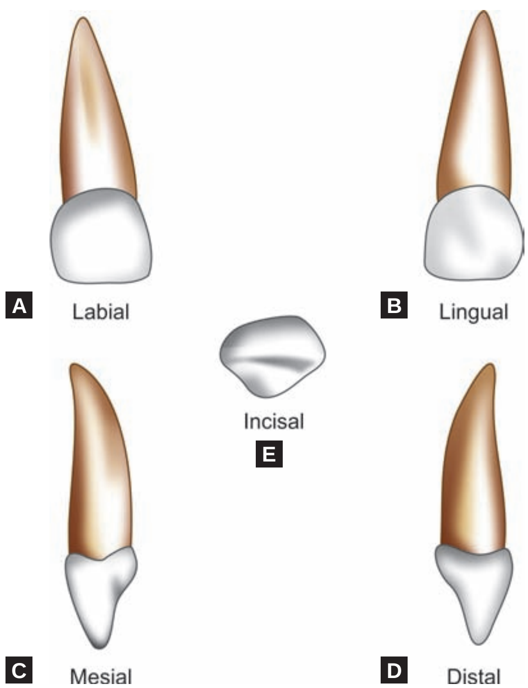
Crown

Labial Aspect (Figs 5.10A and 5.11A)

Geometric shape: As with its permanent counterpart labial aspect of the crown is trapezoidal with shorter of the uneven side towards the cervix.



Figures 5.9A and B (A) Crowding in maxillary anterior region due to premature loss of primary molars and resultant anterior shifting of premolars, leaving inadequate space for canine eruption; (B) A portion of OPG showing band and loop type of space maintainer given on mandibular 1st molar to preserve the space for eruption of canine and premolars



Figures 5.10A to E Primary right maxillary central incisor

Crown Outlines
- *Mesial outline*: It is nearly straight from cervical line to mesioincisal angle
- *Distal outline*: It is more convex, curves down from cervical area to end in a rounded distoincisal angle
- *Incisal outline*: It is rather straight, formed by the incisal ridge
- *Cervical outline*: It is formed by smooth distinct arc of the cervical line that curves apically.

Labial Surface within the Outlines
- Deciduous maxillary incisor crown is noticeably wider mesiodistally and longer cervicoincisally.
- Deciduous maxillary central incisors are the only incisors (in both deciduous and permanent dentition) in which mesiodistal diameter of the crown is greater than the cervicoincisal dimension.
- Labial surface is slightly convex in all planes. It is smooth and devoid of developmental grooves, depressions and lobes.
- Unlike permanent incisors, the deciduous incisors do not show mamelons on their incisal ridge. More often than not, the incisal ridge is attrited to form a straight incisal edge. The mesioincisal angle is sharp and acute while the distoincisal angle is obtuse and rounded.
- *Contact areas:* Contact areas are comparable to that of the permanent counterparts. Mesial contact area is at the incisal third; distal contact area is at the junction of incisal and middle thirds of the crown. With rapid jaw growth in children physiologic spacing develops between deciduous anteriors and the contact areas are lost.

Lingual Aspect (Figs 5.10B and 5.11B)

Geometric shape: Trapezoidal similar to labial aspect.

Crown Outlines
- Outlines are similar to that of labial aspect
- Cervical line curves more apically than it does on labial aspect.

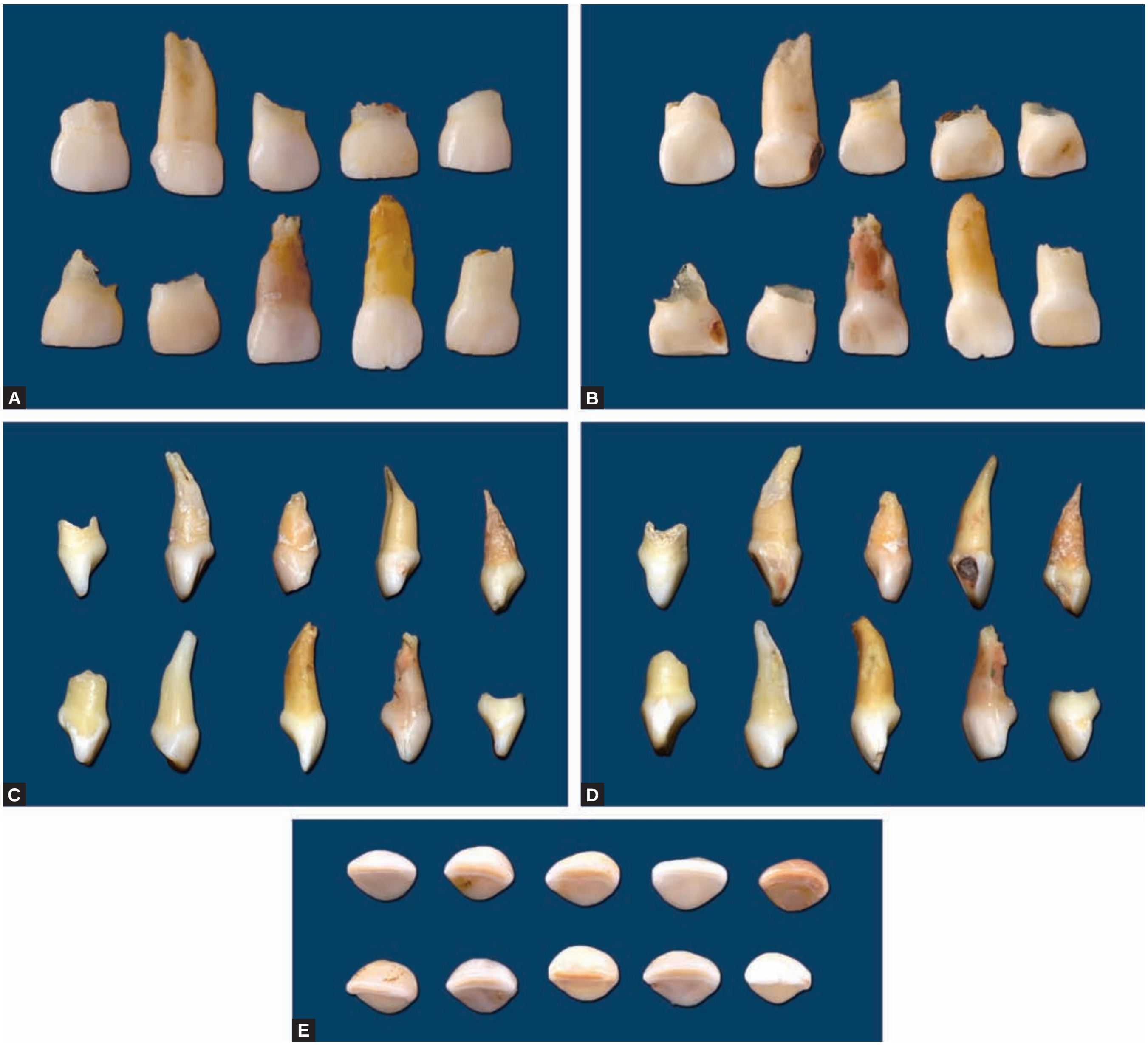
Lingual Surface within the Outlines
- The cingulum is very well developed, proportionally larger than seen on permanent maxillary central incisors.
- It extends far more towards the incisal ridge than that of permanent maxillary central incisors, occupying major part of lingual surface.
- Cingulum is smoothly convex with no grooves/pits.
- The lingual fossa is smaller and shallower.
- The marginal ridges are well developed and distinct.
- As with permanent incisors, the proximal walls of the crown taper towards lingual aspect, making lingual surface narrower than the labial surface.

Mesial Aspect (Figs 5.10C and 5.11C)

Geometric shape: Proximal aspect of deciduous anteriors is *triangular* or *wedge shaped*. This is true for permanent anteriors as well.

Crown Outlines
- *Labial outline*: It is more convex near the cervix due to prominent cervical ridge
- *Lingual outline*: It is 'S' shaped and formed by convexity of cingulum and concavity of the lingual fossa
- *The cervical line* outlining the CEJ is distinct and curves incisally but to a lesser degree than seen on permanent maxillary central incisors
- *The incisal outline*: It formed by the the incisal ridge is a small arc on non attrited tooth. More commonly the crown is attrited forming an incisal edge with a palatal slope.

Mesial Surface within the Outlines
- The crown appears bulkier labiolingually cervical area due to bulges of cervical enamel ridge on one side and cingulum on the other.
- The mesial surface is smooth and convex.
- Incisal ridge located on the root axis/line labial to the root axis line. In other words, the incisal ridge is located labial to the line bisecting the root and crown.
- In permanent maxillary central incisor, the incisal ridge is on line with its root axis line.



Figures 5.11A to E Primary maxillary central incisor—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

Distal Aspect (Figs 5.10D and 5.11D)

- Distal aspect is similar to that of mesial aspect in terms of shape and crown outline.
- As with permanent incisors, the cervical line curvature is less in extent on the distal surface than on the mesial surface.

Incisal Aspect (Figs 5.10E and 5.11E)

Geometric shape: The crown appears diamond-shaped viewed from incisal aspect.

- The mesiodistal diameter is greater than the labiolingual diameter.
- The incisal edge is straight and is centered over the crown.

- Labial surface is smooth and convex mesiodistally.
- The crown tapers lingually towards the cingulum.

Root

Number: Single

Size: The root is longer in proportion to the crown than in permanent central incisor.

The root is about twice the length of its crown.

Form

Labial and Lingual Views

- The root is cone shaped with tapering sides
- Similar to the crown, the roots also converge lingually forming a ridge for its full length.
- Often the roots exhibit physiologic resorption. Resorption occurs on lingual aspect of the roots since the permanent successors of deciduous anteriors are located apical and lingual to them in the jaws.

Mesial and Distal Views

- From proximal views, the root appears broader than labial and lingual aspect.
- Mesial surface of the root may show a developmental groove/concavity while the distal surface is smoothly convex.

Apex

The root apex is generally blunt.

Curvature of the Root

Apical portion of the root may show a labial curvature. This arrangement is believed to provide room for the developing permanent teeth that is located in an apical and lingual portion in the jaw.

Cross-section at the Cervix

Cross-section of the root at the neck of the tooth is triangular with rounded angles. Base of the triangle is towards the labial aspect while the apex is towards lingual aspect.

DECIDUOUS MAXILLARY LATERAL INCISOR

The deciduous maxillary lateral incisor is similar to the central incisor from all the aspects though smaller in size. **Figures 5.12 and 5.13** show deciduous maxillary lateral incisor from various aspects.

Crown

The lateral incisor crown is smaller in all dimensions than the central incisor.

Labial Aspect (Figs 5.12A and 5.13A)

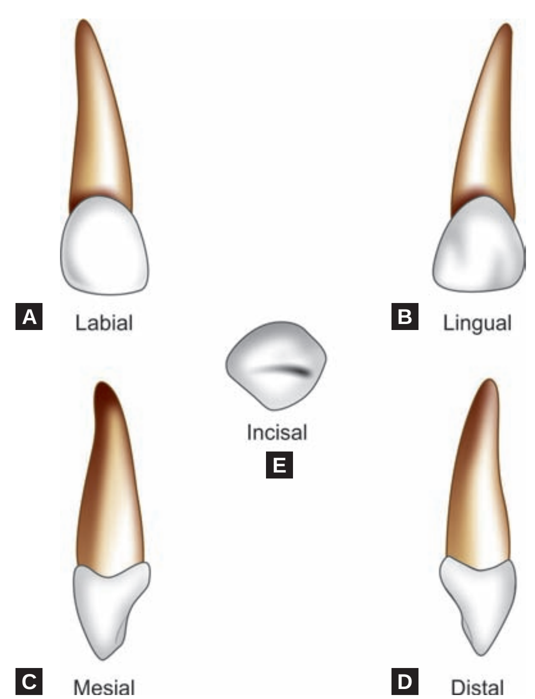
- Cervicoincisal length of the crown is slightly greater than mesiodistal width.
- The crown is longer cervicoincisally than it is wide mesiodistally
- The distoincisal angle is much more rounded than seen in the deciduous maxillary central incisor
- The incisal ride may form a semicircular arc rather than a straight line. There are no mamelons on the incisal margin
- The lateral incisor crown is less symmetrical than the central incisor.

Lingual Aspect (Figs 5.12B and 5.13B)

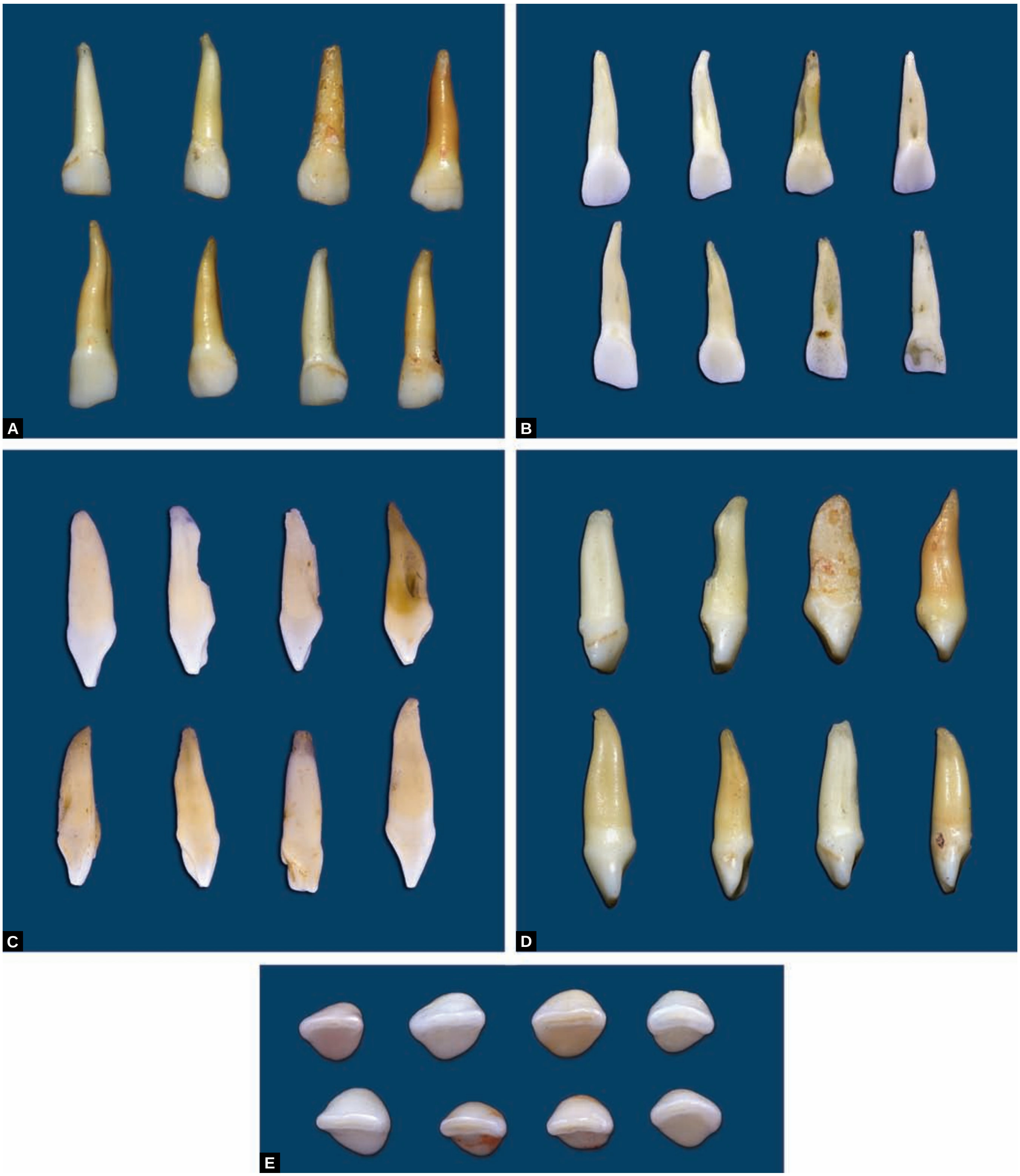
- The cingulum is less pronounced than seen on the central incisor. It does not extend incisally as far as seen in the central incisor.
- Marginal ridges are well-marked and concavity of the lingual fossa is deeper than that of the central incisor.

Mesial and Distal Aspects [Figs 5.12 (C and D) and 5.13 (C and D)]

The lateral incisor crown appears similar to the central incisor from proximal aspects. However, faciolingually, the crown looks less bulky due to less pronounced cingulum and cervical enamel ridge. Constriction of the neck of the tooth is visibly more apparent from proximal views.



Figures 5.12A to E: Primary right maxillary lateral incisor



Figures 5.13A to E Primary maxillary lateral incisor—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

Incisal Aspect (Figs 5.12E and 5.13E)

Geometric shape: From incisal view, the crown appears *circular* rather than diamond shaped as seen in case of the central incisor.

- Incisal ridge is more curved.
- Mesial surface of the tooth appears broader and rounded than the mesial surface from this view.
- Looking from this view, the labial surface is more convex than seen on the central incisor.
- Lingual surface tapers towards cingulum and the lingual fossa is distinct.

Root

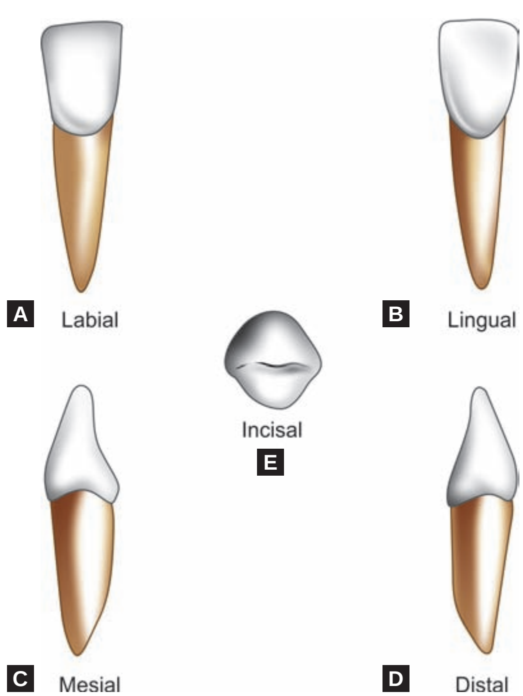
Number: Single.

Size

- The deciduous lateral incisor root is much longer in proportion to its crown than in case of the central incisor.
- The root is more than twice the length of its crown.

Form

- The deciduous lateral incisor root has a conical shape similar to that of central incisor. However, it is less bulky mesiodistally and flatter on mesial and distal surfaces.
- The sides of the root tapers gradually towards its apex.
- The root is often resorbed and the resorption pattern is typically on the lingual surface of the root.



Figures 5.14A to E Primary right mandibular central incisor

Cross-section: Cross-section of the root at the cervix is circular/oval in shape.

Curvature of the root: In a completely formed and non-resorbed tooth the root shows a distal curvature.

Apex: The root apex may be blunt.

DECIDUOUS MANDIBULAR CENTRAL INCISOR

Deciduous mandibular central incisors are the smallest teeth in human dentitions. They are also the first teeth to erupt into oral cavity. **Figures 5.14 and 5.15** show deciduous mandibular central incisor from various aspects.

Crown

Labial Aspect (Figs 5.14A and 5.15A)

Geometric shape: *Trapezoidal* with the shortest of uneven sides towards the cervix. The tooth is bilaterally symmetrical like that of its permanent incisor.

Crown Outlines

- *Mesial* and *distal outlines* are straight, symmetrical, and evenly taper down towards the cervical line.
- *Incisal outline* is formed by the incisal ridge/edge. It is straight line in horizontal plane. There are no mamelons seen
- *Cervical line* signifying the CEJ is distinct. It forms a smooth arc curving apically.

Labial Surface within the Outlines

- The cervicoincisal length of the crown is slightly greater than the mesiodistal width. However, the crown is wider in proportion to permanent successor.
- The crown appears bilaterally symmetrical
- Both the mesioincisal and distoincisal angles are sharp and makes right angles
- The labial surface is smooth, slightly convex and unmarked by developmental grooves and depressions.
- *Contact areas:* As with permanent mandibular central incisor, the mesial and distal contact areas at the same level and located at incisal third.

Lingual Aspect (Figs 5.14B and 5.15B)

Geometrical shape: Trapezoidal like that of labial aspect.

Crown outlines: Similar but reversal to that seen on labial aspect.

Lingual Surface within the Outlines

- The lingual surface is narrower than the labial surface as the proximal walls converge towards lingual aspect.
- The cingulum is not well-developed although as prominent as seen on deciduous maxillary central incisor.
- The marginal ridges are not well-developed.

- The lingual fossa is shallow and smooth.
- The cervical line is positioned more apically lingual than on labial surface.

Mesial and Distal Aspects [Figs 5.14 (C and D) and 5.15 (C and D)]

Geometrical shape: Proximal aspect of the crown is triangular in form with the base of the triangle towards the cervix and apex towards the incisal ridge.

Crown Outlines

- *Labial outline*: It is convex with the crest of curvature located on the cervical enamel ridge at the cervical third.
- *Lingual outline*: It is 'S' shaped, the crest of contour is at cingulum in the cervical third of the crown.
- *Cervical line*: It is located more apically on lingual than on labial surface.
- *Incisal outline*: It is formed by the incisal ridge an incisal edge with a labial slope in attrited tooth.

Proximal Surface within the Outlines

- The incisal ridge is centered over the root axis line. In case of permanent central incisor, the incisal ridge is located lingual to the root axis line.
- The mesial and distal surfaces are smooth and convex.
- The crown appears robust from proximal as compared to its small size although small; the tooth is bulkier in labiolingual dimension. Its labiolingual measurement is comparable to that of maxillary central incisor being only 1 mm smaller.

Incisal Aspect (Figs 5.14E and 5.15E)

Geometrical shape: Viewed incisally, the crown appears circular.

- The incisal ridge is centered over the bulk of the crown.
- Major bulk of the crown is located at cervical third.
- Labial surface is convex and tapers lingually.
- The mesiodistal dimension is almost equal to labiolingual dimension of the crown.

Root

Number: Single.

Size: The root is twice the length of the crown.

Form

From Labial and Lingual Views

- The root is conical, with its sides tapering evenly to its apex
- Similar to all incisors, the root also converges towards lingual aspect, making lingual surface narrower than the labial surface.

From Proximal Views

- The mesial surface is flat and smooth.
- The distal surface of the root often shows a developmental depression.
- The root shows physiologic resorption on lingual aspect the whole root may be gone.
- *Apex*: When not resorbed, the apex is sharp.

Root of curvature: The root is often straight and sometimes may show a labial curvature at the apical portion.

Cross-section: Cross-section of the root at cervix is circular.

DECIDUOUS MANDIBULAR LATERAL INCISOR

As in permanent dentition, morphology of the mandibular lateral incisor is similar to the central incisor but is larger than the latter. The mandibular lateral incisor is larger than the central incisor in all dimensions. However, both the incisors are of same bulk labiolingually. **Figures 5.16 and 5.17** show deciduous mandibular lateral incisor from various aspects.

Crown

Labial Aspect (Figs 5.16A and 5.17A)

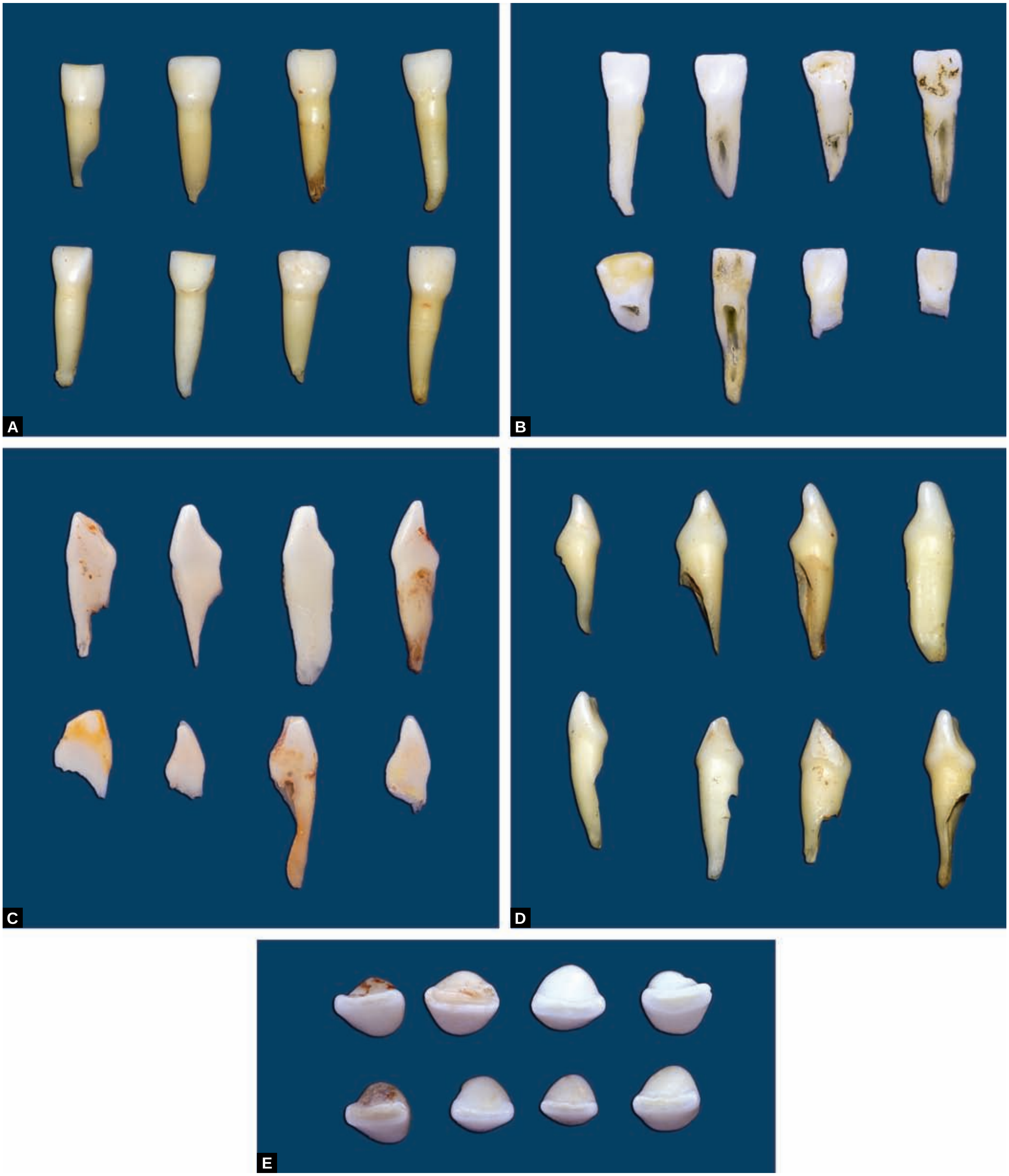
- The deciduous mandibular lateral incisor crown is wider in proportion to its length when compared to its permanent successor.
- The mandibular deciduous lateral incisor is slightly larger than the mandibular deciduous central incisor.
- Unlike the deciduous mandibular central incisor, the lateral incisor is asymmetrical and has sharp mesioincisal angle and the distoincisal angle is rounded than on central incisors.
- When the distoincisal angle is markedly rounded. The tooth mimics maxillary deciduous lateral incisor. Sometimes, it may be difficult to distinguish the two teeth.
- It is observed that, the incisal ridge/edge has a tendency to slope downwards in a distal direction.

Lingual Aspect (Figs 5.16B and 5.17B)

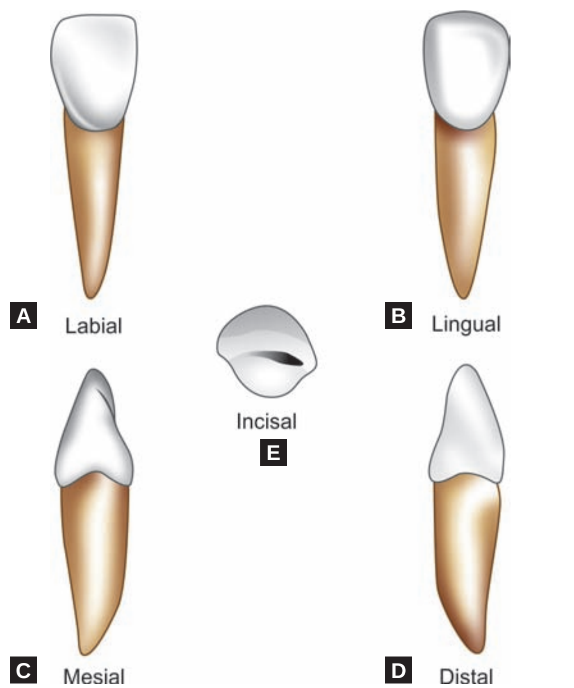
- When compared to the deciduous mandibular central incisor, the cingulum may be more well-developed deciduous mandibular lateral incisor.
- The lingual fossa of the deciduous mandibular lateral incisor may be deeper.

Mesial and Distal Aspects [Fig 5.16 (C and D) and 5.17 (C and D)]

The deciduous mandibular lateral incisor appears identical to the deciduous mandibular central incisor from proximal view. Labiolingual dimension is greater at the cervical third in both the teeth.



Figures 5.15A to E Primary mandibular central incisor—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect



Figures 5.16A to E Primary right mandibular lateral incisor

Incisal Aspect (Figs 5.16E and 5.17E)

Geometric shape: It is *circular*.

- As with mandibular deciduous mandibular central incisor, the mesiodistal and labiolingual dimension of the crown is equal from this view.
- The convexity of the lingual face is more generous than on the mandibular deciduous central incisor.

Root

The morphology of the root is similar to that of mandibular central incisor, though it is slightly longer.

Number: Single.

Size: Longer than the mandibular central incisor root.

Form: The root is conical similar to the mandibular central incisor.

Apex: Root apex when not resorbed may be sharp.

Curvature: The apical half of the root of the shows a labial tilt.

Cross-section: It is oval/circular at cervix.

DECIDUOUS CANINES

DECIDUOUS MAXILLARY CANINE

Deciduous maxillary canines are the most common deciduous teeth to be over retained in the oral cavity. This is due to delayed eruption timing/schedule of permanent maxillary canine which erupts after the eruption of premolars in the arch. When the arch length is reduced, the permanent canine may erupt labially or lingually leading to malocclusion. **Figures 5.18 and 5.19** show deciduous maxillary canine from various aspects.

Crown

Labial Aspect (Figs 5.18A and 5.19A)

Geometrical shape: The crown appears diamond-shaped from labial and lingual views with broader sides pointed tip and constricted neck.

Crown Outlines

- *Mesial outline*: It is convex from cervical line to the mesial contact area.
- *Distal outline*: It is also convex, slopes distally downwards from cervical line to the distal contact area.
- *Cervical outline*: It is formed by the cervical line. It is nearly flat and may curve slightly towards root apex.
- *Incisal outline*: It is 'V' shaped, formed by the mesial and distal slopes of the cusp with its tip at the center.

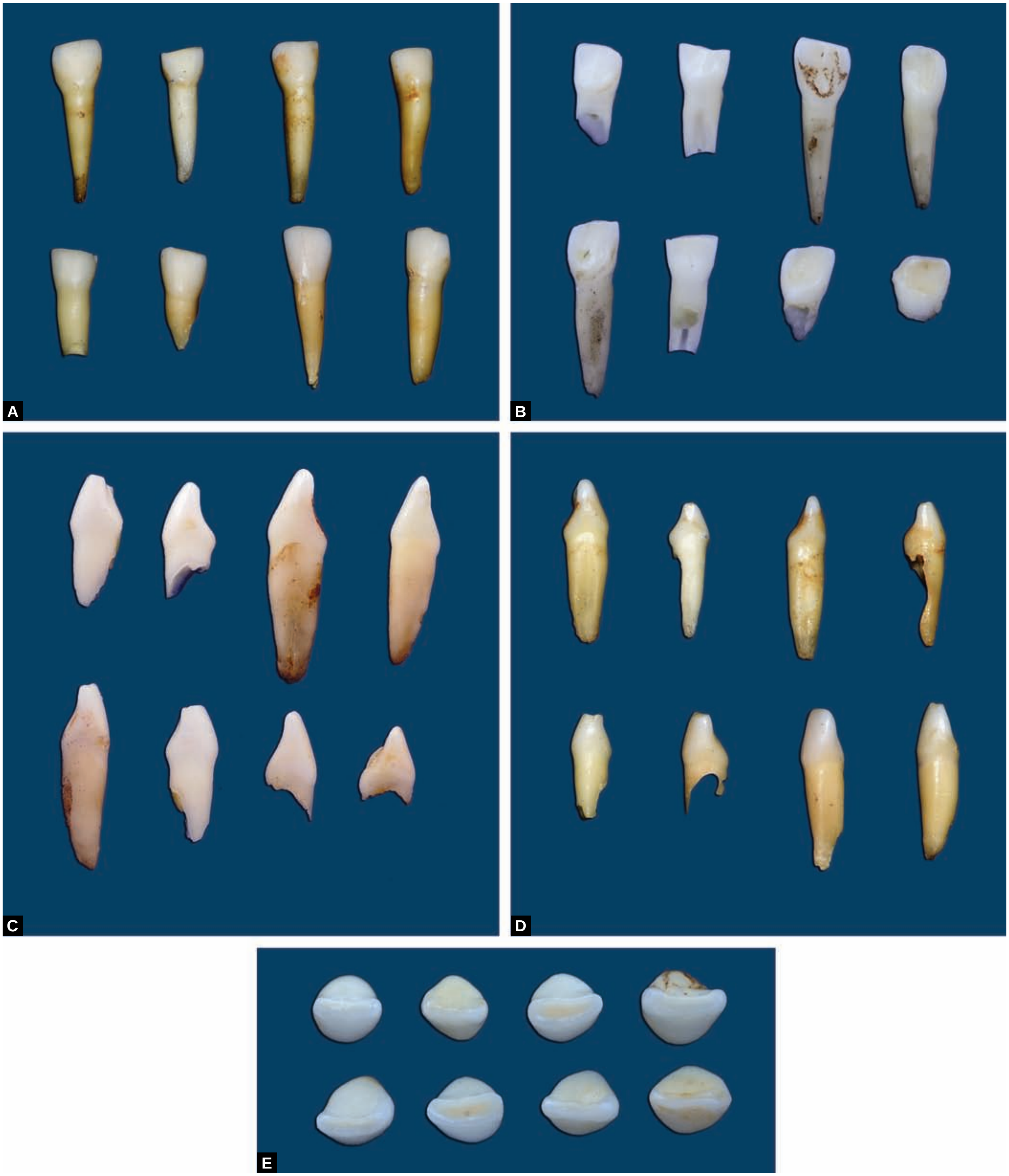
Labial Surface within the Outlines

- In deciduous maxillary canine, the crown is more bulbous in proportion to its root than in its permanent successor.
- There is marked cervical constriction at the neck.
- The mesiodistal diameter of the crown is greater than its cervicoincisal length. This along with the marked cervical constriction makes the crown look bulbous.
- When not worn, the cusp on deciduous canine is much longer, shaper and more pointed compared with that of the permanent maxillary canine.
- The two cusp ridges meet at an acute angle.
- In general, *the distal cusp ridge is longer than the mesial in all teeth except in permanent maxillary 1st premolar and deciduous maxillary canine*.
- *Contact areas:* The mesial and distal contact areas are in middle third near the center of the crown cervicoincisally. Both the contact areas are nearly at same level with mesial contact area slightly cervically placed than the distal contact area.
- The labial surface is smooth and convex.
- There is cervical enamel ridge near the cervix. A labial ridge may be noted running from the cervical ridge to the cusp tip on labial surface.
- A horizontal line drawn through the contact area in primary maxillary canine would bisect the crown into cervical and apical halves. This is sharply in contrast to permanent maxillary canine in which, the mesial and distal contact areas are located at markedly different levels.

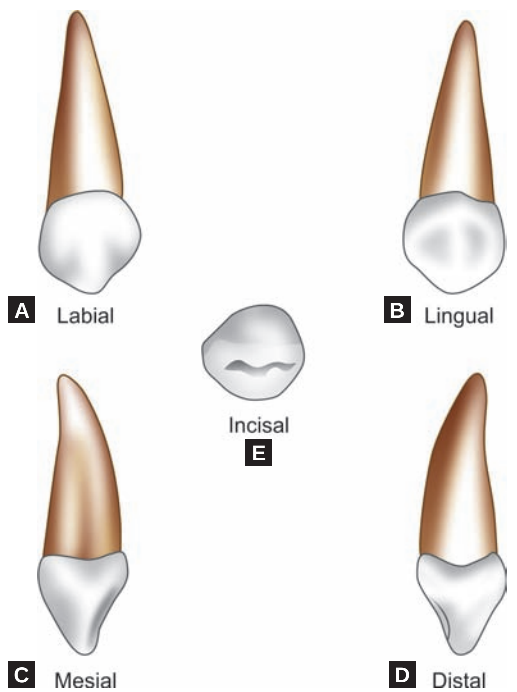
Lingual Aspect (Figs 5.18B and 5.19B)

Geometric shape: *Diamond-shaped* as on labial aspect.

Crown outlines: Similar to seen on labial aspect.



Figures 5.17A to E: Primary mandibular lateral incisor—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect



Figures 5.18A to E Primary right maxillary canine

Lingual Surface within the Outlines
- The cingulum is pronounced that may more than half of the length of the crown.
- As in permanent maxillary canine, linear palatal/lingual ridges arise from cingulum to the cusp tip. It divides the lingual fossa into two small mesial and distal fossa.

Mesial and Distal Aspect [Figs 5.18 (C and D) and 5.19 (C and D)]

Geometric shape: Triangular like all anteriors.

Crown Outlines
- *Labial outline* is much more convex than seen on primary incisors. The crest of curvature is located on prominent cervical ridge
- *Lingual outline* is 'S' shaped, crest of curvature is at the cervical third, located on the cingulum
- *Cervical line* curves incisally and shows a greated curvature on mesial than on distal aspect, located more apically on lingual than on labial aspect
- *Incisal outline* is a small arc formed by the incisal ridge/cusp tip.

Mesial and Distal Surfaces within the Outlines
- The crown is much more bulky at the cervical third when compared with primary incisors
- The labial cervical ridge appears as prominently as the cingulum from proximal aspect
- The incisal ridge/cusp tip is located labial to the root axis line.

Incisal Aspect (Figs 5.18E and 5.19E)

Geometric shape: From the incisal aspect the crown is essentially *diamond-shaped*.
- The canine crown is bulkier in mesiodistal dimension than that of deciduous incisors.
- The crown appears somewhat angular. Angles are formed by mesial and distal contact areas are less rounded than seen on permanent maxillary canine.
- The labial outline is more convex and the crown tapers towards the cingulum.
- The cusp tip is located distal to the center of the crown.
- The mesial half of the crown is thicker than the distal half. This is true for permanent maxillary canine as well.

Root

Number: The deciduous maxillary canine has a single root.

Size: The root of the deciduous maxillary canine is long, more than twice crown length.

Form

- The root is conical appears slender in proportion to its wider crown.
- Like the crown, the root also tapers lingual. The root is wider labiolingually and gives good resistance against masticatory force.
- Roots are often resorbed. Resorption occurs from lingual and apical aspect.

Apex: The root apex is blunt.

Curvature: The root usually shows a distal curvature and sometimes tilts lingually at the apex.

Cross-section: The cross-section of the root at cervix is triangular with rounded angles. The base is towards labial and apex is towards the lingual aspect.

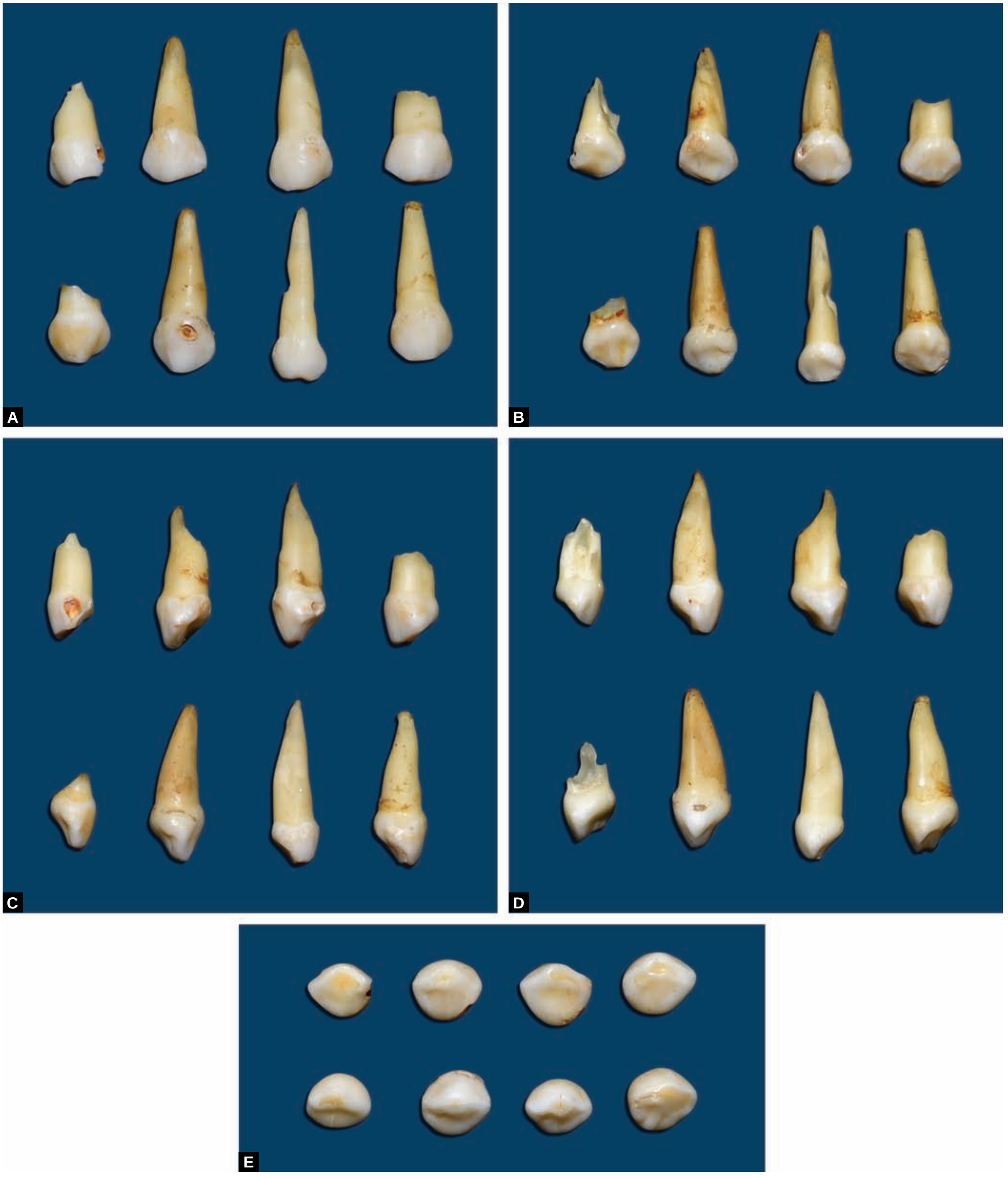
DECIDUOUS MANDIBULAR CANINE

The deciduous mandibular canine is smaller than the deciduous maxillary canine in all dimensions. The crown is asymmetrical and slender than the deciduous maxillary canine. **Figures 5.20 and 5.21** show deciduous mandibular canine from various aspects.

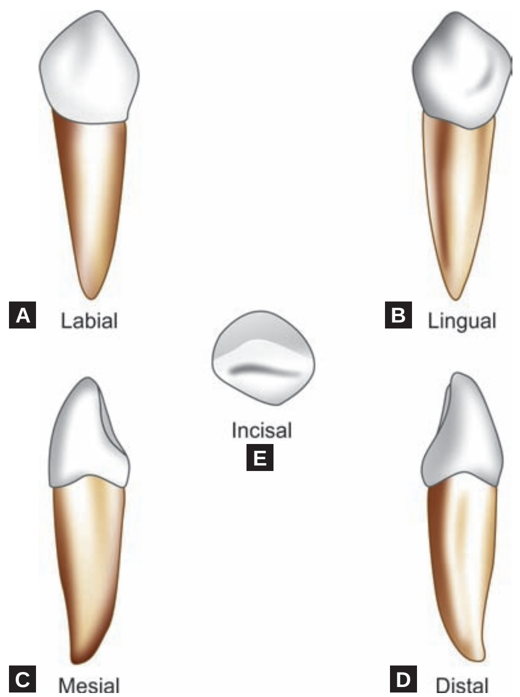
Crown

Labial Aspect (Figs 5.20A and 5.21A)

Geometrical shape: The crown is *pentagonal* from labial and lingual aspect.



Figures 5.19A to E Primary maxillary canine—typical specimen from all aspects. (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect



Figures 5.20A to E Primary right mandibular canine

Crown Outlines

Mesial and distal outlines are less convex and relatively straight. Do not converge noticeably towards cervix as in case of deciduous maxillary canine.

Cervical line is flat like seen in deciduous maxillary canine.

Incisal outline: The cusp tip is pointed, shaped like an arrow when not attrited. Distal cusp is longer than the mesial cusp ridge.

Labial Surface within the Outlines

- The deciduous canine crown is longer than it wider mesiodistally.
- Cervical constriction at the neck is not as marked as in the maxillary canine.
- Maximum mesiodistal dimension of the crown is comparable to the mesiodistal width of the root at cervix. Thus, the root appears thicker at the cervix.
- The mesial cusp ridge is shorter than the distal. The opposite is true for deciduous maxillary canine. This helps in proper intercuspation during mastication.
- Labial ridge is not as prominent as seen on the deciduous maxillary canine.
- *Contact areas:* Distal contact area is cervically placed than the mesial contact area.

Lingual Aspect (Figs 5.20B and 5.21B)

Geometric shape: *Pentagonal* in shape.

The crown outlines are reverse that of labial aspect.

Lingual Surface within the Outlines

- The marginal ridges are less developed
- The cingulum is placed more cervically and is less pronounced than that of deciduous maxillary canine.
- The lingual ridges are distinct and there is a single lingual fossa.

Mesial and Distal Aspects [Figs 5.20 (C and D) and 5.21(C and D)]

Geometric shape: Geometric shape of deciduous mandibular canine is *triangular*.

Crown Outlines

- The *labial outline* is not as markedly convex as that of deciduous maxillary canine.
- The bulge of cingulum on lingual outline is less pronounced and is more cervically placed than seen on the deciduous maxillary canine.
- The *cervical line* curves incisally to as lesser extent than in case of deciduous maxillary canine.
- The *incisal outline* marked by the cusp tip is pointed.

Proximal Aspect within the Outlines

- Proximal form of deciduous mandibular canine is comparable to that of the deciduous maxillary central incisors.
- The crown is noticeably less bulkier in labiolingual dimension at cervix portion than in deciduous maxillary canine.
- The mesial and distal surfaces are smooth and convex.
- The tip of the cusp is located lingual to the root axis line in case of permanent canine.

Incisal Aspect (Figs 5.20E and 5.21E)

Geometric shape: *Diamond-shaped* from incisal view.

- The cusp tip is located mesial to the center of the crown.
- The crown seems to have slightly more bulk on the distal half.

Root

Number: Single.

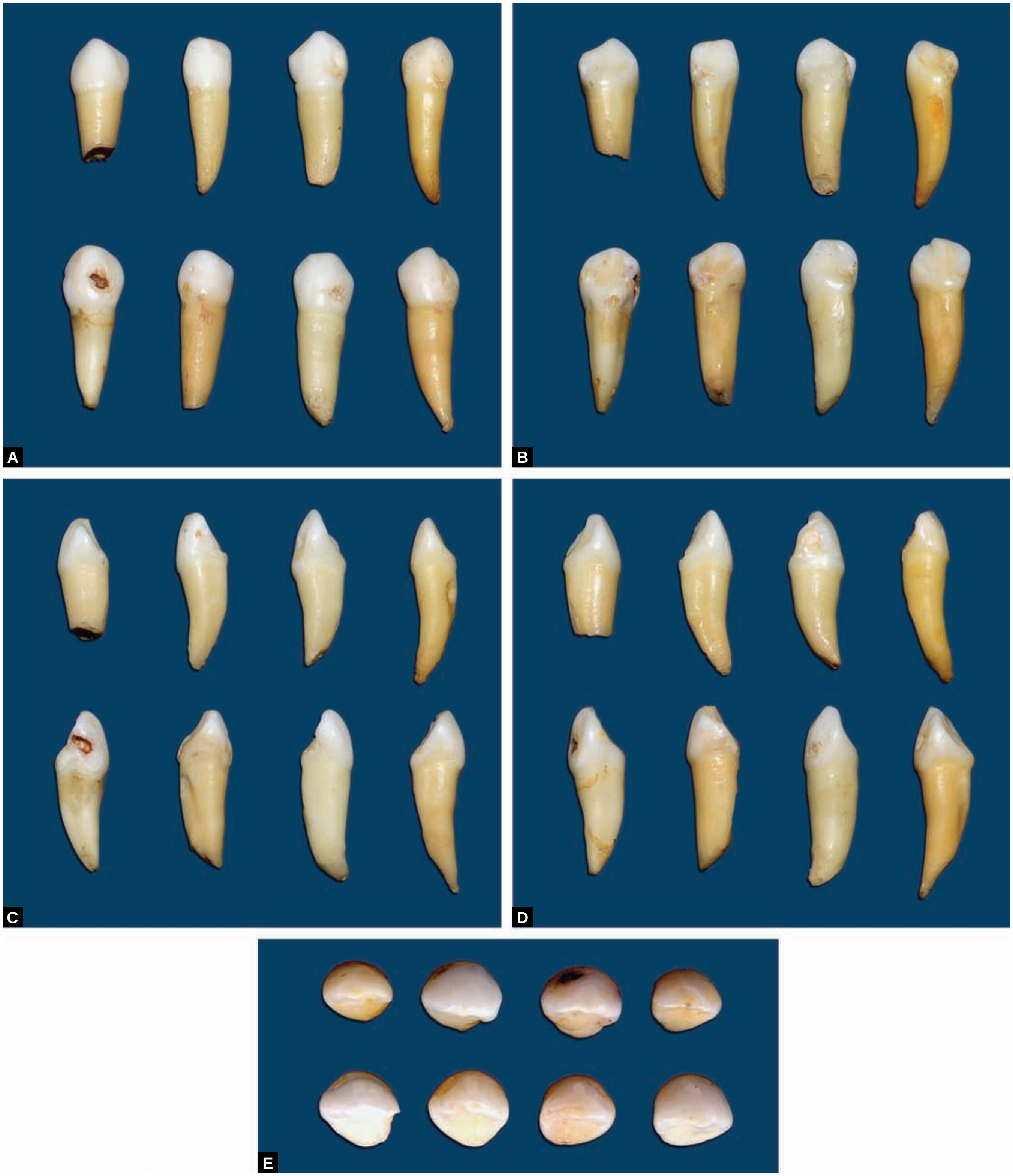
Size: The root is proportionally larger comparable to its slender crown. It is about 2 mm shorter than the deciduous maxillary root.

Form: The root is conical, appears bulky in cervical and middle thirds, and tapers more in the apical third. The root is usually resorbed, sometimes up to the cervix.

Apex: When not resorbed, the root tip is pointed.

Curvature: The root is generally straight and sometimes may show a distal tilt at the apex.

Cross-section: Cross-section of the root triangular.



Figures 5.21A to E Primary mandibular canine—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

DECIDUOUS MOLARS

- There are only two molars in each quadrant in deciduous dentition.
- There are no 3rd molars in deciduous dentition.
- Primary molars erupt immediately distal to the primary canines since premolars are absent in primary dentition.
- They are wider mesiodistally than their successors—1st and 2nd premolars. Thus, they save space in the arch for the permanent premolars.
- The combined mesiodistal width of the primary canines, 1st and 2nd molars is greater than the combined mesiodistal width of the permanent successors that is permanent canines, 1st and 2nd premolars. This difference in their mesiodistal dimension is known as *Lee-way space of Nance* and provides space for mesial migration of permanent 1st molar and subsequent establishment of normal occlusion.
- It is interesting to note that the primary 2nd molars are larger than primary 1st molars. On the contrary, in permanent dentition, the 1st molars are generally the largest.
- Primary 1st molars are more unique in their morphology, while the primary 2nd molars closely resemble the permanent 1st molars.
- Primary maxillary 1st molar is regarded as the most atypical of all molars (in both dentitions) by many authors. Some feel that they somewhat resemble the permanent premolars. Others postulate that their morphology appears to be an intermediate between a premolar and a molar.
- The primary mandibular 1st molar is very unique in its crown morphology. It is generally agreed that *the primary mandibular 1st molar does not resemble any tooth in either of the dentitions.*
- The roots of the primary molars are delicate, slender and diverge widely to make room for developing permanent successor teeth.
- Care has to be taken while extracting deciduous molars. Extraction of a deciduous molar when tooth are complete and before they have begun to resorb, may lead to inadvertent removal of the permanent successor tooth along with the primary molars.
- Inflammation from deciduous pulp can easily reach to the developing permanent tooth germ (Turner's hypoplasia).
- The primary molars provide chewing surface to the child in early growing years from 2½ to 6 years.
- After 6 years until they are shed, the primary molars are associated in function by the permanent 1st molars that erupt distal to them in the dental arch before any of the deciduous teeth are shed.

DECIDUOUS MAXILLARY 1ST MOLAR

Primary maxillary 1st molar is the smallest among all the molars in both the dentitions. The crown has unique form that is regarded as an intermediate between a premolar and a molar. Like permanent maxillary molars it has three roots. Primary maxillary 1st molar is much smaller than the maxillary 2nd molar in all the dimensions. **Figures 5.22 and 5.23** show deciduous maxillary 1st molar from various aspects.

Crown

Buccal Aspect (Figs 5.22A and 5.23A)

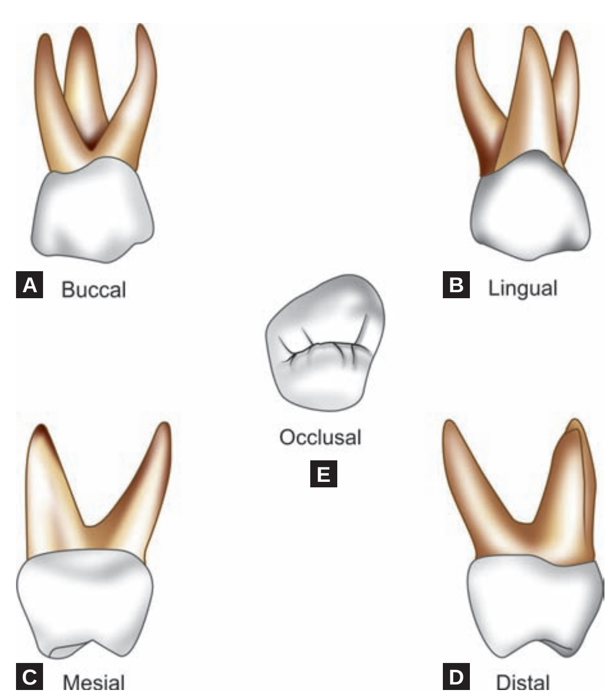
Geometric shape: Labial and lingual aspects are *trapezoidal* with shortest and the uneven sides towards the cervix.

Crown Outlines

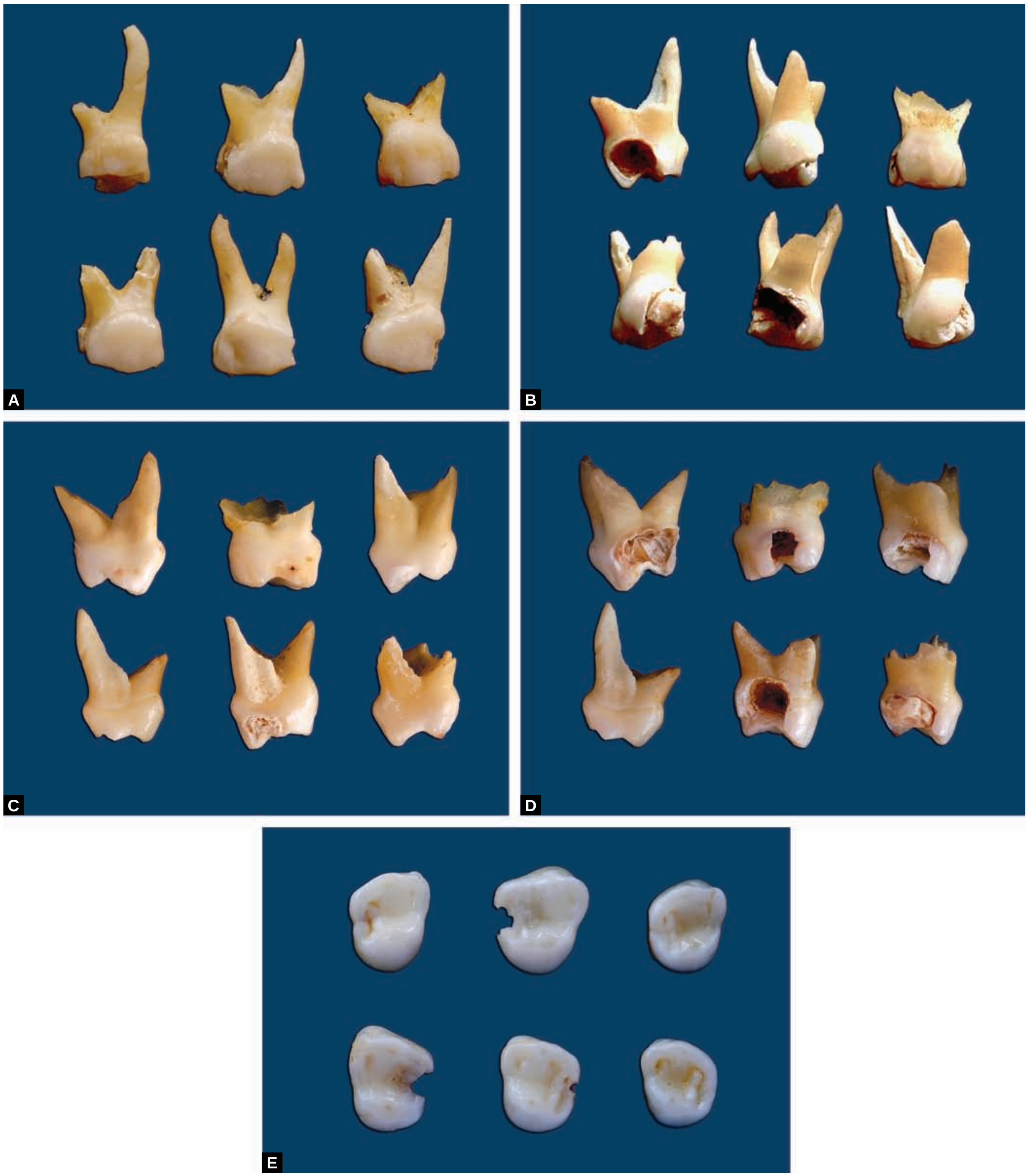
- The *mesial* and *distal outlines* are convex, diverging from a narrow cervix in an occlusal direction. The crest of contour on the mesial outline is at the occlusal third where the contact area lies. The crest of contour on the distal outline at the middle third.
- The *occlusal outline* is relatively flat with no definite cusp form.
- The *cervical line* is quite distinct. It is sinuous, higher mesially than distally.

Buccal Surface within the Outlines

- The much smaller size of the primary 1st molar compared to the maxillary 2nd molar is easily appreciated from this aspect.



Figures 5.22A to E Primary right maxillary 1st molar



Figures 5.23A to E Primary maxillary 1st molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

- The tooth wider mesiodistally than its cervico-occlusal height.
- The tooth is noticeably constricted at the neck, with proximal walls diverging occlusally.
- The buccal surface is smooth, generally devoid of any developmental grooves.
- The mesiobuccal cusp is prominently visible from this view.
- The cervical ridge, sometimes called as buccal cingulum running mesiodistally is most prominent on primary 1st molar both maxillary and mandibular.
- It is more prominent on maxillary 1st molar than on mandibular 1st molar.
- The bulge is thicker mesially than distally.
- *Contact areas:* The mesial contact area is flat in the occlusal 3rd of the tooth and makes contact with the canine. The distal contact area is in the middle 3rd of the crown, contacting with 2nd molar.

Lingual Aspect (Figs 5.22B and 5.23B)

Geometric shape: *Trapezoidal* like the labial aspect.

Crown Outlines

- The mesial crown outlines are just reversal that on labial aspect.
- Occlusal outline shows the cusp tip and cuspal form of the mesiolingual cusp and sometimes that of the smaller distolingual cusp.
- The cervical line is nearly flat.

Lingual Surface within the Outlines

- The crown noticeably taper towards the lingual aspect, making the lingual surface narrower than the buccal aspect.
- From this aspect, the mesiolingual cusp, which is the longest and sharpest cusp of this tooth is prominently visible.
- The smaller and shorter distolingual cusp may be seen.
- The lingual surface is smooth. It is more convex mesiodistally and less convex cervico-occlusally.

Mesial Aspect (Figs 5.22C and 5.23C)

Geometric shape: *Trapezoidal*.

Crown Outlines

- The *buccal outline* shows a pronounced convexity of the cervical enamel ridge at the cervical 3rd of the crown. From this marked convexity the buccal outline is straight line converging noticeably in an occlusal direction. This makes the occlusal table of primary molars narrower buccolingually than in case of permanent molars.
- The *lingual outline* less convex than the buccal outline and gradually converges occlusally from the cervical line.
- *Occlusal outline* is V-shaped, formed by the cusp tips mesiobuccal and mesiolingual cusps, their mesial cusp ridges and the mesial marginal ridge.
- The *cervical outline,* formed by the cervical bone curves slightly in an occlusal direction.

Mesial Surface within the Outlines

- As with any molar (both primary and permanent) the buccolingual dimension of the crown is greater at the cervical 3rd than at the occlusal 3rd when viewed from proximal aspects.
- However, the crown is much more wider at cervically than occlusally in case of primary molars.
- The crown tapers drastically towards the occlusal surface from their buccal and lingual convexities.
- The mesial surface broader than distal surface. It is smoothly convex.
- The mesial surface makes contact with the canine and the contact area is at the occlusal 3rd.

Distal Aspect (Figs 5.22D and 5.23D)

Geometric shape: *Trapezoidal* like that of mesial aspect.

Crown Outlines

- *Buccal and lingual outlines* are similar to that seen on mesial aspect.
- The *cervical line* is nearly flat and is higher buccally than lingually.
- The *occlusal outline* is scalloped, shows the distal marginal ridge.

Distal Surface within the Outlines

- The distal surface is narrower buccolingually than the mesial surface.
- This is because the buccal and the lingual surfaces of the crown converge from mesial to distal aspect.
- The distal surface is more convex than the mesial one.
- The distal contact area, making contact with the 2nd molar is at the middle 3rd of the crown.

Occlusal Aspect (Figs 5.22E and 5.23E)

Geometric shape: Occlusal outline is roughly *quadrilateral.*

- The mesial arm is longer than the distal; and buccal arm is longer than the lingual.
- In other words, the crown outline tapers lingually from buccal and distally from the mesial aspect (may appear heart shaped when only 3 cusps are present).

Crown Form

- The primary maxillary 1st molar resembles a maxillary premolar and is regarded as the premolar section and primary dentition.
- The resemblance is nicely appreciated from occlusal view.
- However, the tooth is essentially a molar in junction with three roots giving good anchorage in the alveolar bone.

Cusps
- The primary maxillary 1st molar generally has four cusps: two larger and two smaller.
- The two larger cusps namely, *mesiobuccal and mesiolingual cusps*, confer premolar like form to the tooth especially from an occlusal view.
- The two smaller cusps are the *distobuccal* and the often in conspicuous *distolingual cusp*.
- Not uncommonly, the distolingual cusp may be absent giving a triangular occlusal form to the tooth that resembles a maxillary premolar more closely. This is referred to as a 3 cusp molar.
- The mesiolingual cusp is the longest and the sharpest. Next largest is the mesiobuccal cusp. The distobuccal cusp is small, less distinct. The smallest is the distolingual cusp which may be absent.

Cusp Ridges
- The mesial and distal marginal ridges form the 2 smaller sides/arms of the occlusal quadrilateral form.
- The distal marginal ridge is much smaller than the mesial since the crown converges distally.
- Mesial and distal cusp ridges of the larger mesiobuccal and distobuccal cusps are well developed. Cusp ridges of distobuccal and distolingual cusps are less distinct.
- The mesiobuccal and mesiolingual cusps have well-defined triangular ridges. Sometimes, a well developed triangular ridge connects the mesiolingual and distobuccal cusp and is called the oblique ridge.

Fossae
- The primary maxillary 1st molar has three fossae—a central fossa, a mesial triangular fossa and a distal triangular fossa
- The mesial triangular fossae is larger and the distal triangular fossae is the smaller one.

Grooves and Pits
- The groove pattern is often describe as a H-pattern. The *central developmental groove* runs mesiodistally across the center of the occlusal surface from the mesial pit in the mesial triangular fossae to the distal pit in the distal triangular fossae.
- The *buccal developmental groove* separates the mesiobuccal and distobuccal cusps and may extend onto buccal surface.
- It joins the central developmental groove in the central fossae to form a central pit.
- The *distal developmental groove* divides the smaller distolingual cusps. It may or may not extend onto the lingual surface.
- Supplemental grooves may radiate from the mesial pit on buccal, lingual and mesial directions. The groove running in a mesial direction may cross the mesial marginal ridge.

Root

Number: In line with maxillary arch traits, the primary maxillary 1st molar has three roots: mesiobuccal, distobuccal and palatal.

Size: The tooth has three long, slender and widely diverging roots. The lingual root is the longest and largest. The distobuccal root is shorter than the mesiobuccal root.

Form

- All the three roots are seen from buccal and lingual aspects. Only mesiobuccal and palatal roots can be seen from mesial aspect. From distal view, the palatal root and distobuccal root are seen in the fore front. The outline and apex of the mesiobuccal root is also seen since it is longer than the distobuccal root.
- The roots flare out widely to accommodate the developing permanent successor between the roots. The trifurcation begins nearly at the cervical line itself thus having a very small root trunk if it is present at all. This feature is true for all the primary molars, which is in contrast to permanent molars. In permanent molars, bifurcation and trifurcation begins at some distance (4–5 mm) from the cervical line, thus they have a well-defined and strong root trunks.
- The mesiobuccal root is flattened mesiodistally, the distobuccal root is smaller and circular. The distobuccal and palatal roots may be partly fused.

Root Curvature
The mesiobuccal and distobuccal roots flare out in respective directions and may show distal and mesial curvature at their apical 3rd respectively the palatal root has a buccal curvature at the apical 3rd.

DECIDUOUS MAXILLARY 2ND MOLAR

As said earlier, the primary 2nd molars closely resemble the permanent 1st molars that erupt distal to the tooth. It is the replica of permanent molar in form, albeit smaller. However, the primary 2nd molar can be easily distinguished from the permanent 1st molar by its smaller size, whitish color, prominent buccal cervical ridge and widely diverging roots. Like the permanent maxillary 1st molars, it also has the major cusps namely the mesiobuccal, mesiolingual, distobuccal, distolingual and a small accessory cusp referred to as cusp of Carabelli/the 5th cusp. **Figures 5.24 and 5.25** show deciduous maxillary 2nd molar from various aspects.

Crown

Buccal Aspect (Figs 5.24A and 5.25A)

Geometric shape: It is *trapezoidal* with the shortest of the uneven sides towards the cervix.

Crown Outlines

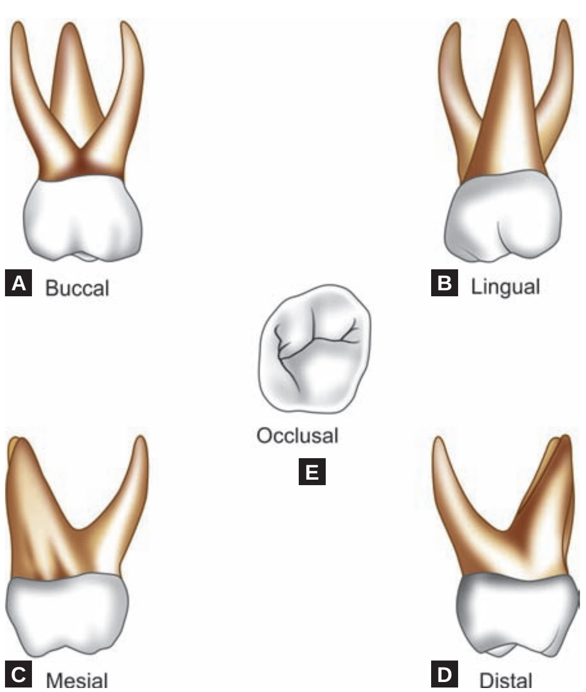
- The *mesial and distal outlines* begin at the narrow cervix and diverge out in an occlusal direction. The mesial outline is relatively straight and the distal outline is more convex
- The *occlusal outline* is formed by the tips of mesiobuccal and distobuccal cusps.
- The *cervical line* is slightly curved in an apical direction.

Buccal Surface within the Outlines

- The primary maxillary 2nd molar is considers larger than the primary maxillary 1st molar. As with all primary molars, the crown has a much constricted cervix on comparison to its mesiodistal dimension at the contact areas.
- Two buccal cusps are nearly of same size and development. The crown is longer mesially than distally.
- The buccal surface is convex except for buccal developmental groove that separated the two buccal cusps.
- The bulge of buccal cervical ridge is prominent and runs mesiodistally at the cervical 3rd of crown.
- *Contact areas:* The mesial contact area at occlusal 3rd, the distal contact area is cervically placed than on mesial surface.

Lingual Aspect (Figs 5.24B and 5.25B)

Geometric shape: Trapezoidal.



Figures 5.24A to E Primary right maxillary 2nd molar

Crown Outlines

- Mesial and distal crown outlines are similar to that seen from buccal aspect.
- The cervical line is nearly flat.
- The occlusal outline shows the cusp forms of mesiolingual and distolingual cusps.

Lingual Surface within the Outlines

Three cusps are seen from the lingual view:

1. *Mesiolingual cusp*: Larger and well-developed
2. *Distolingual cusp*: That is more well-developed than seen on primary maxillary 1st molar.
3. *Cusp of Carabelli/the 5th cusp*: Less prominent than seen in permanent maxillary 1st molar. The trait may be in the form of well-developed cusp, a small ridge or a groove. It adds to the bulk of the mesiolingual cusp (fossae buttress around it).

Mesial Aspect (Figs 5.24C and 5.25C)

Geometric shape: *Trapezoidal* with shortest and uneven sides towards the occlusal surface.

Crown Outlines

- The buccal outline shows a prominent convexity at the cervical 3rd—the buccal cervical ridge from here the outline is straight, converging towards occlusal surface.
- The lingual outline is markedly convex with crest and contour at the middle 3rd of crown. Also shows the outline of the 5th cusp.
- Cervical line is may be flat or may curve slightly in occlusal direction.
- Occlusal outline shows mesial marginal ridge and cusp tips of mesiobuccal and mesiolingual cusps.

Mesial Surface within the Outlines

- The crown form appears similar to permanent maxillary 1st molar from this aspect.
- The buccolingual dimension is narrower occlusally than cervically.
- The bulge of buccal cervical ridge is not as prominent as seen on the primary maxillary 1st molar.
- The mesial surface is smooth and convex.

Distal Aspect (Figs 5.24D and 5.25D)

Geometric shape: *Trapezoidal* with shorter of uneven sides towards the occlusal surface.

Crown Outlines

- Buccal outline is similar but the prominent bulge of cervical ridge is not very evident.
- Lingual outline is smooth and convex.
- Occlusal outline formed by distal marginal ridge and cusp tips of distobuccal and distolingual cusps.
- Cervical line is flat.

Distal Surface within the Outlines
- The distal surface of crown is narrower than the mesial surface as the crown tapers distally.
- The distobuccal cusp is long and sharp while the distolingual cusp is poorly developed.
- It is from three occlusal aspect that the tooth appear as exact replica and the permanent maxillary 1st molar.

Occlusal Aspect (Figs 5.24E and 5.25E)

Geometric shape: *Rhomboidal* as in case of permanent maxillary 1st molar.
- However, the crown somewhat tapers towards lingual (this is not true in case of maxillary 1st molar).
- The crown tapers towards distal is more marked than seen in case of maxillary 1st molar due to prominent buccal cervical ridge on the mesial half of buccal surface.
- The mesiolingual angle is much more obtuse than seen on permanent maxillary 1st molar.
- The mesiolingual corner of the crown appears to be flattened/compressed towards distal.
- This makes the mesiolingual cusp shift in a distal direction; and thus the oblique ridge has a more straighter and less oblique course buccolingually.

Cusps and Cusp Ridges
- There are four major cusps:
  1. *Mesiolingual*
  2. *Mesiobuccal*
  3. *Distobuccal*
  4. *Distolingual*

  and one minor cusp—*the cusp of Carabelli*.
- The mesiolingual is the largest cusp, although the mesiobuccal cusp may be as bigger.
- Cusp ridges of mesiobuccal and mesiolingual cusps are well-defined.
- Mesial marginal ridge is longer and well-developed than the distal.
- The distal marginal ridge is well-developed than that of the primary maxillary 1st molar.
- The prominent oblique ridge connects the mesiolingual and the distobuccal cusps.
- It is less oblique and more straighter in its course than that seen on permanent 1st maxillary molar.

Fossae, Grooves and Pits
- There is a *central fossa, mesial triangular* and smaller distal *triangular fossa*.
- The *central developmental groove* runs at the bottom of the sulcus that connects the mesial triangular fossa with the central fossa.
- The *buccal developmental groove* runs buccally from the central pit in the central fossa and separate the mesiobuccal and distobuccal cusps.
- The *distal fossa* is located distal to the oblique ridge.
- At the bottom of distal fossa, the *distal developmental groove* runs a short course.
- A less distinct distal triangular fossa is seen just mesial to the distal marginal ridge which shows supplementary groove.
- The distal developmental groove separates the mesiolingual and the distolingual cusps and continues onto the lingual surface as the lingual developmental groove.

Root

- *Number*: Three roots; mesiobuccal, distobuccal and palatal.
- *Size*: The roots are much longer and stronger than that of maxillary 1st primary molar. Palatal root is larger and heavier than the other roots. It may be longer or of the same length as the mesiobuccal root. The distobuccal root is generally the shortest.
- *Form*: The root are slender and long in proportion to crown. They diverge widely from their point of trifurcation. Trifurcation occurs immediately near the cervical line leaving no root trunk.
- *From the buccal and lingual aspects*: All the roots can be seen from this aspect. Palatal root is the widest and largest. Only the mesiobuccal and palatal root can be seen from mesial aspect. When viewed from distal, the palatal and distobuccal roots are seen in foreground. Outline and apex of the mesiobuccal root can also be seen since it is longer than their distobuccal root.
- *Curvature*: The palatal root diverge out in lingual direction for most of its course and curves buccally at its apical 3rd, the mesiobuccal and distobuccal roots diverge out in respective directions. The mesiobuccal roots may show distal curvature at its apex. The distobuccal root often shows a mesial curvature at its apex.
- *Apex*: Palatal root apex is pointed, buccal root apices are blunt.

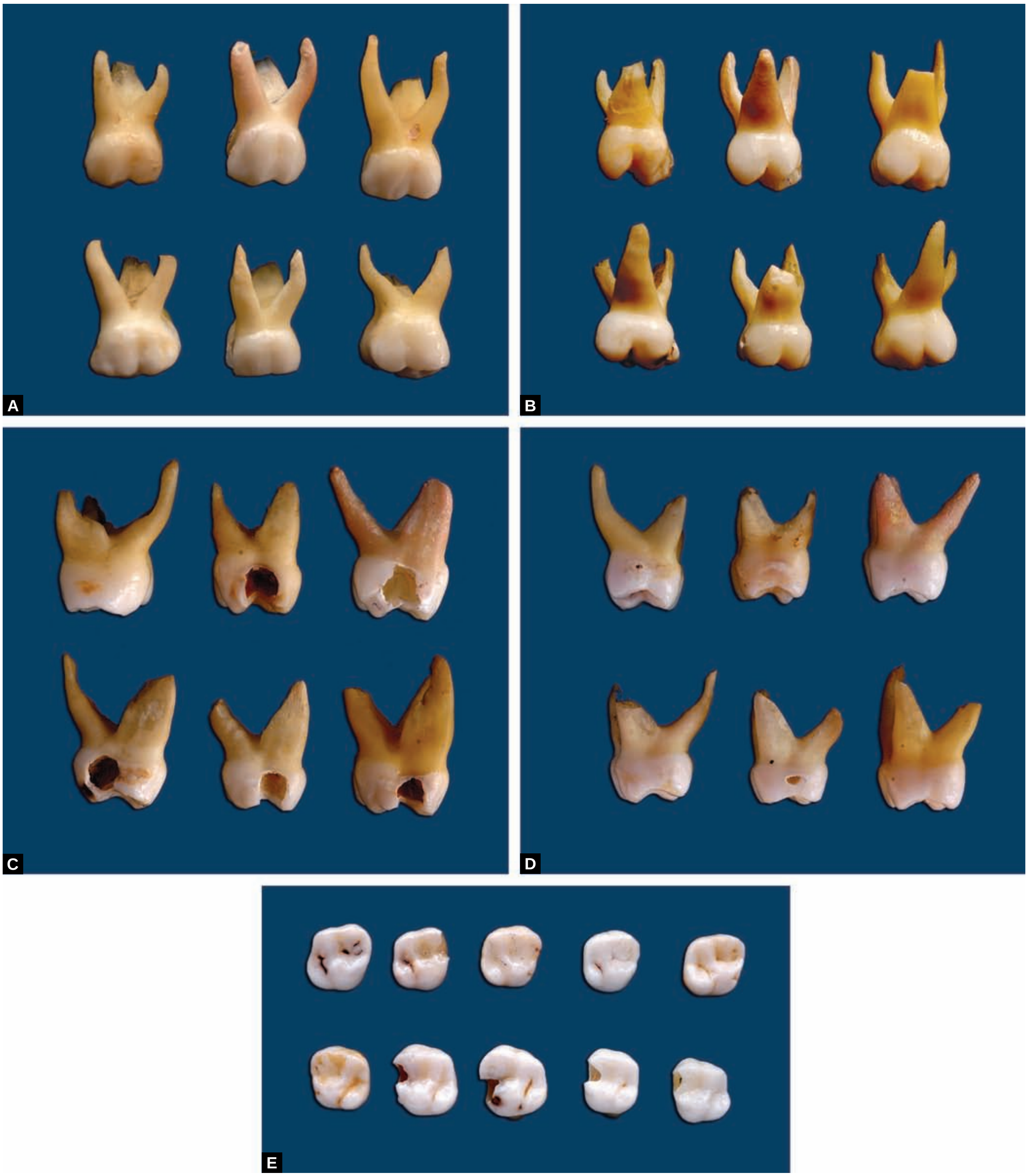
DECIDUOUS MANDIBULAR 1ST MOLAR

The primary mandibular 1st molar does not resemble any other tooth in primary and permanent dentition. It has a very unique morphology that is sometimes described as primitive in nature. Unlike primary maxillary 1st molar it is molariform. The tooth has four cusps and the two roots. The crown height varies from different aspects. The cervical line curvature is unique, different from all other teeth. **Figures 5.26 and 5.27** show deciduous mandibular 1st molar from various aspects.

Crown

Buccal Aspect (Figs 5.26A and 5.27A)

Geometric shape: *Trapezoidal* with shortest of uneven sides towards cervix.



Figures 5.25A to E Primary maxillary 2nd molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

Crown Outlines

- The tooth has most dissimilar mesial and distal outlines among molars from buccal aspect. The *mesial outline* is a straight line from the mesial contact area at the occlusal third of the crown to the cervix, with little constriction of the neck of the tooth.
- The *distal outline* on the other hand, is markedly convex. Its crest of curvature signifying the distal contact area is at the middle 3rd of the crown.
- The *occlusal outline* shows cusp forms of two buccal cusps. There is a depression rather than a groove separating these cusps buccally.
- The *cervical outline* formed by cervical line is distinct. The cervical line curvature on buccal surface is unique. It is slightly convex near distal third of crown, then apically to marked degree surround the prominent mesiobuccal cervical ridge before joining the mesial root.

Buccal Surface within the Outlines

- Buccal aspect offers some unique features of primary maxillary 1st molar. The crown is much wider mesiodistally than it is cervicoincisally.
- The distal portion of the crown is noticeably shorter than the mesial portion. This is due to the cervical line design on buccal surface that dips apically on the mesial half of the crown.
- Two buccal cusps are visible from this view.
- The mesiobuccal cusp is larger than distobuccal cusp occupying 2/3rd of buccal surface. The two cusps are separated by a depression/fissure rather than a groove on the buccal surface.
- The linear cervical ridge is very prominent located on mesial portion of crown. The apical slope of cervical line on buccal surface accentuated by the mesiobuccal cervical ridge and appears to encircle the prominent bulge.
- The buccal surface is convex mesiodistally and is flat cervicoincisally above buccocervical ridge slanting in a lingual direction. This arrangement is true for all mandibular molars—primary and permanent.

Contact Areas

- Mesial contact is at the occlusal third of the crown.
- Distal contact area is extended distally to make contact with 2nd molar. It is at middle third of the crown.

Lingual Aspect (Figs 5.26B and 5.27B)

Geometric shape: *Trapezoidal.*

Crown Outlines

- *Mesial and distal outlines* are similar to that seen on buccal aspect.
- *Occlusal outline* shows conical cuspal forms and mesiolingual and rounder distolingual cusp outlines of the buccal cusp may also be seen.
- *Cervical line* on the lingual surface is nearly a straight line from mesial to distal. This is in sharp contrast to that seen on the buccal surface (buccal cervical bone slopes apically from distal to mesial).

Lingual Surface within the Outlines

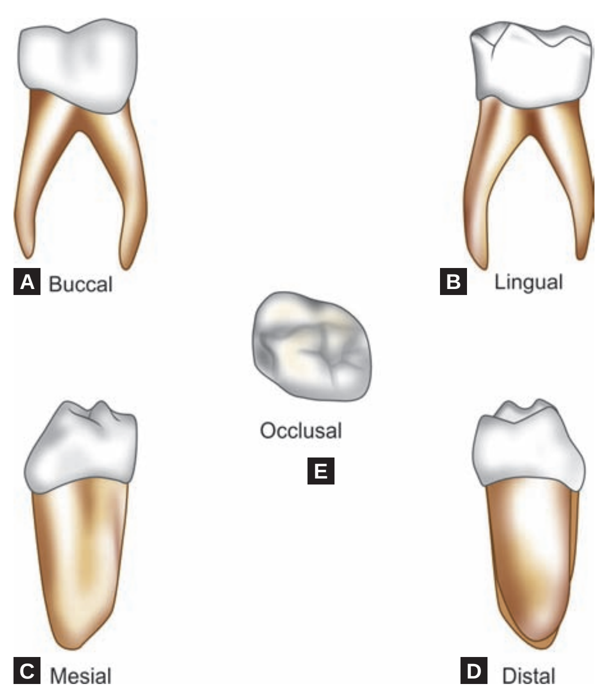
- From lingual aspect, the crown length is nearly equal mesially and distally cervical line is straighter.
- This makes the lingual surface as wide as buccal surface mesiodistally. The mesial wall of the crown and root converge noticeably in a lingual direction, however, the distal proximal wall converge buccally rather than lingually.
- The mesiolingual cusp is larger than distolingual cusp. The mesiolingual cusp is longer and sharper at the tip and is located nearly at the center lingually.
- The prominent conical and sharp mesiolingual cusp is the outstanding feature of this tooth.
- The distolingual cusp is small and is more rounded.
- The mesial marginal ridge is extremely well-developed in primary mandibular 1st molar and appear as a small cusp from this view.

Mesial Aspect (Figs 5.26C and 5.27C)

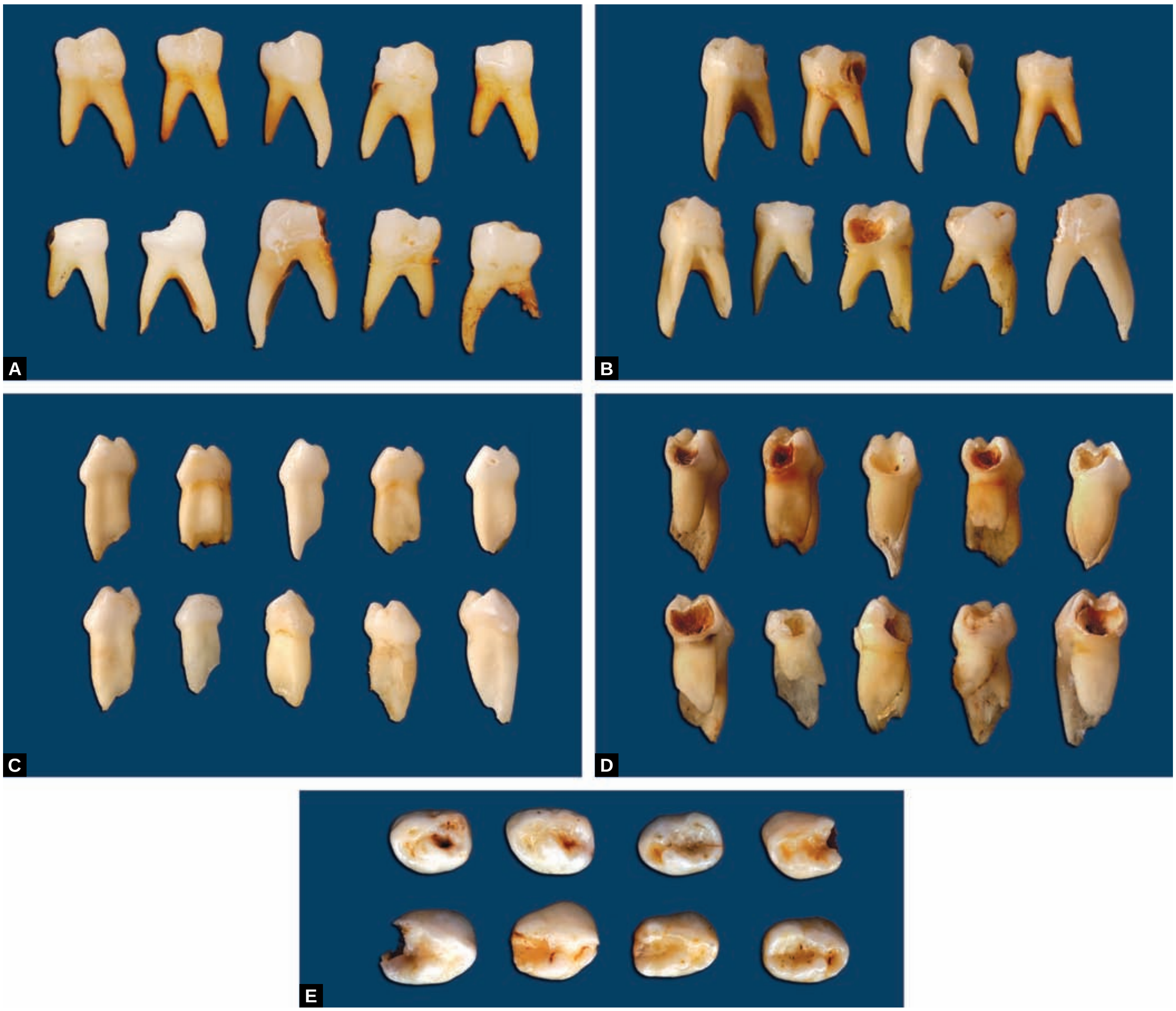
Geometric shape: *Rhomboidal.*

Crown Outlines

- *Buccal outline* shows prominent convexity of the *buccal cervical ridge* at the cervical third of the crown. Primary



Figures 5.26 Primary right mandibular 1st molar



Figures 5.27A to E Primary mandibular1st molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

maxillary and mandibular 1st molars exhibit extreme curvature of buccal cervical ridge on their buccal outlines when views from proximal aspects.

- Although the buccal cervical ridge is a common feature exhibited by all primary teeth. It is most dramatic in maxillary 1st molar followed by mandibular 1st molar.
- This prominent bulge on the buccal surface has to be considered while crowns are planned on these teeth.
- As with all mandibular molars, the buccal outline is flat/straight above the crest of curvature at the cervical third and slopes in a lingual direction. This makes the tip of buccal cusps on the line with the root axis line.
- The *lingual outline* is convex with the crest of the curvature at the middle third of crown. It extends lingually often to place the linguals out of confines of the root base.
- The *occlusal outline* shows cusp forms of mesiobuccal and mesiolingual cusps and the prominent mesial marginal ridge.
- The *cervical line* slopes down from lingual to buccal; since the crown height is greater at the mesiobuccal portion.

Mesial Surface within the Outlines

- The tooth shows a typical proximal form of any mandibular molar with a lingual tilt of the crown at its root base.

- The crown appears to lean lingually on the root base. This feature is accentuated by prominent bulge of buccal cervical ridge.
- Like all mandibular molars, crest of curvature is buccally at cervical third and lingually is at middle third of the crown.
- Buccal outline shows extreme curvature of cervical ridge.
- The crown length is greater buccally than lingually viewed from mesial aspect, mesiobuccal and mesiolingual cusp are seen along with prominent mesial marginal ridge.
- The buccal cusp are centered over the root base. A line bisecting the root would pass through cusp tips of buccal cusp. The lingual cusp outline extend outward lingually beyond the confines of root base.
- The mesial surface of the crown is relatively flat cervicoincisally and converges in a lingual direction on the buccal aspect.

Distal Aspect (Figs 5.26D and 5.27D)

Geometric shape: *Rhomboidal.*

Crown Outlines

- Buccal and lingual outlines are similar to mesial aspect.
- Occlusal outline is formed by distobuccal and distolingual cusp form and distal marginal ridge.
- Cervical line is rather straight buccolingually unlike on mesial aspect it does not slope buccally.

Distal Surface within the Outlines

- The crown is of uniform height buccally and lingually when viewed from distal aspect.
- The distobuccal and distolingual cusp are not as long as mesial cusps.
- The distal marginal ridge is not as well-developed as the mesial marginal ridge.
- The distal surface converges buccally rather than lingually. This feature is not seen in any other mandibular molar.

Occlusal Aspect (Figs 5.26E and 5.27E)

Occlusal aspect offers most unique and characteristic feature of primary mandibular 1st molar.

Geometric Shape

Occlusal outline of the tooth is *rhomboidal* and is elongated mesiodistally. It is to be noted that all other mandibular molars have rectangular occlusal outline that converge lingually. The mesiobuccal corner of the rhombus is extended due to the mesiobuccal cervical ridge. The mesiolingual angle and distobuccal angle is markedly obtuse and corner is flattened.

Crown Tapers and Dimensions

- The crown tapers markedly in a lingual direction only from its mesial surface. Usually, the distal wall tapers buccally
- The mesiodistal dimension of the crown is greater than buccolingual dimension.

Cusps and Ridges

- The primary mandibular 1st molar has four cusps: two buccal and two lingual.
- The mesial cusps are larger than the distal cusps with distolingual cusp as the smallest and poorly developed.
- The mesiolingual cusp is longest, sharpest and very well-developed.
- The mesiobuccal cusp is larger than the distobuccal cusp occupying 2/3rd of buccal half of the occlusal surface. The mesiobuccal cusp is well-formed with long mesial and distal cusp ridges while in occlusion, with opposing during mastication.
- It is sort of compressed buccolingually.
- The triangular ridge is well-defined and runs down from cusp tip to central fissure.
- The distolingual cusp is smaller and shorter than mesiobuccal cusp, appears as a small protuberance.
- The mesiolingual cusp is often the longest and most developed of all the cusps with sharp conical cusp tip that is nearly centered lingually.
- The sharper and prominent mesiolingual cusp as viewed occlusally is the outstanding feature of this tooth.
- A *transverse ridge* may be noted formed by joining of triangular ridges of mesiobuccal and mesiolingual cusps.
- The mesial marginal ridge is prominent, longer buccolingually and is overdeveloped that it appears as a small cusp lingually and occlusally.
- The distal marginal ridge is shorter and cervically placed than that of the mesial marginal ridge.
- The occlusal table between the cusp ridges and marginal ridges is rhomboidal and narrower buccolingually. It is wider, larger distal to transverse ridge.

Fossae, Grooves and Pits

- The occlusal table is divided buccolingually by central developmental groove. It runs mesiodistally from mesial pit in mesial triangular fossa to a central pit towards distal portion of the occlusal aspect. The central developmental groove separates mesiobuccal and mesiolingual cusps.
- A short buccal developmental groove divides two buccal cusp extending occlusally and joins the central developmental groove at the central pit. The buccal developmental groove does not extend onto buccal surface.
- Since both the lingual cusp are larger occupying 2/4th of the occlusal surface, the central pit is in large distal fossa. There is no central fossa. A distal pit may also be seen in the smaller distal triangular fossa just mesial to distal marginal ridge.
- *Lingual groove:* A short lingual developmental groove extends from central pit towards distolingual line angle, separating the mesiolingual and distolingual cusps. It ends as a fissure. Depression between the two lingual cusps on the lingual cusps on the lingual surface.

- Two to three short supplementary grooves may be seen in mesial triangular fossa and distal triangular fossa.

Root

Number: The primary mandibular 1st molar has two roots: mesial and distal. This is in line with the mandibular arch traits of the both dentition.

Size: Both the roots are flatter mesiodistally and wider buccolingually. The mesial root is much longer and wider than the distal root.

Form: As with all primary molars the bifurcation is immediately apical to the cervical line.

From buccal and lingual views: Both the roots are visible from this view. The mesial and distal roots diverge from point of bifurcation, are slender and long in comparison to the crown. The distal root is smaller and sharper.

From mesial view: Only the mesial root is visible. The mesial root form is unique and does not resemble any other root form. Buccal and lingual outlines of the mesial root drop down straight from the cervical line, running parallel to each other nearly up to the apex, where they converge to form a squarish root tip.

There is a developmental depression at the center of the mesial root running to its full length.

From distal view: The smaller and shorter distal root is in foreground. Outline and apex of mesial root can also be seen.

The buccal and lingual outlines of the distal root converge steadily from middle 3rd to its apex.

Apices: Apex of mesial root is squarish and blunt. Apex of the distal root is sharp.

Curvature: Mesial root shows distal curvature at the apex. Distal root is straighter or curves mesially.

DECIDUOUS MANDIBULAR 2ND MOLAR

Deciduous mandibular 2nd molar is similar to permanent mandibular 1st molar in morphology although there are some differences. It has five cusps—*mesiobuccal, distobuccal, mesiolingual and distolingual*, and two roots—*mesial and distal*. **Figures 5.28 and 5.29** show deciduous mandibular 2nd molar from various aspects.

Crown

Buccal Aspect (Figs 5.28A and 5.29A)

Geometric shape: *Trapezoidal* with shorter uneven side towards the cervix.

Crown Outlines
- *Mesial and distal outlines*: Begin at narrow cervical area and diverge in an occlusal direction. The mesial outline is relatively straight while the distal outline is more convex.
- *Occlusal outline*: Formed by the cusp tips of mesiobuccal, buccal and distobuccal cusps
- *Cervical outline*: Formed by the cervical line, which is slightly curved apically.

Buccal Surface within the Outlines
- From buccal aspect, the tooth exhibits marked cervical constriction, i.e. the crown is narrower cervically and broader occlusally.
- The buccal surface of the crown occlusally is divided into three cuspal portions by mesiobuccal and distobuccal developmental grooves.
- Thus the primary mandibular 2nd molar has a straight buccal surface with three equal buccal cusps: mesiobuccal, buccal and distobuccal cusps. This arrangement differs from permanent 1st mandibular molar in which buccal surface is uneven with two buccal cusps and one small distal cusp.

Lingual Aspect (Figs 5.28B and 5.29B)

Geometric shape: *Trapezoidal* like buccal aspect.

Crown Outlines
- *Mesial and distal outlines*: Similar to those of buccal aspect
- *Occlusal outline*: Sharper cusp tips of lingual cusps form occlusal outline. Buccal cusps could be seen in the background
- Cervical line is relatively straight.

Lingual Surface within the Outlines
- Two lingual cusps of equal size are seen from this view, which are separated by the lingual development groove.
- The lingual surface is narrower than the buccal surface as the crown tapers lingually.

Mesial Aspect (Figs 5.28C and 5.29C)

Geometric shape: *Rhomboidal* like that of the mandibular permanent 1st molar.

Crown Outlines
- *Buccal outline*: Shows extreme convexity at the cervical 3rd due to prominent cervical ridge present in primary molars. After the crest of buccal contour, the buccal outline converges occlusally.
- *Lingual outline*: It is evenly convex with crest of lingual contour in the middle 3rd
- *Occlusal outline*: It is formed by cusp tips of mesiobuccal and mesiolingual cusps and the mesial marginal ridge.
- Cervical line curves slightly in an occlusal direction.

Mesial Surface within the Outlines
- The crown shows lingual inclination over the root base, which is true for all mandibular posteriors with the buccal

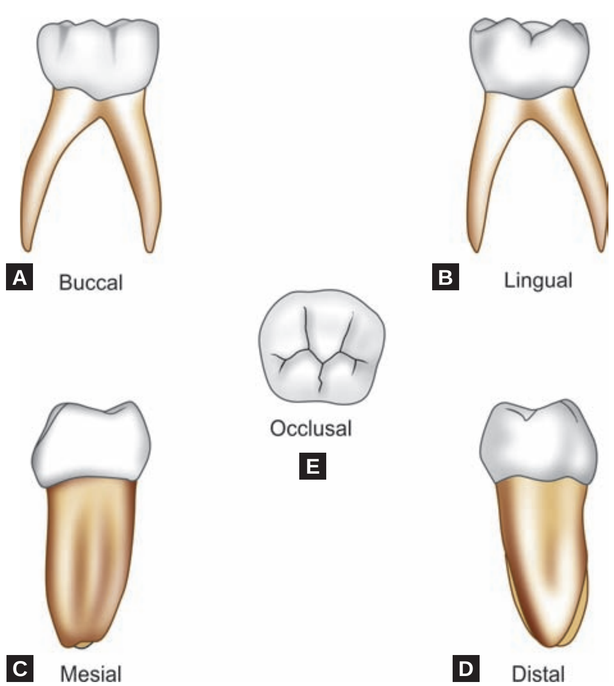
cusp, is over the root and the lingual outline of the crown extending beyond the root line.
- The mesiobuccal and mesiolingual cusps are seen from this view. Mesiolingual cusp is higher than the mesiobuccal cusp.
- Buccal cervical ridge is very prominent, which is not so in mandibular permanent 2nd molar.
- Crown is constricted occlusally due to flattened buccal surface above the cervical ridge.

Distal Aspect (Figs 5.28D and 5.29D)

Geometric shape: *Rhomboidal* similar to mesial aspect.

Crown Outlines
- Buccal and lingual outlines—similar to those of mesial aspect.
- Occlusal outline—is formed by cusp tips of distobuccal and distolingual cusps and the distal marginal ridge.
- Cervical line is rather straight on distal surface.

Distal Surface within the Outlines
- The distal surface is narrower and shorter than that of the mesial surface.
- Distobuccal and distolingual cusps are seen with a portion of other buccal cusps.
- Distal marginal ridge is shorter and at a lower level than the mesial marginal ridge. Thus a portion of occlusal surface can be seen from distal view.



Figures 5.28A to E Primary right mandibular 2nd molar

Occlusal Aspect (Figs 5.28E and 5.29E)

Geometric shape: It is roughly *rectangular*.

Relative Dimensions
- Mesiodistal width of the crown is greater than the buccolingual dimension.
- Crown shows slight lingual convergence, i.e. crown is narrower lingually.

Cusps and Cusp Ridges

There are 5 cusps as seen in permanent mandibular 1st molar.

Three buccal cusps of nearly equal size:
1. Mesiobuccal cusp
2. Distobuccal cusp
3. Distal cusp.

Two lingual cusps of equal size:
4. Mesiolingual
5. Distolingual.

In the deciduous mandibular 2nd molar, the 3 buccal cusps are of nearly equal size and development. Whereas, in the permanent mandibular 1st molar, the distal cusp is much smaller than the other buccal cusps.
- Well-defined triangular ridges extend occlusally from each other of these cusp tips.
- Mesial marginal ridge is well developed than the distal marginal ridge, which is shorter and at a lower level.

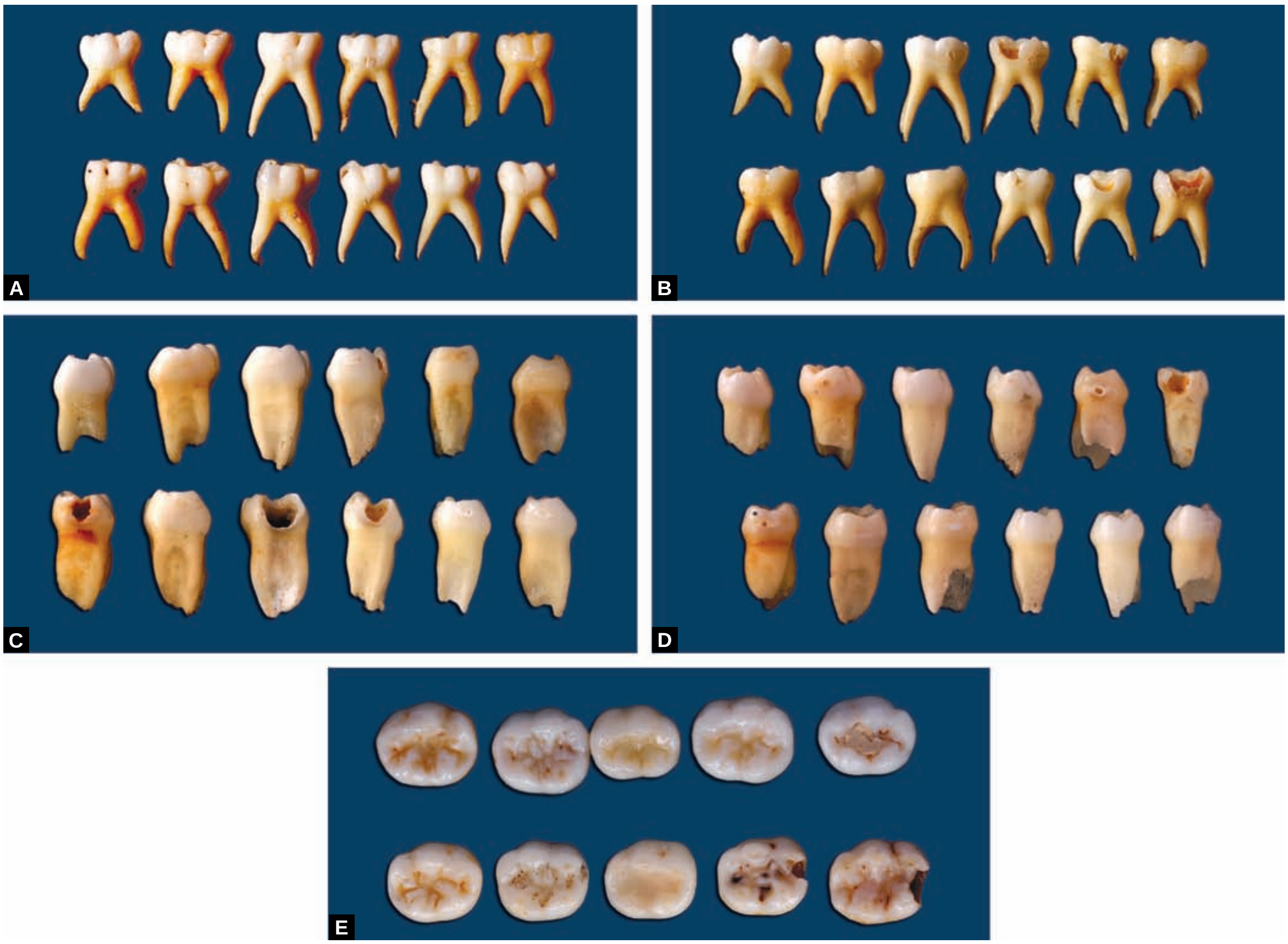
Fossae, Grooves and Pits

Fossae
There are two fossae:
1. Mesial triangular fossa
2. Distal triangular fossa.

Mesial and distal marginal ridges form the base of the triangle while mesial and distal pits form the apex for the respective triangular fossae.

Grooves
There are four grooves:
1. *Central developmental groove* has a zigzag course in across the center of the occlusal surface running from mesial pit to distal pit dividing the buccal and lingual cusps
2. *Mesiobuccal developmental groove*
3. *Distobuccal developmental groove* originates from central pit and run in a buccal direction extending onto the buccal surface to separate the three buccal cusps.
4. *Lingual developmental groove* originates from the central pit and runs lingually onto the lingual surface, separating the two lingual cusps.

Pits
- *Central pit* in the center
- *Mesial and distal pits* in mesial and distal triangular fossae.



Figures 5.29A to E Primary mandibular 2nd molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

Root

Number

There are two roots:
1. Mesial
2. Distal.

Size

The roots are twice as long as the crown and both roots are equal length.

Form

- The roots are slender and long.
- The point of bifurcation of roots starts immediately below the CEJ without much root trunk left.
- The roots characteristically flare out to accommodate permanent successor tooth germ in the alveolus.
- The roots are thin mesiodistally and broad and flattened buccolingually.

Apices

Mesial root has blunt apex and distal root has a sharp apex.

Curvature

The apical third and roots may curve towards center to face each other.

BIBLIOGRAPHY

1. Barker BC. Anatomy of root canals: IV. Deciduous teeth. Aust Dent J. 1975;20:101.
2. Fanning EA. Effect of extraction of deciduous molars on the formation and eruption of their successors. Angle Orthod. 1962;32:44.

3. Morrees CFA, Chadha M. Crown diameters of corresponding tooth groups in the deciduous and permanent dentition. J Dent Res. 1962;41:466.
4. Richardson AS, Castaldi CR. Dental development during the first two years of life. J Canad Dent Assoc. 1967;33:418.
5. Woo RK, et al. Accessory canals in the deciduous molars. J Int Assoc Dent Child.1981;12:51.

MULTIPLE CHOICE QUESTIONS

1. Primary/deciduous dentition consists of:
   a. 30 teeth, 15 in each jaw
   b. 32 teeth, 16 in each jaw
   c. 20 teeth, 10 in each jaw
   d. 12 teeth, 6 in each jaw
2. Each quadrant in deciduous dentition consists of:
   a. 4 teeth
   b. 5 teeth
   c. 6 teeth
   d. 8 teeth
3. The term 'deciduous' comes from latin meaning:
   a. The first set
   b. The important
   c. The small
   d. To fall off
4. The following terms are also used to describe primary teeth except:
   a. Milk teeth
   b. Lacteal teeth
   c. Succedaneous teeth
   d. Baby teeth
5. The following classes of teeth are present in primary dentition:
   a. Incisors, canines, premolars, molars
   b. Incisors, canines, molars
   c. Incisors, premolars, molars
   d. Canines, premolars and molars
6. Teeth that are not present in primary dentition:
   a. Premolars
   b. Canines, premolars
   c. Premolars, molars
   d. Premolars, 3rd molar
7. Each quadrant in primary dentition contains the following teeth:
   a. Central incisor, lateral incisor, canine, 1st premolar, 1st molar
   b. Central incisor, lateral incisor, canine, 1st molar, 2nd molar
   c. Central incisor, lateral incisor, 1st molar, 2nd molar
   d. Central incisor, lateral incisor, canine, 1st premolar, 2nd premolar, 1st molar, 2nd molar and 3rd molar
8. In mixed dentition period, the primary molars are replaced by:
   a. Permanent molars
   b. Permanent canines
   c. Permanent premolars
   d. None of the above
9. There are how many molars in primary dentition:
   a. 3—1st, 2nd and 3rd molars
   b. 2—1st and 2nd molars
   c. 4—1st, 2nd, 3rd and 4th molars
   d. 1—1st molar
10. There are how many premolars in primary dentition:
    a. 2
    b. 1
    c. 3
    d. There are no premolars in primary dentition

Answers

1. c	2. b	3. d	4. c	5. b	6. d	7. b	8. c	9. b	10. d

CHAPTER 6

Differences between Primary and Permanent Dentitions

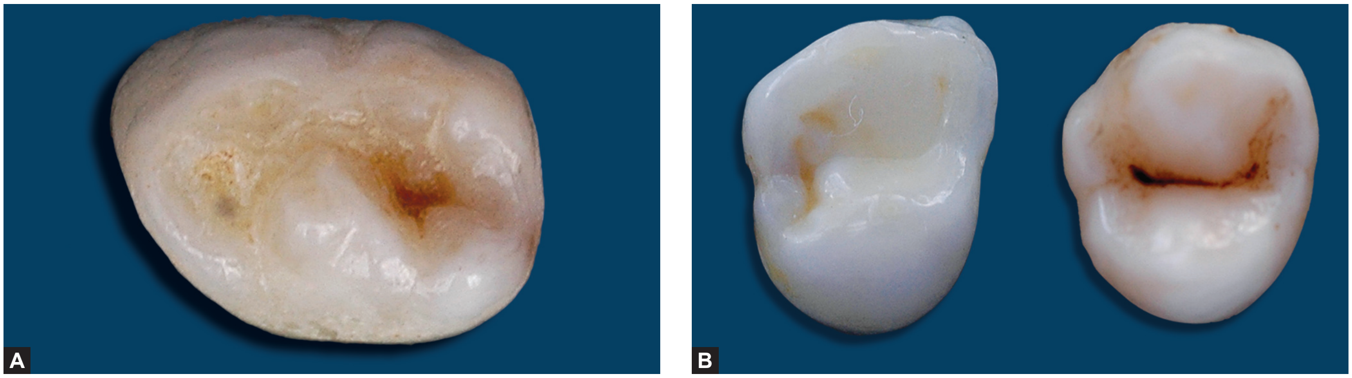
In general, primary teeth pretty much resemble their corresponding permanent teeth in morphology (**Figs 6.1A and B**). One major exception is that the deciduous mandibular 1st molar does not resemble any tooth in the permanent dentition (**Fig. 6.2A**). In addition, deciduous maxillary 1st molar resembles a permanent maxillary premolar rather than a permanent molar in crown anatomy; however, it has three roots, a trait common to all the maxillary molars (**Fig. 6.2B**). The deciduous 2nd molars closely resemble the permanent 1st molars in both the arches and appear as their replicas though smaller in size (**Figs 6.3A to C**).

Smaller sized jaws of the child functionally require and can accommodate fewer and smaller teeth. Thus, there are only 20 teeth in deciduous dentition as against 32 in the permanent dentition. *There are no premolars in the deciduous dentition*. Furthermore, there are only two molars (1st and 2nd deciduous molars) in the deciduous dentition. In other words, *there are no 3rd molars in deciduous dentition*.

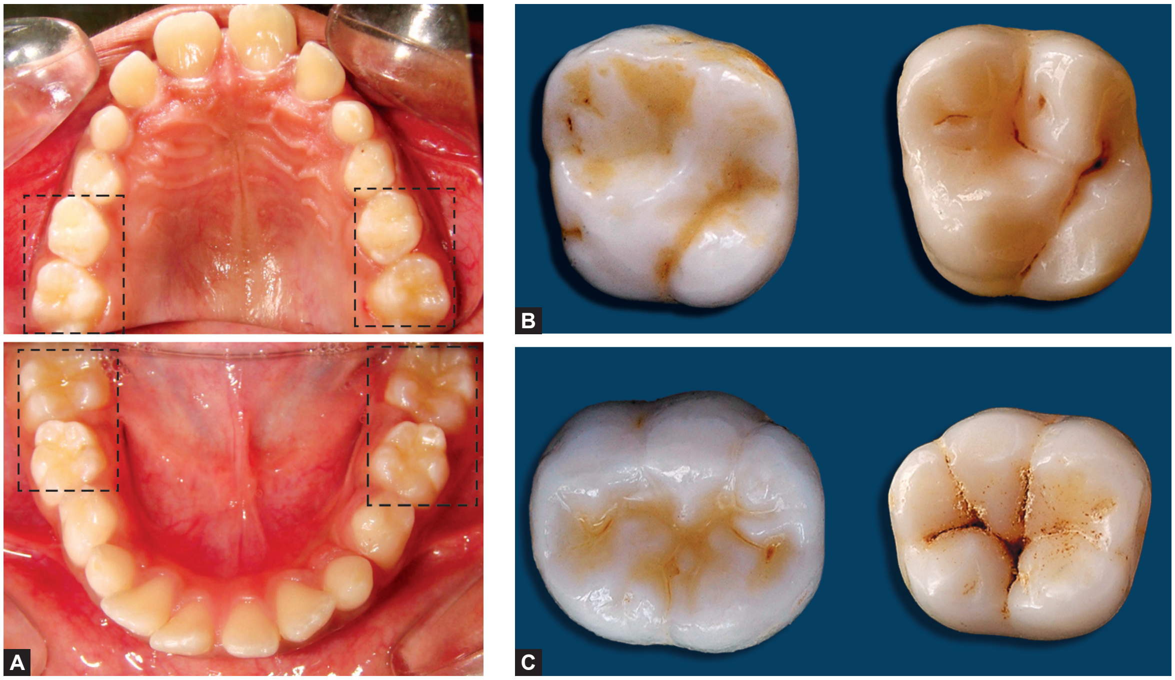
Furthermore, there are some important differences between primary and permanent teeth in terms of external morphology, structure, mineral density, etc. that have to be borne in mind while rendering dental treatment. Many of the routine dental procedures for instance, restorative cavity cutting, crown preparation, extractions, etc. have to be modified while treating primary teeth so as to accommodate these differences.

The differences between primary and permanent teeth are listed in **Table 6.1**.

Figures 6.1A and B Primary anteriors resemble their corresponding permanent anteriors



Figures 6.2A and B (A) Primary mandibular 1st molar has unique crown morphology and do not resemble any tooth in either of the dentitions; (B) Primary maxillary 1st molar crown resembles a permanent premolar



Figures 6.3A to C Primary 2nd molar, closely resembles permanent 1st molar of respective dental arches: (A) Clinical photograph; (B) Teeth specimen of primary maxillary 2nd molar and permanent 1st molar; (C) Teeth specimen of primary mandibular 2nd molar and permanent 1st molar

Table 6.1 Difference between primary and permanent teeth

	Primary dentition	*Permanent dentition*
	GENERAL FEATURES	
Number (**Figs 6.1A and B**)	A total of 20 teeth 10 in each jaw, 5 in each quadrant	A total of 32 teeth 16 in each jaw, 8 in each quadrant
Classes of teeth present	There are 2 incisors, 1 canine, 2 molars in each quadrant (*Premolars* and *3rd molars* are not there in deciduous dentition)	There are 2 incisors, 1 canine, 2 premolars and 3 molars in each quadrant
Dental formula	I 2/2 C 1/1 M 2/2 (212)	I 2/2 C 1/1 PM 2/2 M 3/3 (2123)

Contd...

Contd...

	Primary dentition	*Permanent dentition*
Duration of dentition	Deciduous dentition period lasts from 6 months to 6 years	12 years and beyond
Eruption	Primary teeth begin to erupt at 6 months. By 2½ to 3 years of age, a child would have his/her complete set of deciduous teeth	Eruption of permanent teeth begins at 6 years and completes at 12–13 years except for 3rd molars
Eruption sequence	AB D C E A B D CE	*Maxillary teeth*: 6 1 2 4 3 5 7 or 6 1 2 4 5 3 7 *Mandibular teeth*: 6 1 2 3 4 5 7
	MACROSCOPIC FEATURES	
CROWN		
Size (**Figs 6.1A and B**)	Primary teeth are smaller in overall size and crown dimensions when compared to their permanent counterparts	Permanent teeth are larger in overall dimension
Color (**Figs 6.1A and B**)*	Primary teeth are lighter in color. They appear bluish-white (milky white) and are also called as *milk teeth*. Their refractive index is comparable to that of milk	Permanent teeth are darker in color. They appear yellowish, white or grayish, white
* Thus for primary resin restorations, lighter shades should be selected.		
Shape	Crowns of primary teeth are wider mesiodistally in comparison to their crown height This gives a cup-shaped appearance to anterior teeth and "squat" shaped appearance to deciduous molars (**Fig. 6.4A**)	The crowns of permanent anterior teeth appear longer as their cervicoincisal height is greater than mesiodistal width (**Fig. 6.4B**)
Cervical constriction (**Figs 6.4A and B**)	Deciduous teeth are more constricted at the cervical portion of the crown, i.e. are narrower at their *necks*	Crowns of permanent teeth are not so constricted at their *necks*
Cervical ridge	Cervical ridges on buccal aspect of deciduous crown are more prominent (especially on 1st molars) (**Fig. 6.5A**)	Cervical ridges on permanent crowns are flatter (**Fig. 6.5B**)
Incisors		
Mamelons	*Primary incisors do not exhibit mamelons* (**Fig. 6.6 A**)	Newly erupted permanent incisors exhibit mamelons (**Fig. 6.6B**)
Crown width (**Figs 6.4A and B**)	Primary incisors are noticeably *wider mesiodistally* than they are long cervicoincisally	Permanent incisors are *longer cervicoincisally* than they are wider mesiodistally
Canines	Primary canines tend to be more conical in shape and cusp tip is more pointed and sharp	Permanent canines are less *conical*; their cusps tips are less pointed
Premolars	No premolars in deciduous dentition	There are two premolars in each quadrant
Molars		
Number	There are only 2 molars in each quadrant. No 3rd molars in deciduous dentition	There are 3 molars in each quadrant—1st, 2nd and 3rd molars
Size (**Figs 6.1A and B**)	Crown of 2nd molar is larger than the crown of 1st molar	1st permanent molar is larger than 2nd and 3rd molars. Size of crown gradually decreases from 1st to 3rd molars
Shape	Deciduous molars are more bulbous, bell-shaped and with marked cervical constriction. * (Applied aspect): Cervical ridges are more pronounced especially on buccal aspect of 1st primary molars. These cervical bulges have to be reproduced during restoration/ crown prosthesis. Sharp cervical constriction has to be kept in mind and special care should be taken while forming gingival floor during class II cavity preparation.	Permanent molars have less constriction of neck.

Contd...

Contd...

	Primary dentition	*Permanent dentition*
Occlusal table	Buccal and lingual surfaces of primary molars, especially that of 1st molars converge sharply occlusally, thus forming narrow occlusal table in buccolingual dimension (**Fig. 6.7A**). **Deciduous molars are functionally adapted to withstand less occlusal load.* **Occlusal cavity preparations should be kept narrow in bucco-lingual plane.*	There is less convergence of buccal and lingual surfaces of molars towards occlusal surface. Thus have broader occlusal table (**Fig. 6.7B**)
Occlusal plane	Occlusal plane is relatively flat.	Occlusal plane have more curved contour and more intricate design
Grooves	Supplemental grooves are more (**Fig. 6.8A**). ** Primary molars are more caries prone due to easy food lodgment.* ** Pit and fissure sealants are advisable to prevent caries.*	Supplemental grooves are less (**Fig. 6.8B**)
Contact areas	Contact areas between primary molars are broader, flatter and situated gingivally. ** During class II cavity preparation for amalgam buccal and lingual extensions/walls of class II cavity should be located in selfcleansing areas.* In order to clear the broad contact areas of the primary molars, the class II cavity design should have wider and divergent buccal and lingual extensions of proximal box	Contact areas between permanent molars are narrower and situated occlusally
Upper 1st molar	Has 3 cusps (resembles a premolar)	Has 4 cusps + 1 accessory cusp
Upper 2nd molar	4 cusps + one accessory cusp (resembles permanent upper 1st molar)	Has 4 cusps
Lower 1st molar	4 cusps (does not resemble any permanent tooth)	Has 5 cusps
Lower 2nd molar	5 cusps (resembles permanent lower 1st molar)	Has 4 cusps
ROOT	(**Fig. 6.9A**)	(**Fig. 6.9B**)
Size	Primary roots are more delicate. Roots of primary teeth are proportionately longer and more slender in comparison to crown size	Permanent roots are stronger and provide good anchorage in jaw bone. They are shorter and bulkier in comparison to their crown
Width	Roots are narrower mesiodistally	Roots are broader mesiodistally
Trunk	Furcation of molar roots is placed more cervically so that the root trunk is much smaller	Furcation in permanent molars is placed more apically and thus root trunk is larger
Flaring	Roots of primary molars flare out markedly from cervical area to their tips **Roots of primary molars are flared out to accommodate permanent tooth buds between their roots*	Marked flaring of roots is absent
Resorption	Primary roots undergo physiologic resorption and the primary teeth are shed naturally	Physiologic resorption is absent.
PULP	(**Fig. 6.10A**)	(**Fig. 6.10B**)
Pulp chamber	Pulp chambers of deciduous teeth are proportionately larger when compared to crown size	Pulp chamber is smaller in relation to crown size
Pulpal outline	Pulpal outline of primary tooth follows DEJ more closely than that of permanent tooth	Pulp outline follows DEJ less closely
Pulp horns	Pulp horns of deciduous molars (especially mesial horns) are higher and closer to outer surface than that of permanent molars. Primary pulp horns are more pointed and longer than cusps would indicate. **Depth of cavity preparation in primary teeth should be kept shallow. Care should be taken not to expose the pulp.*	Pulp horns are comparatively lower and away from outer surface

Contd...

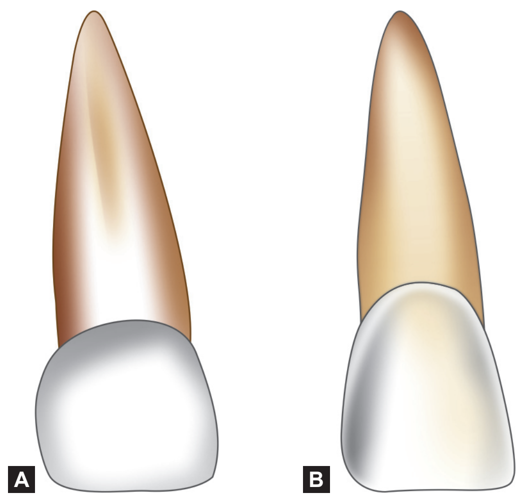
Contd...

	Primary dentition	*Permanent dentition*
Root canals	Root canals are more ribbon-like, follows a thin, tortuous and branching path. **Multiple ramification of primary pulp make complete debridement (almost) impossible!*	Root canals of permanent teeth are well-defined and less branching
Accessory canals	Floor of the pulp chamber is more porous. Accessory canals in pulp chambers of primary molars directly lead to inter-radicular furcation areas. **Inflammation/infection from pulp can easily reach periodontium and vice versa in case of primary molars.* **Enamel of underlying permanent successor teeth may become hypoplastic due to spread of inflammation. This can result in 'turner's hypoplasia' of permanent tooth.*	Floor of the pulp chamber do not have many accessory canals.
Apical foramen	Apical portion of the canal is much less constricted than that of permanent tooth and apical foramen is wider.	Apical portion of the canal is constricted and apical foramen is smaller/narrower.
	MICROSCOPIC/ HISTOLOGIC FEATURES	
ENAMEL		
Thickness (**Figs 6.10A and B**)	Enamel is thinner and is about 1 mm thick but of uniform thickness. **Less pressure/force is required during cavity preparation of primary teeth. Depth of the cavity preparation is less.*	Enamel is 2–3 mm thick and is not uniform in thickness.
Direction of rods	Enamel rods at the cervical third of primary crowns are directed occlusally instead of gingivally as seen in permanent teeth (**Fig. 6.11A**). **Due to this difference in the direction of enamel rods, gingival bevel is not given in class II cavity preparation.*	Enamel rods at the cervix are directed apically (**Fig. 6.11B**) **In class II cavity preparation of permanent teeth, gingival bevel should be given to remove unsupported enamel.*
Incremental lines	Incremental lines of Retzius are less common in enamel. **This may be partly responsible for bluish-white color of enamel.* Primary enamel is less mineralized and more organic content is present. Enamel is more prismatic. **Etching time in primary teeth is prolonged to 90–120 seconds.*	Lines of Retzius are more common in enamel. Enamel is highly mineralized. **Usual etching time for permanent teeth is 30 seconds*
DENTIN		
Thickness (**Figs 6.10A and B**)	Dentin thickness is half that of permanent teeth. (however, comparatively greater thickness of dentin is present over the pulpal wall at the occlusal fossa of primary molars). **Depth of occlusal cavity preparation in primary molars should be kept shallow (There is less thickness of protective dentin over pulp).*	Greater thickness of dentin over pulpal roof.
Dentinal tubules	Dentinal tubules are less regular.	Dentinal tubules are more regular.
Interglobular dentin	Interglobular dentin is absent.	Interglobular dentin is present beneath the well-calcified mantle layer of dentin.
PULP		
Blood supply	Primary roots have wide enlarged apical foramen. Thus primary teeth have abundant blood supply and exhibit a more typical inflammatory response. Thus, poor localization of infection and inflammation.	Apical foramen is constricted. Reduced blood supply follows healing by calcific scarring. Thus, infection and inflammation are comparatively well-localized.
Nerve supply	Primary pulp is less densely innervated. Nerve fibers terminate near odontoblastic zone as free nerve endings. **Thus primary teeth are less sensitive to operating procedure compared to permanent teeth.*	Permanent pulp is densely innervated. Nerve fibers terminate among odontoblasts and even pass beyond predentin.

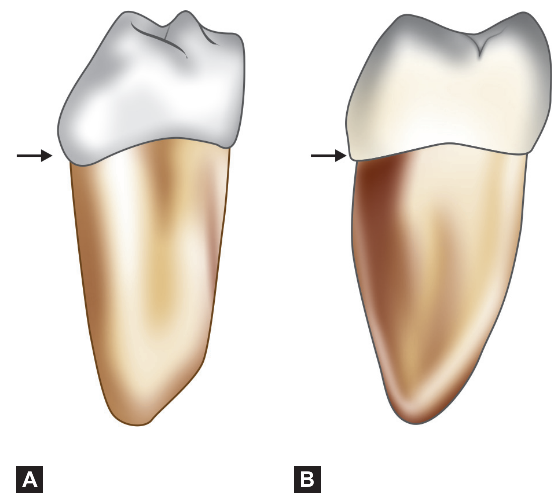
Contd...

Contd...

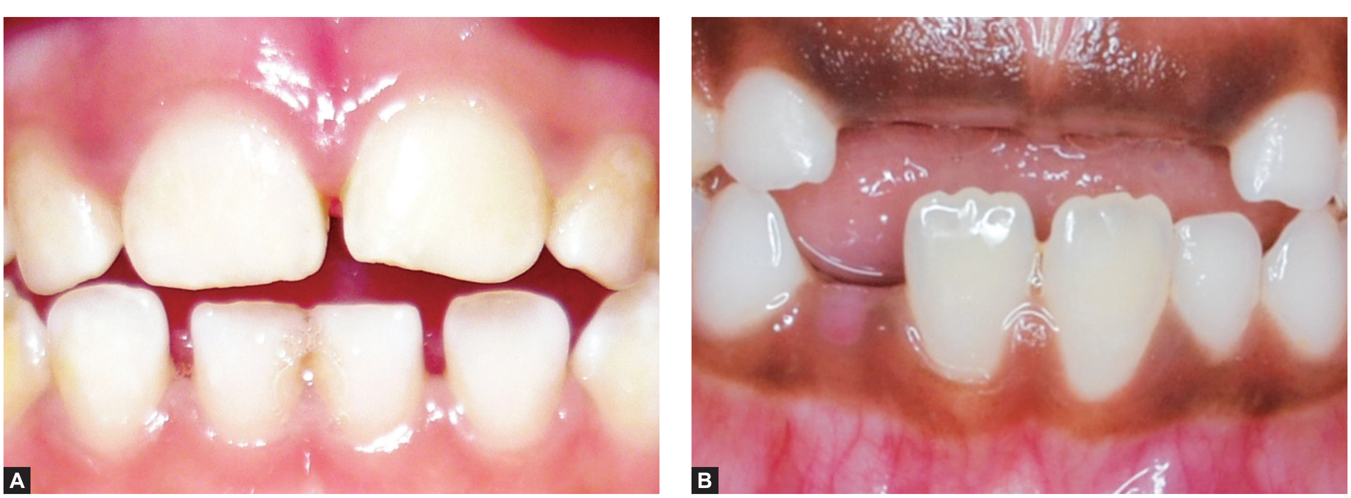
	Primary dentition	*Permanent dentition*
Cementum	In primary teeth the cementum is thin and made-up of only primary cementum. **This shows that permanent teeth are firmly anchored in alveolar bone and are not easily resorbed. Whereas anchorage of primary teeth is comparatively less firm and easily resorbed, and can be easily extracted.*	Cementum is thick. Both primary and secondary cementum present.
Mineral content	Both enamel and dentin are less mineralized and less dense. **This difference can be easily appreciated clinically by the resistance offered during cavity cutting. Primary teeth dentin is cut more easily.*	Enamel and dentin are more mineralized.
Neonatal line	Neonatal lines are present in all primary teeth both in enamel and dentin.	Neonatal lines are seen only in 1st molar (since mineralization begins at birth)



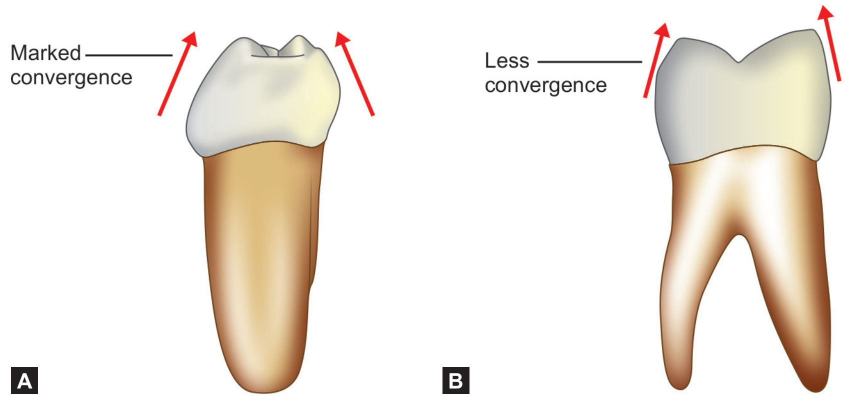
Figures 6.4A and B Comparison of mesiodistal dimensions of crown: (A) Primary teeth wider mesiodistally; (B) Permanent anteriors have greater length than width



Figures 6.5A and B (A) Prominent cervical ridge; (B) Flatter cervical ridge

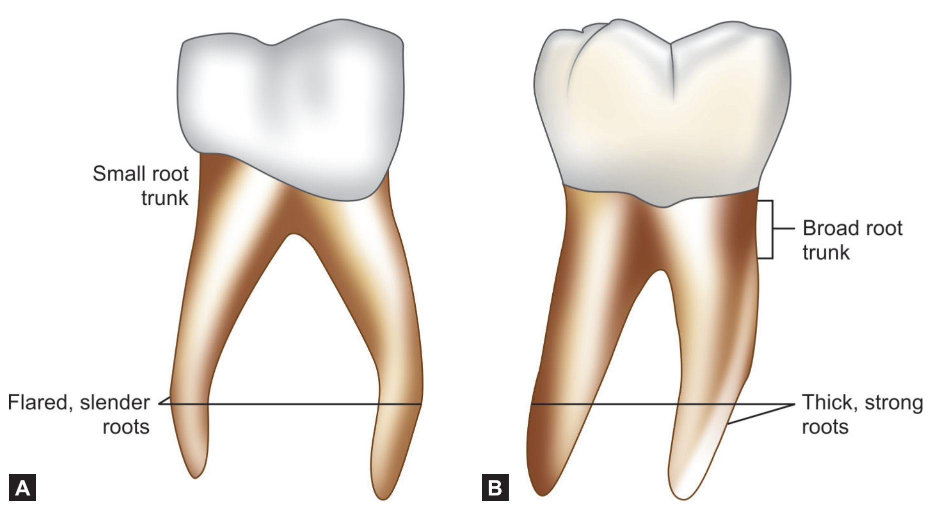


Figures 6.6A and B (A) Mamelons absent in primary incisor; (B) Mamelons present in permanent incisor

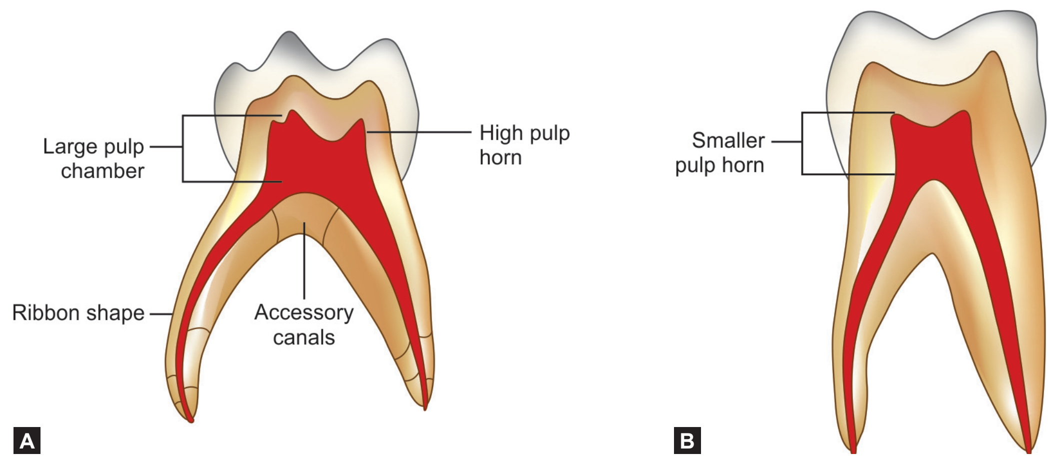


Figures 6.7A and B (A) Primary molars have narrow occlusal table; (B) Permanent molars have wider occlusal table

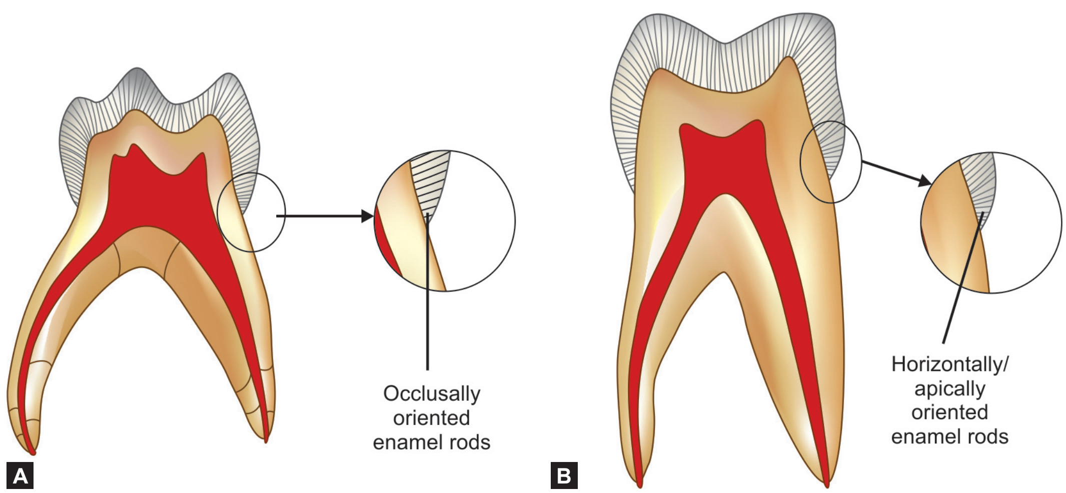
Figures 6.8A and B (A) More supplementary grooves in primary molar; (B) Less supplementary grooves in permanent molar



Figures 6.9A and B (A) Primary roots are slender, narrower, proportionately longer, and flare out markedly, root trunk is smaller; (B) Permanent roots are stronger, wider, do not flare much and have long root trunk



Figures 6.10A and B (A) Primary pulp cavity—long pulp horns, tortuous pulp canal, more accessory canals and wide apical foramen; (B) Permanent pulp cavity—shorter pulp horns, well-defined pulp canals, less accessory canals and constricted apical foramen



Figures 6.11A and B (A) Enamel rods are directed occlusally at the cervical 3rd; (B) Enamel rods at cervical 3rd directed apically

BIBLIOGRAPHY

1. Barker BC. Anatomy of root canals: IV. Deciduous teeth. Aust Dent J. 1975;20:101.
2. Kraus B, Jordan R, Abrams L. Dental anatomy and occlusion. Baltimore: Williams and Wilkins; 1969.
3. Morrees CFA, Chadha M. Crown diameters of corresponding tooth groups in the deciduous and permanent dentition. J Dent Res. 1962;41:466.
4. Woo RK, et al. Accessory canals in deciduous molars. J Int Assoc Dent Child. 1981;12:51.

MULTIPLE CHOICE QUESTIONS

1. Total number of deciduous teeth in each quadrant are:
   a. 20
   b. 10
   c. 5
   d. 8
2. The differences between deciduous and permanent teeth with regards to classes of teeth are:
   a. 3 classes of teeth seen in deciduous dentition
   b. 4 classes of teeth seen in deciduous dentition

c. Both of the above
d. None of the above

3. The dental formula for the permanent dentition is:
   a. I 2/2 C 1/1 M 2/2
   b. I 2/2 C 1/1 PM 2/2 M 3/3
   c. I 1/1 C 1/1 M 1/1
   d. I 2/2 C 2/2 M 2/2
4. By what age the child would have his/her complete set of deciduous dentition:
   a. 2½–3 years of age
   b. 1–2 years
   c. 0–1½ years
   d. 3½–6 years
5. The sequence of eruption of maxillary permanent teeth is:
   a. 6 1 2 4 5 3 7 8
   b. 6 1 2 3 4 5 7 8
   c. 1 2 3 4 5 6 7 8
   d. 6 1 2 4 3 5 7 8
6. Which of the following statements is incorrect?
   a. Crown of deciduous teeth are more wider mesiodistally than cervicoincisally
   b. Crowns of permanent anterior are longer and more cervicoincisally and less mesiodistally
   c. Deciduous teeth are more constricted at the cervical portion of the crown
   d. Permanent teeth are constricted at their necks.
7. In deciduous dentition, the contact area between molars are:
   a. More broader and flatter
   b. Narrower
   c. Situated occlusally
   d. Both b and c
8. In comparison to crown size of permanent teeth, the roots of primary teeth are:
   a. Proportionately longer and more slender
   b. Proportionately smaller and less slender
   c. Proportionately smaller and more slender
   d. Proportionately longer and less slender
9. In permanent dentition, the dentinal tubules are:
   a. Less regular
   b. More regular
   c. Less irregular
   d. More irregular
10. Direction of enamel rods in the primary teeth at cervical thirds of crown is:
    a. Directed occlusally
    b. Directed apically
    c. Absent in deciduous teeth
    d. Absent in permanent teeth

Answers

1. c	2. c	3. b	4. a	5. a	6. d	7. a	8. a	9. b	10. a

SECTION

4

Permanent Dentition

CHAPTER 7

The Permanent Maxillary Incisors

There are eight incisors; four in each arch and two in each quadrant. The central incisors are at the center of their respective arches, one on either side of the midline. The lateral incisors are distal to the central incisors. By virtue of being at the midline, the maxillary and mandibular central incisors are the only teeth with their mesial surfaces facing each other. In case of all other teeth, the mesial surface of one tooth is in contact with the distal surface of the neighboring tooth and vice versa. In the maxillary arch, the central incisor is larger than the lateral incisor, whereas in the mandibular arch the lateral incisor is larger. All the incisors have single roots.

FUNCTIONS OF INCISORS

- Incisor are used for biting, cutting and shearing the food during masticatory process
- Maxillary and mandibular incisor act as cutting blades
- They are of great importance in esthetics and phonation too.

Common characteristics of all incisors (Class traits of incisors):

- All incisors develop from four lobes; three labial lobes and one lingual lobe for cingulum
- They have single, cone shaped tapering roots
- Their labial and lingual aspects are trapezoidal and the proximal aspects are triangular in shape
- The incisal portions of the incisors are designed like the edges of blades
- The newly erupted incisors have three rounded eminences on their incisal portion called the *mamelons*, which represent the three labial lobes
- All incisors have cingulum at the cervical portion of their lingual aspects and concave lingual fossa at the center of lingual surfaces
- The contact areas are relatively smaller and are nearly at the same level, especially so in the mandibular incisors
- Their labial surfaces are convex and lingual surface are concavoconvex
- The crests of both labial and lingual contours are at the same level, in the cervical third of the crown, facing each other
- Positioned at the center of dental arches, the incisors are important for the esthetics and phonetics
- The cervical lines on their proximal surfaces exhibit greater curvature than on other teeth.

PERMANENT MAXILLARY CENTRAL INCISOR

The maxillary central incisors are esthetically the most prominent teeth in the mouth. An ideal smile should have incisal dominance, i.e. maxillary incisors should be the most prominent teeth visible when one smiles (**Fig. 7.1**). Any defects in the form and alignment of these teeth are easily noticed, and adversely affect the normal facial appearance (**Fig. 7.2**). The mesiodistal dimension of maxillary central incisor is wider than that of any other anterior tooth. The chronology and measurement of the maxillary central incisor is given in **Table 7.1**.

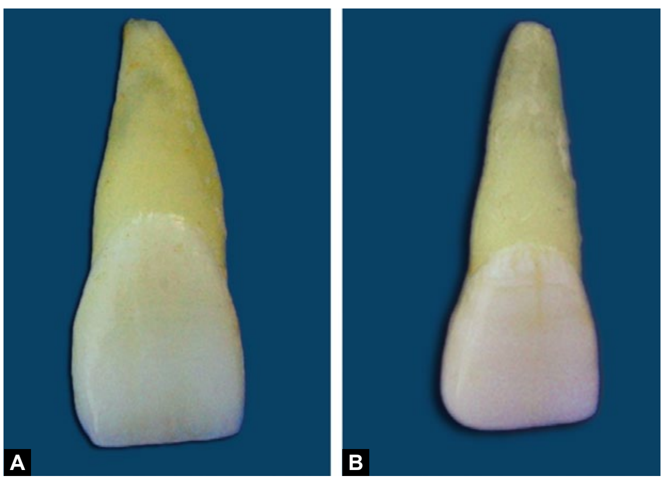
Morphologically, there are two basic forms of maxillary central incisors (**Figs 7.3A and B**):

Figure 7.1 An ideal smile has incisal dominance

Figure 7.2 Maxillary central incisors are esthetically the most prominent teeth and any defect is easily noticed. Overlapping of maxillary central incisors in this patient is adversely affecting the facial esthetics

Table 7.1 Maxillary central incisor—chronology and dimensions

Chronology	
First evidence of calcification Enamel completed Eruption Root completed	3–4 years 4–5 years 7–8 years 10 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervicoincisal length of crown	10.5
Length of root	13.0
Mesiodistal diameter of crown	8.5
Mesiodistal diameter of crown at cervix	7.0
Labiolingual diameter of crown	7.0
Labiolingual diameter of crown at cervix	6.0
Curvature of cervical line—mesial	3.5
Curvature of cervical line—distal	2.5



Figures 7.3A and B Maxillary central incisors can be of two forms: (A) Square form; (B) Tapering form

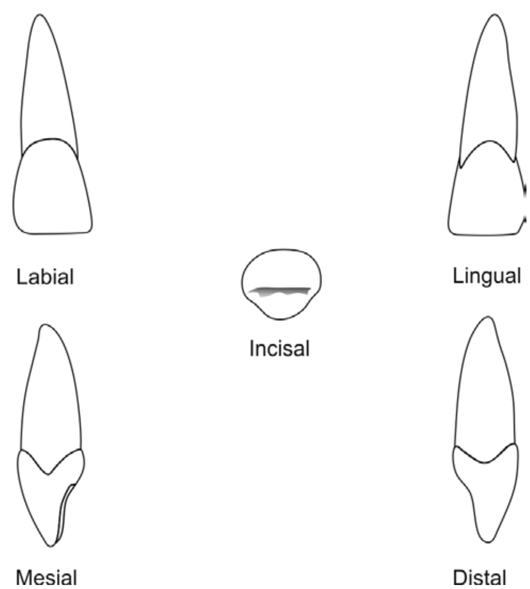


Figure 7.4 Maxillary central incisor—line drawings

1. *Square form*: The tooth is relatively wider at cervix (neck of tooth) in comparison with the mesiodistal diameter of the crown at the contact areas.
2. *Tapering form*: With relatively narrow cervical width in comparison with the mesiodistal width at the contact areas.

DETAILED DESCRIPTION OF MAXILLARY CENTRAL INCISOR FROM ALL ASPECTS

While describing the morphology of each tooth, the crown and root are considered separately. The anatomy of crown will be described by discussing its morphology from five aspects namely:

1. Labial/buccal aspect
2. Lingual aspect
3. Mesial aspect
4. Distal aspect
5. Incisal/occlusal aspect.

Figures 7.4 to 7.6 show permanent maxillary central incisor from various aspects.

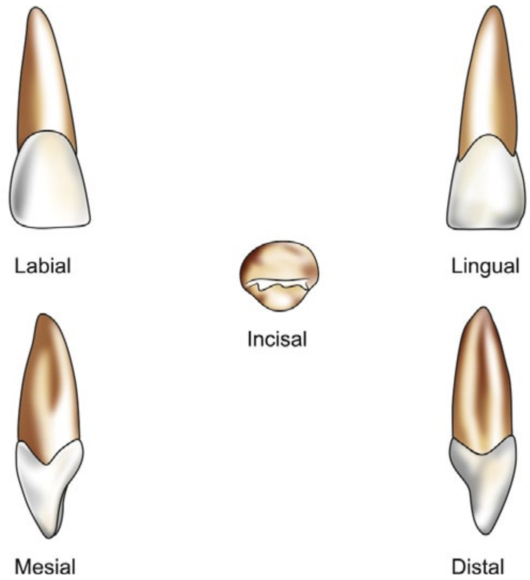


Figure 7.5 Maxillary central incisor—graphic illustration

CROWN

Five aspects describe the anatomy of crown.

Labial Aspect (Fig. 7.7)

Geometric shape: General shape of the central incisor from labial aspect is *trapezoid* with shortest of the uneven sides towards the cervix.

Crown Outlines

Mesial Outline

- The mesial outline is relatively straight and meets incisal edge at a sharp angle.
- The crest of curvature of mesial outline (*mesial contact area*) is at incisal third of the crown near the mesioincisal angle.

Distal Outline

- The distal outline is more convex than the mesial outline.
- The distoincisal angle is more rounded.
- The crest of curvature of the distal outline (*distal contact area*) is higher towards the cervical line, at the junction of incisal and middle third of the crown.

Incisal Outline

- Incisal outline is formed by the incisal ridge
- It is usually regular and straight mesiodistally.

Cervical Outline

- Cervical outline is formed by the cervical line
- The cervical line on the labial aspect is a semicircular curvature towards the root.

Labial Surface within the Outlines

- The tooth is longer cervicoincisally than it is wider mesiodistally
- The labial surface of maxillary central incisor is smooth and convex both mesiodistally and cervicoincisally. Convexity is more near cervical third and becomes flattened towards the mesial and incisal third of the crown
- Newly erupted incisors show three elevations at incisal portion called 'mamelons' corresponding to three labial lobes (**Fig. 7.8**). The mamelons disappear soon as the incisal surface of the tooth gets worn by mastication.

Lingual Aspect (Fig. 7.9)

Geometric Shape

- General shape of lingual aspect is also a *trapezoid*
- The lingual topography gives a scoop-like form to the crown
- Mesial, distal, incisal and cervical outlines are similar to there of labial aspect.

Crown Outlines

- *Mesial outline* is similar to mesial outline of labial aspect except that a portion of incisal wall can be viewed
- *Distal outline* is similar to distal outline of labial aspect except that a portion of distal wall can be viewed
- *Incisal outline* is similar to incisal outline of labial aspect
- The *cervical outline* curves apically.

Lingual Surface within the Outlines

- Lingual surface of crown and root is narrower than the labial surface as the mesial and distal walls taper towards lingual aspect (lingual convergence)
- Because of this lingual convergence, the labial line angles can be viewed from lingual aspect
- Unlike labial aspect, lingual surface is irregular with convexities and a concavity
- The convexity found immediately below the cervical line is called the "*cingulum*", and the central concavity is the "*lingual fossa*".

Cingulum (Fig. 7.9)

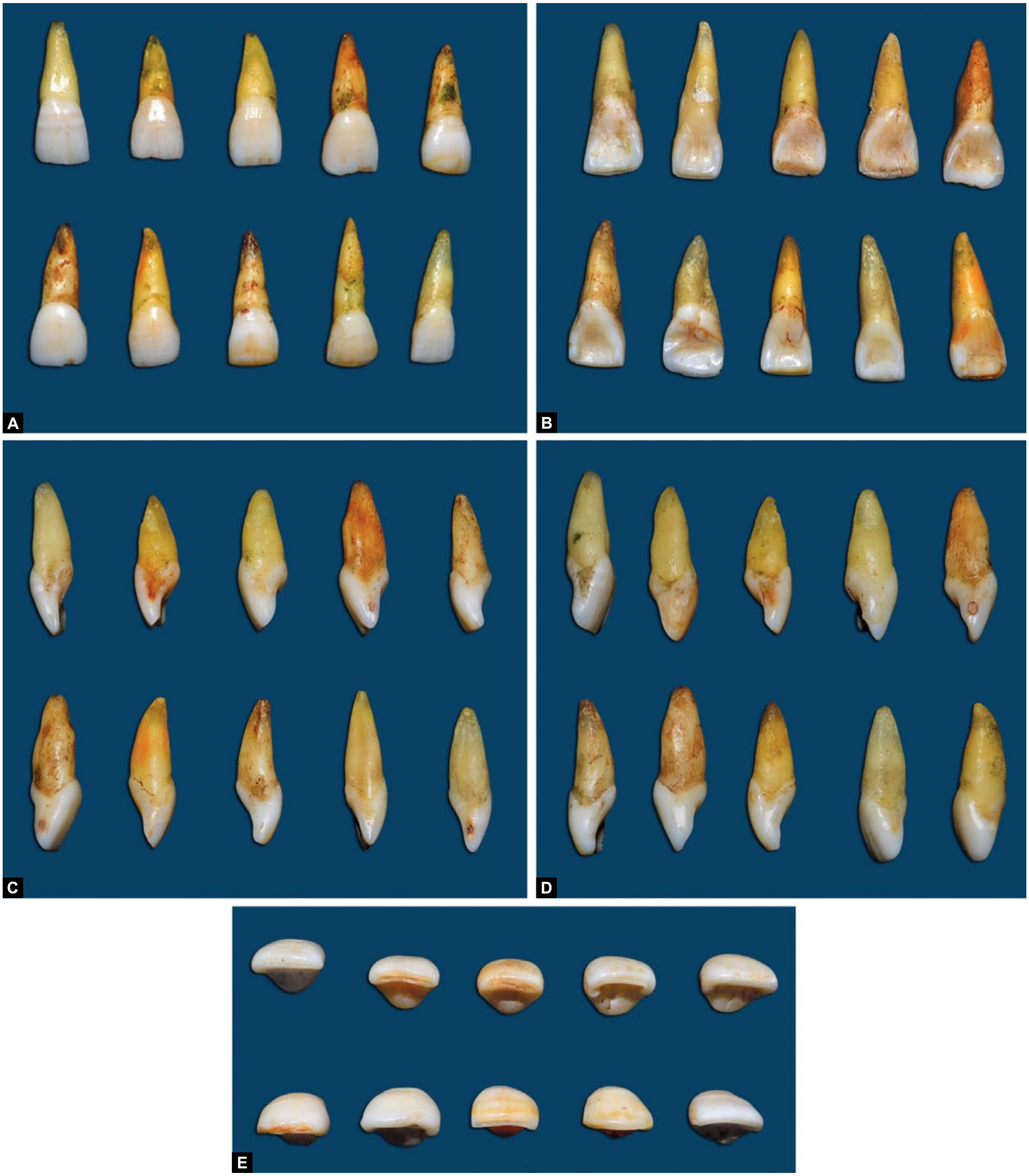
Definition: It is the convexity encircling the lingual surface of anteriors at the cervical third like a girdle.

Location

- Cingulum is found on lingual surfaces of all anteriors immediately below the cervical line
- It occupies the cervical third of lingual surface.

Development

Cingulum develops from the lingual developmental lobe of the anteriors.



Figures 7.6A to E Maxillary central incisor—typical specimen from all aspect: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

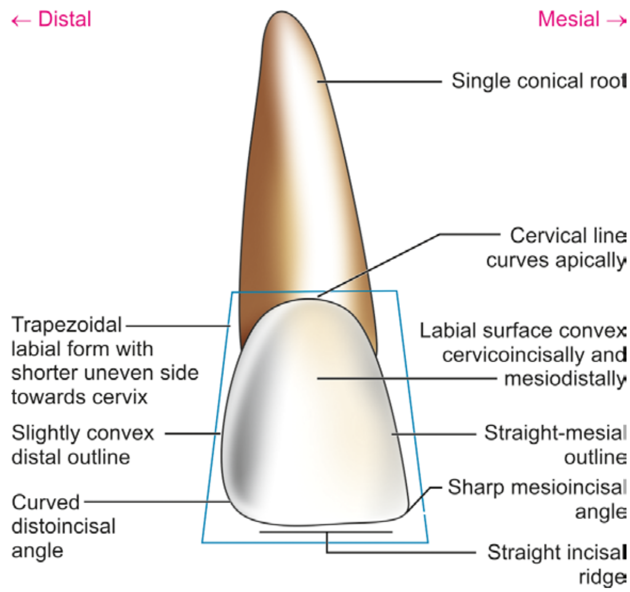


Figure 7.7 Maxillary central incisor—labial aspect

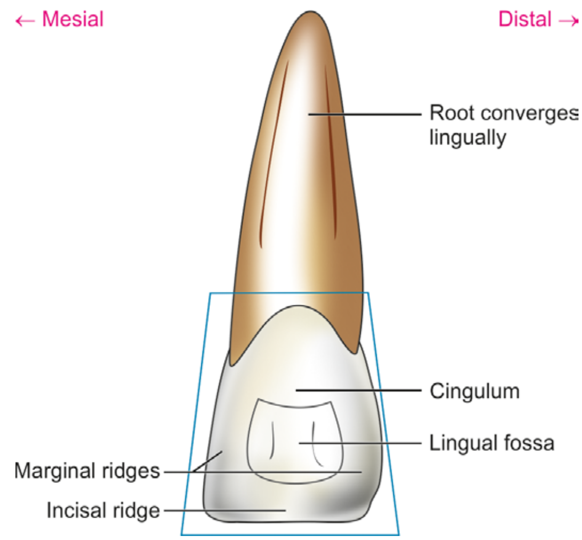


Figure 7.9 Maxillary central incisor—lingual aspect

Figure 7.8 Mamelons on erupting incisor teeth

Anatomy

- The cingulum is smooth and convex both mesiodistally and cervicoincisally
- It makes up the bulk of cervical third of the lingual surface
- Marginal ridges extend from cingulum forming the mesial and distal borders of the lingual fossa
- There is a concavity next to the cingulum incisally, called the lingual fossa
- Cingulum forms the cervical boundary of the lingual fossa
- Usually two developmental grooves extend from cingulum into the lingual fossa; especially on canines and maxillary incisors.

Lingual Fossa

- There is a concavity in the center of lingual aspect of all anteriors called lingual fossa
- Lingual fossa is bordered cervically by the cingulum, mesially by the mesial marginal ridge, distally by the distal marginal ridge and incisally by the incisal ridge.

Mesial Aspect (Fig. 7.10)

Geometric Shape

- Proximal aspect of maxillary central incisor is wedge shaped or *triangular*. It is true for proximal aspects of all the anteriors
- Base of the triangle is at the cervix and the apex of the triangle is towards the incisal ridge.

Crown Outlines

Labial Outline

- Labial outline is convex and curves smoothly from the cervical line to incisal ridge
- Height of labial contour of the crown is at the cervical third.

Lingual Outline

- Lingual outline is irregular with a convexity formed by cingulum in the cervical portion and a concavity formed by lingual fossa towards the incisal portion.
- Height of lingual contour of the crown is also at the cervical third.

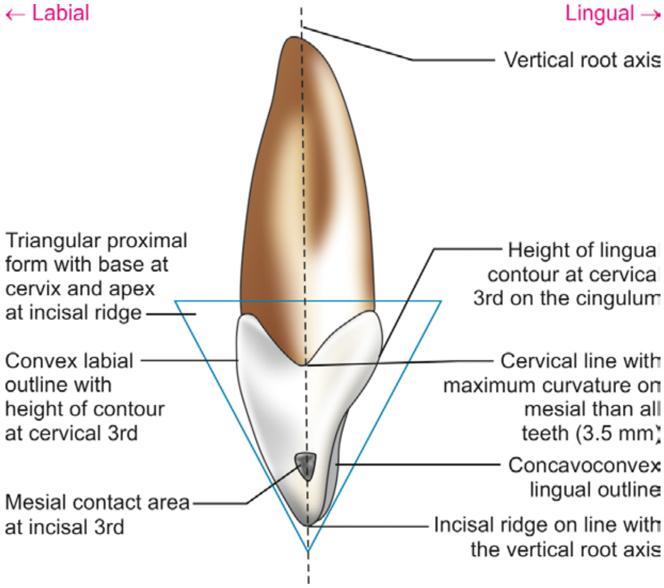


Figure 7.10 Maxillary central incisor—mesial aspect

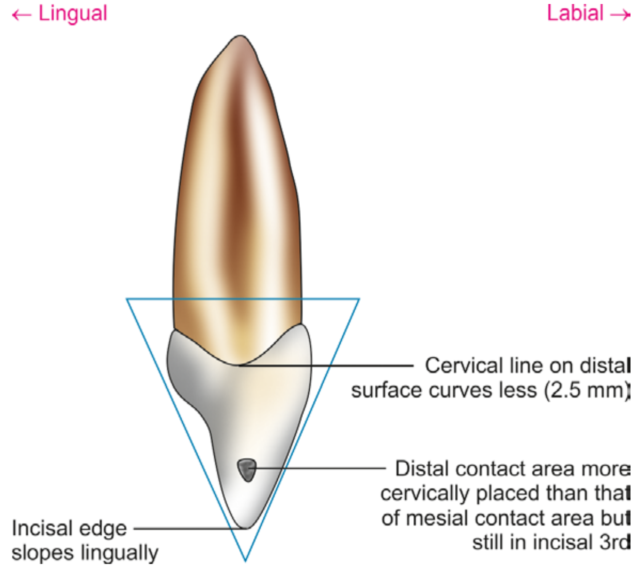


Figure 7.11 Maxillary central incisor—distal aspect

Incisal Outline

Incisal outline is formed by a rounded *incisal ridge* in a newly erupted tooth and a flat *incisal edge* in a worn functional tooth.

Cervical Outline

- The cervical line on mesial surface of central incisor curves incisally up to 3–4 mm
- Curvature of the cervical line on mesial aspect of central incisor is greater than that of any other tooth, on any aspect.

Mesial Surface within the Outlines

- Mesial surface is covex labiolingually and cervico-incisally with less convexity at the cervical area
- An imaginary line bisecting the tooth labiolingually passes through the incisal ridge
- *Mesial contact area* is at incisal third, immediately next to incisal edge.

Incisal Ridge and Incisal Edge

Incisal Ridge

- It is the rounded incisal portion of a newly erupted incisor, which merges with the mesioincisal and distoincisal angles and the labial and lingual surfaces
- This linear elevation on incisal aspect of crown is called the *incisal ridge* (**Fig. 7.10**).

Incisal Edge

- In a functional tooth with occlusal wear, an incisal edge can be seen.
- The term 'edge' means an angle formed by the merging of two flat surfaces. Incisal edge is not present in newly erupted incisor.
- In a functional incisor, a flattened surface is created linguoincisally due to occlusal wear (attrition). This linguoincisal surface forms an angle with the labial surface.
- This angle formed by linguoincisal surface ("incisal surface") and labial surface is called *incisal edge*.

Distal Aspect (Fig. 7.11)

General shape: Resembles mesial aspect with a wedge/ *triangle form*.

Crown Outlines

- *Labial outline* is convex from cervix to the incisal ridge, similar to mesial aspect
- *Lingual outline* is concavoconvex, similar to mesial aspect
- *Incisal outline* of maxillary central incisor is straight
- *Curvature of cervical line* is less in extent on distal surface than on mesial surface. This feature is same for all other teeth.

Distal Surface within the Outlines

- Distal surface within the outline is similar to mesial surface except that the crown appears thicker towards the incisal third
- *Distal contact area* is at the junction of incisal and middle thirds of the crow cervicoincisally and at the center labiolingually.

Incisal Aspect (Fig. 7.12)

Geometric shape: The incisal aspect of most central incisors appear *triangular* in shape with base of the triangle towards the labial surface and apex towards the cingulum.

Relative Dimensions

- The mesiodistal dimension of the crown is only slightly greater than the buccolingual dimension. But the linear incisal ridge extending mesiodistally gives an illusion of much greater mesiodistal dimension
- From this aspect, the crown appears bulkier than other aspects. Most of the labial surface is seen from this aspect, which is more convex cervically and flatter incisally
- The cingulum forms a smaller convex arc and the crown tapers rapidly from the labial surface towards the cingulum
- The mesiolabial and distolabial line angles are prominent from this aspect
- The incisal ridge/edge is at right angles to a line bisecting the tooth buccolingually
- The incisal edge in a worn tooth shows a lingual slope.

ROOT

Number

Permanent maxillary central incisor has single root.

Size

The root is about one and half times as long as the crown.

Form

- Root of central incisor is cone-shaped, tappering gradually from cervical line to apex
- Root surface is narrower on lingual aspect.

Cross-section

- Cross-section of root at cervix shows triangular shape with rounded border.
- Base of the triangular is formed by labial aspect and the apex by lingual aspect.
- *Apex:* Apex is usually blunt.
- *Curvature:* Root is usually straight without any curvature.

VARIATIONS (FIG. 7.13)

- Short root
- Long root
- Shovel-shaped incisor (prominent marginal ridge seen in Mongoloid races).

DEVELOPMENTAL ANOMALIES (FIGS 7.14A TO C)

- *Mesiodens* is a supernumerary tooth between the maxillary central incisors in midline (**Fig. 7.14A**)
- Talon's cusp (**Fig. 7.14B**)
- Fusion
- Gemination (**Fig. 7.14C**)
- Dens invaginatus.

CLINICAL CONSIDERATIONS

- Maxillary central incisors ideally should be the most prominent teeth when one smiles. This is called incisal dominance
- Maxillary central incisors are more prone to trauma especially in class II malocclusion (forwardly placed upper incisors).

A brief summary of maxillary central incisor anatomy is given in **Flow charts 7.1 and 7.2**.

Box 7.1 lists the identification point.

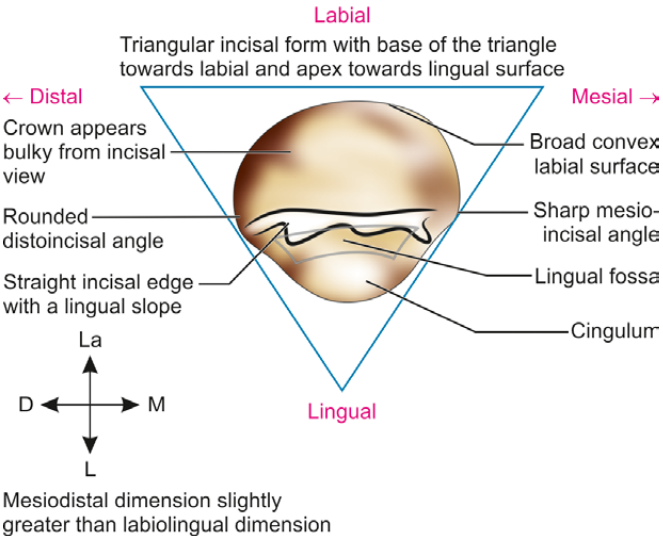


Figure 7.12 Maxillary central incisor—incisal aspect

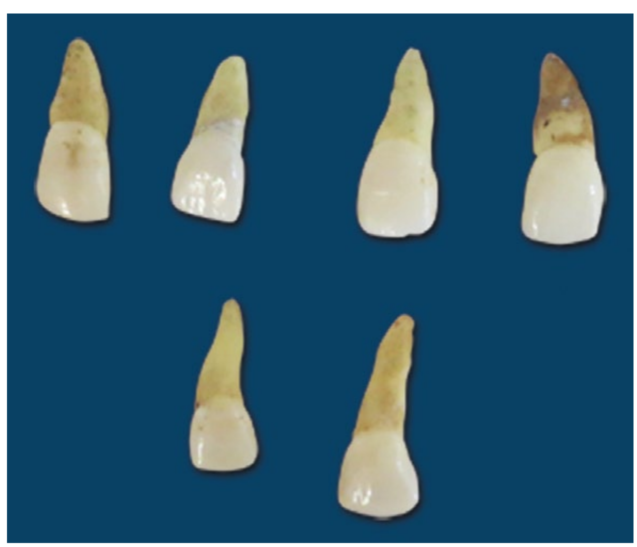
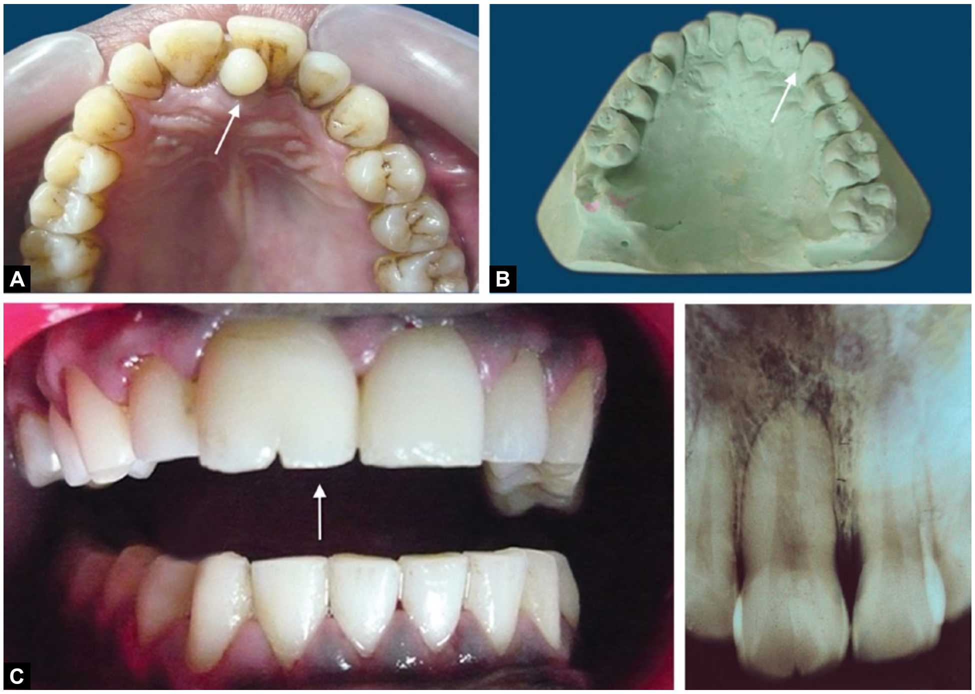
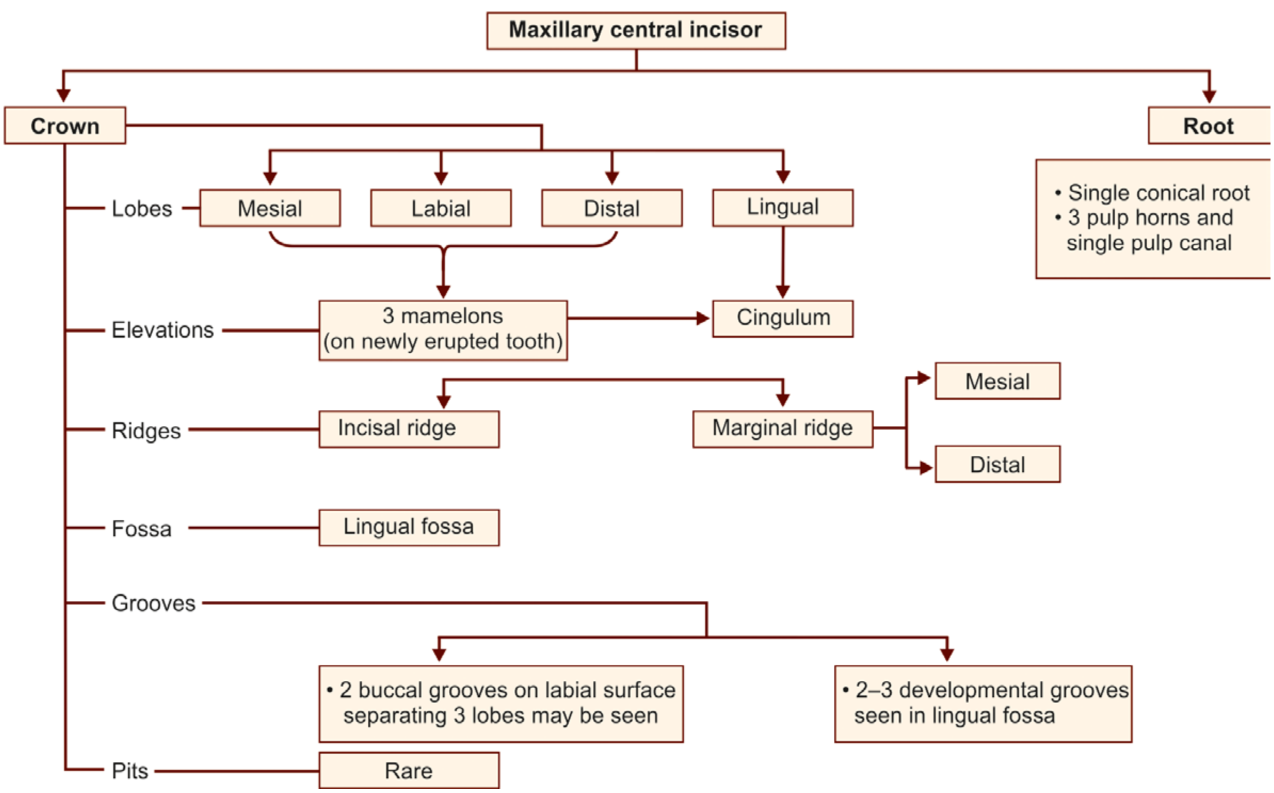


Figure 7.13 Maxillary central incisor—variations



Figures 7.14A to C Developmental anomalies related to maxillary central incisors: (A) Mesiodens; (B) Talon's cusp; (C) Gemination of maxillary central incisor

Flow chart 7.1 Maxillary central incisor—major anatomic landmarks



Flow chart 7.2 Maxillary central incisor—summary

Maxillary central incisor

Crown

Labial aspect

Geometric form
- Trapezoidal
- Mesioincisal angle—sharp
- Distoincisal angle—rounded
- Incisal ridge—very straight
- Labial surface—smooth,convex both cervico-incisally and mesiodistally
- Height of labial contour—at cervical third

Lingual aspect

- Trapezoidal
- Crown converges lingually
- Lingual surface—irregular
- Cingulum in cervical third
- Shallow lingual fossa in middle and incisal third
- Usually 2 developmental grooves in lingual fossa
- Height of lingual contour—at cervical third

Mesial aspect

- Wedge/triangular shaped
- Labial outline—convex
- Lingual outline—concavoconvex
- Height of labial contour—at cervical 3rd
- Height of lingual contour—at cervical 3rd
- Cervical line—curves incisally (maximum curvature among all teeth 3.5 mm)
- Incisal ridge is in line with vertical root axis
- Mesial contact—area at incisal 3rd near incisal ridge

Distal aspect

- Wedge/triangular
- Curvature of cervical line 1 mm shorter (2–5 mm)
- Distal contact area junction of incisal and middle third

Incisal aspect

- Triangular
- Appears bulky from incisal view
- Wider mesiodistally than labiolingually
- Labially broad and convex
- Lingually—cingulum seen
- Incisal edge—clearly seen sloping lingually perpendicular to labiolingual bisecting line

Root

Number
- Single

Size
- 2–3 mm longer than crown

Form
- Conical root, evenly tapers to apex

Cross-section at cervix
- Triangular with base labially and apex lingually

Apical root curvature
- Usually straight, sometimes labial curvature

Apex
- Blunt

Box 7.1 Maxillary central incisor—identification features

Identification features of maxillary central incisor

- Tooth with longest crown and single comical, straight root
- Crown more symmetrical and wider mesiodistally
- Greatest cervical line curvature among all teeth
- Lingual fossa and cingulum on lingual aspect
- Straight incisal ridge

Side identification

- Sharp mesioincisal angle and rounded distoincisal angle

PERMANENT MAXILLARY LATERAL INCISOR

The maxillary permanent lateral incisor has close resemblance to maxillary permanent central incisor as it supplements the latter in function. It is smaller than the central incisor in all dimensions except root length. The chronology and measurement of the maxillary lateral incisor is given in **Table 7.2**. Maxillary lateral incisors show greater variation

Table 7.2 Maxillary lateral incisor—chronology and dimension

Chronology	
First evidence of calcification	1 year
Enamel completed	4–5 years
Eruption	8–9 years
Roots completed	11 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervicoincisal length of crown	9.0
Length of root	13.0
Mesiodistal diameter of crown	6.5
Mesiodistal diameter of crown at cervix	5.0
Labiolingual diameter of crown	6.0
Labiolingual diameter of crown at cervix	5.0
Curvature of cervical line—mesial	3.0
Curvature of cervical line—distal	2.0

in morphology than any other teeth except third molars. Variations in development and form are considered later.

DETAILED DESCRIPTION OF MAXILLARY LATERAL INCISOR FROM ALL ASPECTS

Figures 7.15 to 7.17 show maxillary lateral incisor from various aspects.

CROWN

Following aspects describe the anatomy of crown.

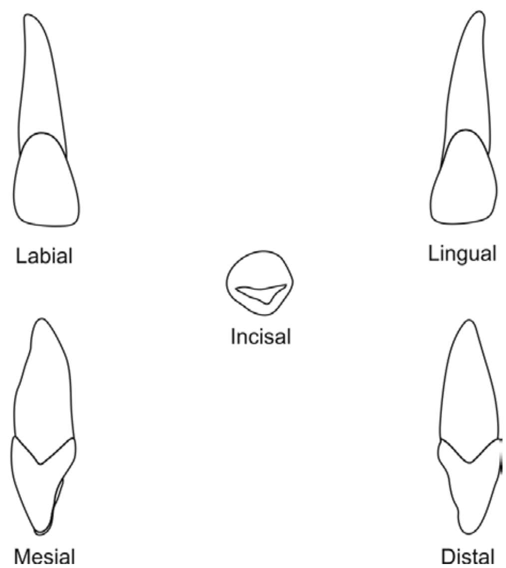


Figure 7.15 Maxillary lateral incisor—line drawings

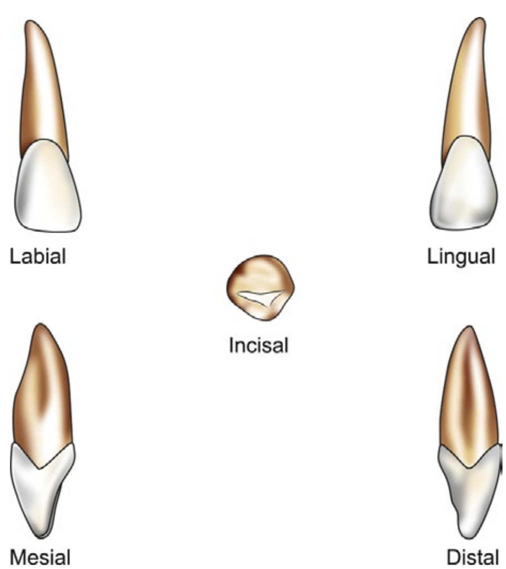


Figure 7.16 Maxillary lateral incisor—graphic illustration

Labial Aspect (Fig. 7.18)

Geometric shape: *Trapezoid* similar to labial aspect of maxillary permanent central incisor.

Crown Outlines

Mesial Outline

- Mesial outline of permanent maxillary lateral incisor is similar to that maxillary permanent central incisor except that mesioincisal angle is more rounded
- Height of mesial contour is at the junction of middle and incisal thirds.

Distal Outline

- Distal outline is shorter than mesial outline
- It is more rounded than found in maxillary permanent central incisor with more rounded distoincisal angle
- In some maxillary permanent lateral incisors, the distal outline may be a semicircle extending from cervix up to center of the incisal ridge.
- The height of distal contour is at the center of the middle third.

Incisal Outline

- It is formed by the incisal ridge
- Mesial half of incisal outline is relatively straight and distal half is more rounded curving towards cervical line to join the distal outline.

Cervical Outline

The cervical line is more convex apically than that of maxillary permanent central incisor.

Labial Surface within the Outlines

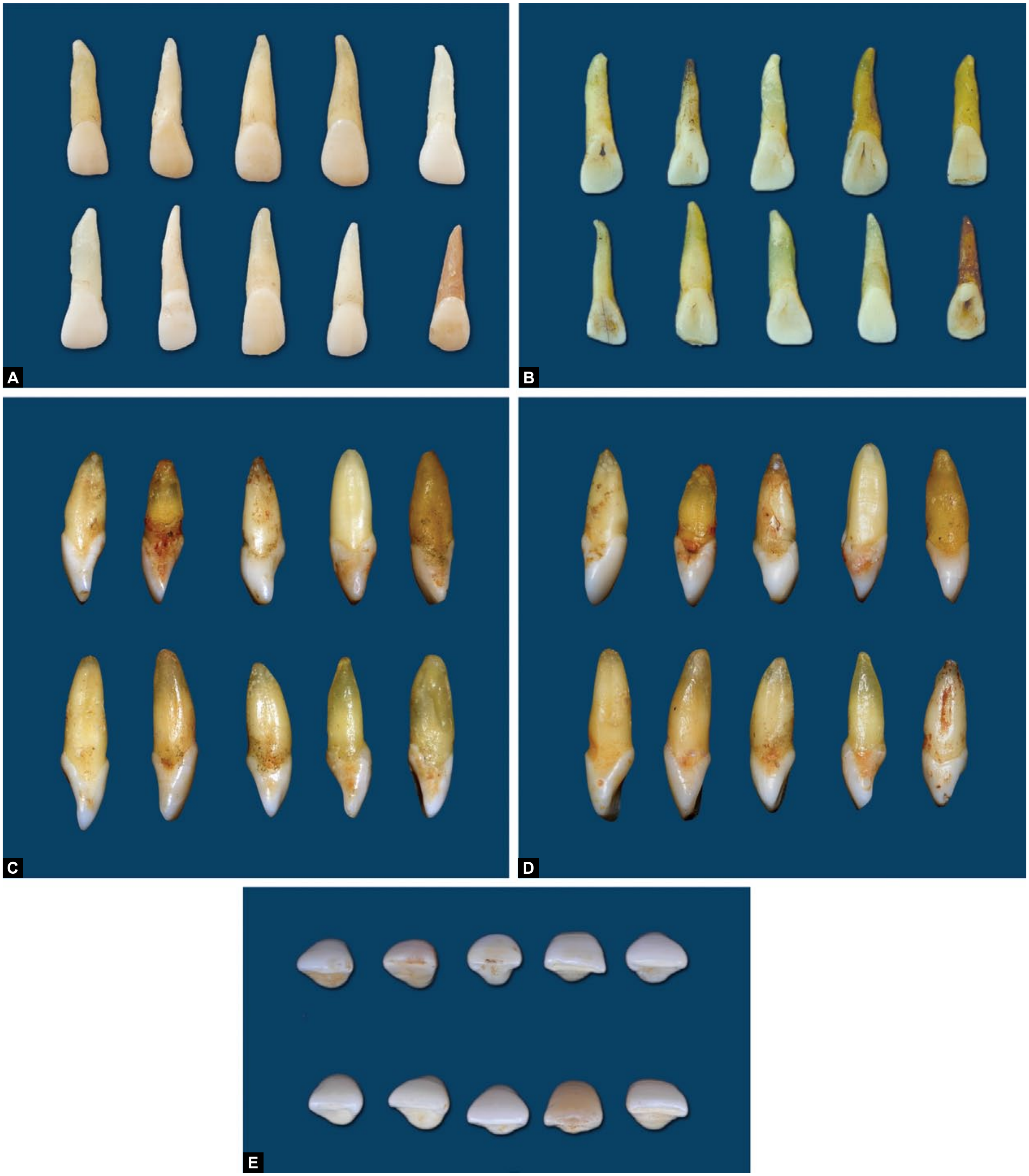
- Labial surface is about 2 mm narrower and 2 to 3 mm shorter than the maxillary permanent central incisor.
- It is more convex than that of maxillary permanent central incisor.

Lingual Aspect (Fig. 7.19)

- *Geometric shape: Trapezoid* similar to the labial aspect
- *Crown outlines:* Similar to labial aspect.

Lingual Surface within the Outlines

- There is lingual convergence of proximal walls as seen in maxillary permanent central incisor
- Lingual surface is more regular
- Marginal ridges are more prominent and stronger than found on central incisor
- Lingual fossa is deeper and well-circumscribed
- Cingulum is more prominent
- There may be a deep developmental groove crossing the distal side of the cingulum extending on the root for a varying length



Figures 7.17A to E Maxillary lateral incisors—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

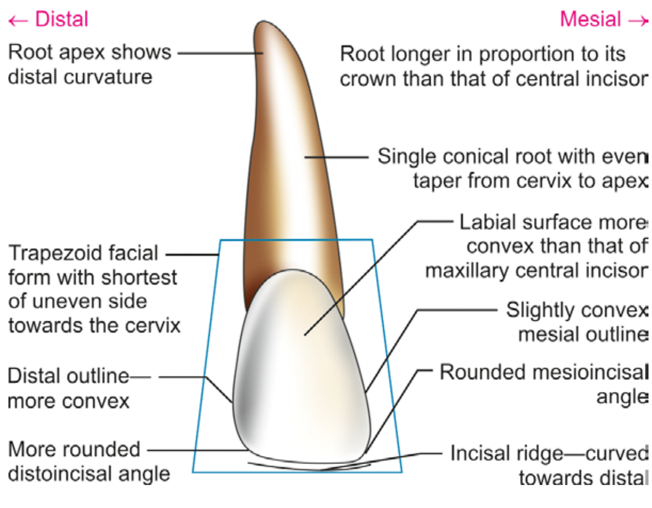


Figure 7.18 Maxillary lateral incisor—labial aspect

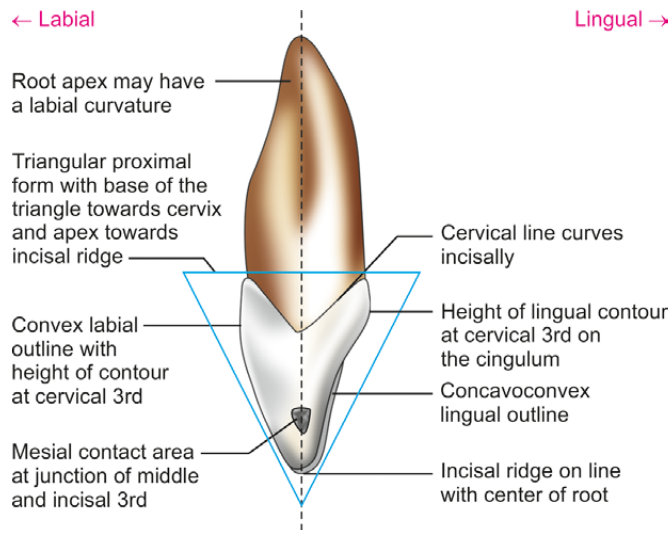


Figure 7.20 Maxillary lateral incisor—mesial aspect

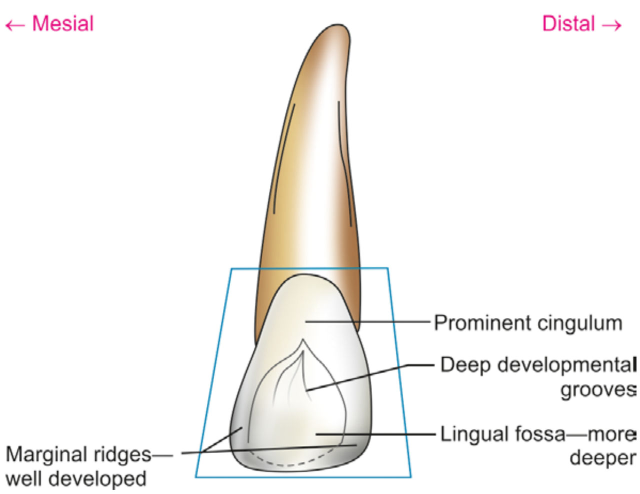


Figure 7.19 Maxillary lateral incisor—lingual aspect

- This groove is called as *palatogingival groove or palatoradicular groove.*

Mesial Aspect (Fig. 7.20)

Geometric shape: Like all anteriors, the proximal aspect of maxillary permanent lateral incisor is *triangle* or wedge-shaped.

Crown Outlines

- *Labial outline* of maxillary permanent lateral incisor is less convex than labial outline of maxillary permanent central incisor with crest of curvature at cervical third.
- *Lingual outline* is similar to that of central incisor.
- *Incisal outline* is formed by the incisal ridge which is more rounded.
- *Cervical line* shows marked curvature incisally.

Mesial Surface within the Outlines

From this aspect, incisal portion appears thicker than that of maxillary permanent central incisor as incisal ridge is heavily developed.

- Mesial contact area is at junction of the incisal and middle thirds.
- The incisal ridge is in line with the center of the root. Thus, a line drawn through the center of proximal aspect of crown will bisect the incisal ridge and also the root apex.
- *Mesial contact area* is at junction of incisal and middle third.

Distal Aspect (Fig. 7.21)

Geometric shape: *Triangle* or wedge shaped.

Crown outlines: Labial, lingual, incisal outlines are similar to the mesial aspect.

Cervical outline: The curvature of cervical line on distal side is 1 mm less in extent than on mesial surface.

Distal Surface within the Outlines

- The crown appears thicker from distal aspect
- Palatogingival/palatoradicular developmental groove may be seen on distal side of crown extending onto the root
- *Distal contact area* is of maxillary permanent lateral incisor at the middle third.

Incisal Aspect (Fig. 7.22)

Geometric Shape

- Most maxillary permanent lateral incisors resemble maxillary permanent central incisors from this aspect, i.e. *triangular* outline
- Some maxillary permanent lateral incisors resemble small maxillary permanent canines from incisal aspect, i.e. *oval* outline, due to their prominent large cingulum and occlusal ridges.
- *Relative dimensions*: Mesiodistal dimension is slightly more than labiolingual dimension.
- *Labially*: Crown is more convex than that of maxillary permanent central incisors.
- *Lingually* crown at cervical third appears more convex than that of maxillary permanent central incisor.
- *Symmetry*: A line bisecting the incisal ridge in mesiodistal direction is always straight and bisects the short arches representing mesial and distal contact areas.

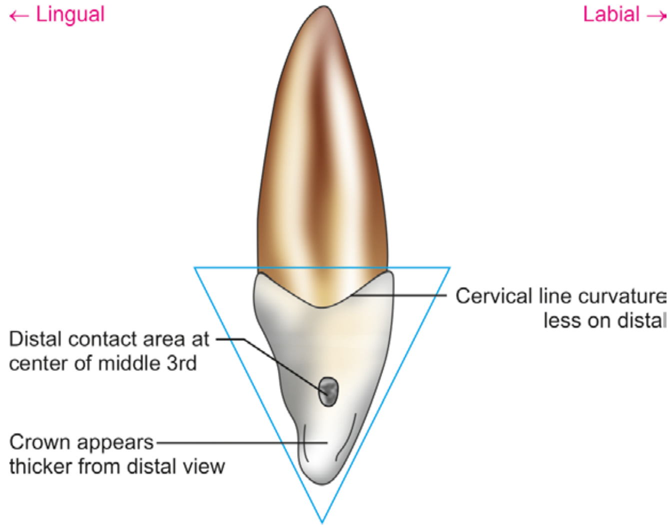


Figure 7.21 Maxillary lateral incisor—distal aspect

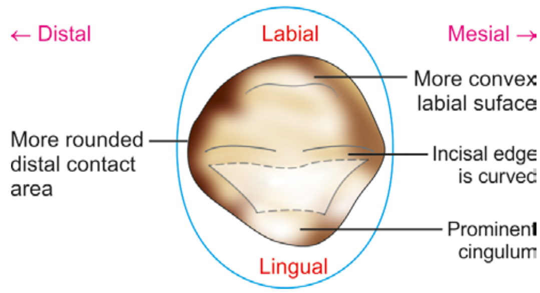


Figure 7.22 Maxillary lateral incisor—incisal aspect

ROOT

Number

Maxillary permanent lateral incisor has single root.

Size

- Root is about one and a half times the length of the crown
- Root length is greater in proportion to the crown length when compared to central incisor.

Form

- The shape of maxillary permanent lateral incisor is flat labiolingually
- Root tapers evenly from cervical line up to two-thirds of root length
- May show developmental groove on mesial and distal surfaces.

Cross-section

Cross-section of root at cervix is oval.

Root Curvature

Apical third of root usually shows distal curvature.

Apex

Apex of maxillary permanent lateral incisor is usually pointed.

VARIATIONS (FIG. 7.23)

Maxillary permanent lateral incisor shows great variation in development and morphology.

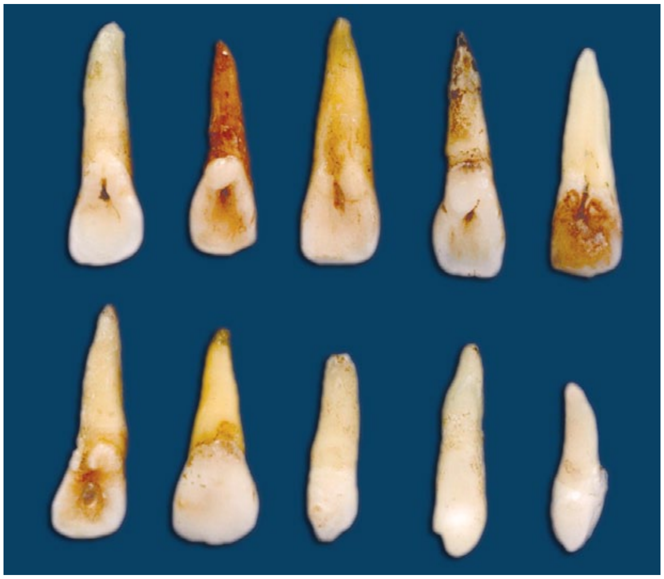
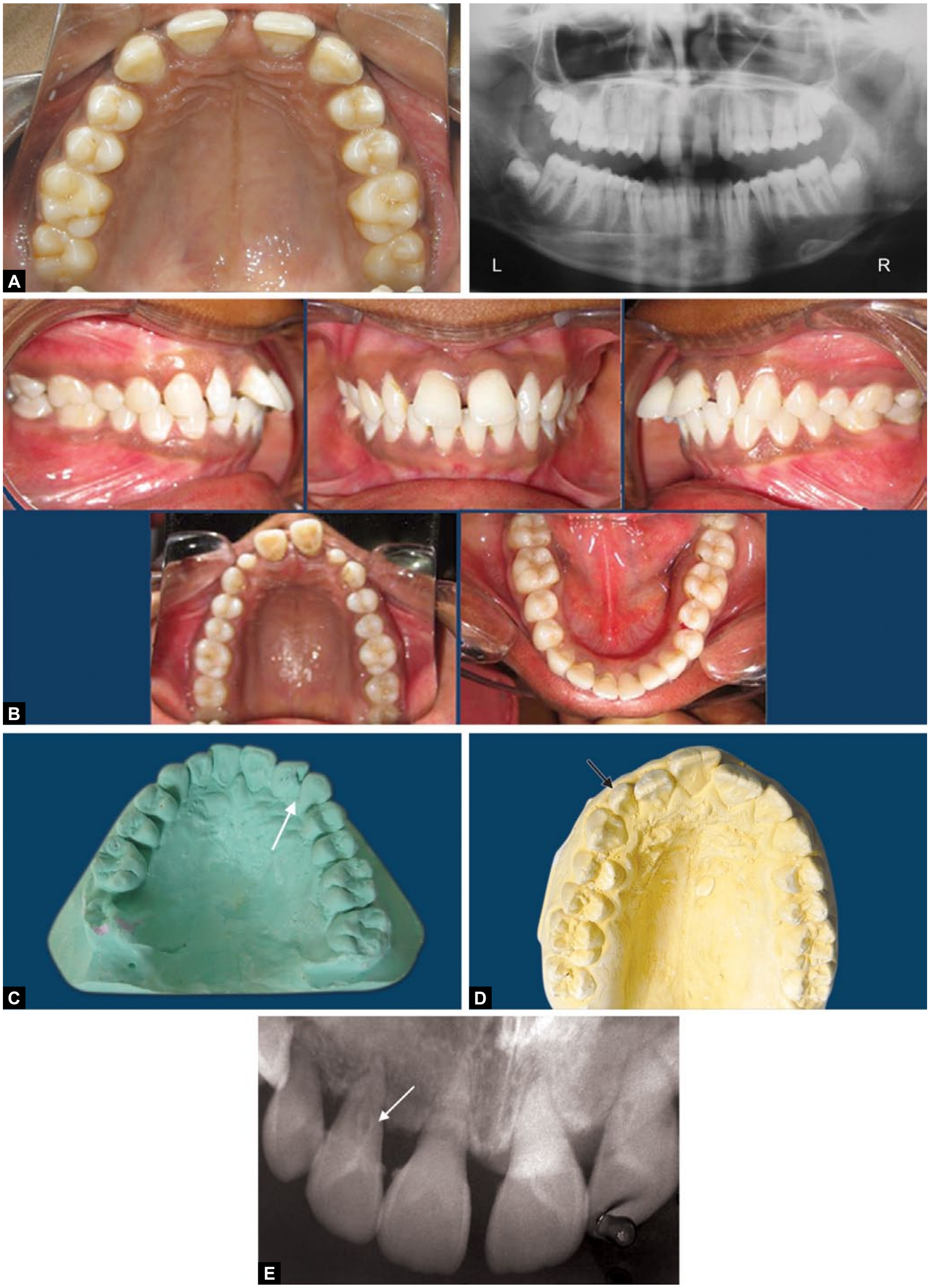
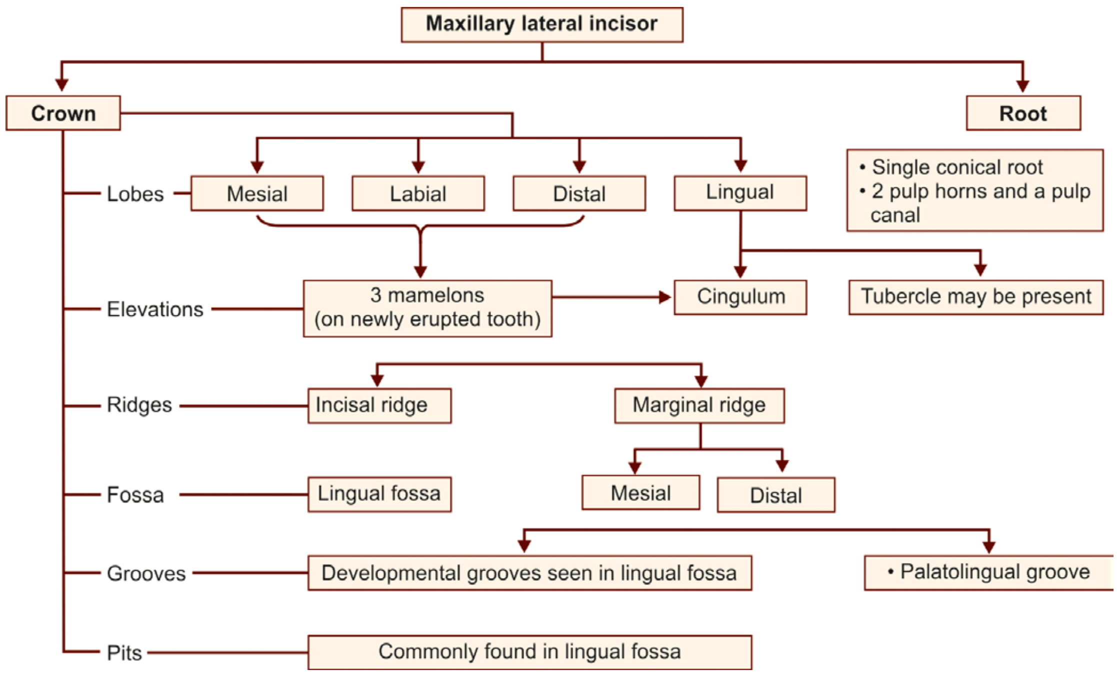


Figure 7.23 Maxillary lateral incisor—variations

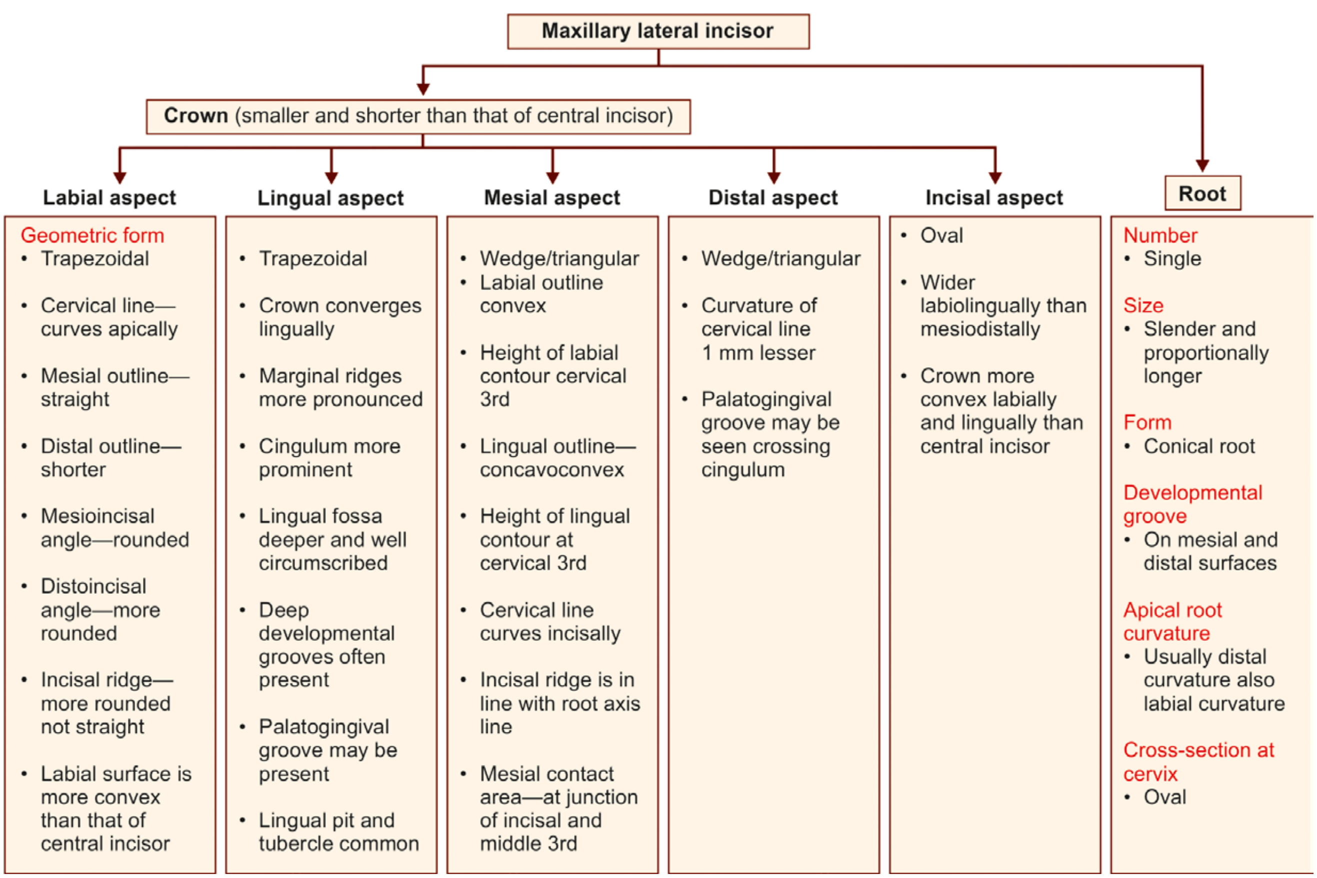


Figures 7.24A to E Developmental anomalies related to maxillary lateral incisors: (A) Congenitally missing laterals; (B) Peg shaped laterals; (C) Talon's cusp; (D) Supplemental lateral; (E) Dens invaginatus

Flow chart 7.3 Maxillary lateral incisor—major anatomic landmarks



Flow chart 7.4 Maxillary lateral incisor—summary



Box 7.2 Maxillary lateral incisor—identification features

Identification features of maxillary lateral incisor
- Tooth with small asymmetrical crown
- Slender and propertionately long root
- Round mesioincisal and more rounded distoincisal angle
- Rounded incisal ridge
- Deep lingual foosa with grooves and pits

Side identification
- More rounded distoincisal angle
- Incisal ridge starts distally
- Root shows distal curvature at apical 3rd

- Large size resembling a maxillary permanent central incisor
- Deep developmental groove (palatoradicular groove) on the distal aspect
- Pit in the lingual fossa
- Twisted crown or root
- Lingual tubercle may be present.

DEVELOPMENTAL ANOMALIES (FIGS 7.24A TO E)

- *Congenitally missing laterals (**Fig. 7.24A**)*: Most common tooth to be missing next to 3rd molars
- *Peg shaped laterals (**Fig. 7.24B**)*: Small conical pointed crown
- Talon's cusp (**Fig. 7.24C**)
- Supplemental laterals/supernumerary lateral incisor (**Fig. 7.24D**)
- *Dens invaginatus **(Fig. 7.24E)***: Most common tooth affected.

CLINICAL CONSIDERATIONS

- Congenitally missing lateral incisors may need prosthetic replacement such as implants
- Microdontic/Peg shaped laterals may require crown/veneers for esthetic purpose
- Deep palatogingival developmental groove may cause localized periodontal disease.

Flow charts 7.3 and 7.4 give the brief summary maxillary lateral incisor morphology. **Box 7.2** gives the identification features of the tooth.

BIBLIOGRAPHY

1. Garib DG, Alencar BM, Lauris JR, Baccetti T. Agenesis of maxillary lateral incisors and associated dental anomalies. Am J Orthod Dentofacial Orthop. 2010;137(6):732-3.
2. Kogon SL. The prevalence, location and conformation of palato-radicular grooves in maxillary incisors. J Periodontol. 1986;57:231-4.
3. Oliver RG, Mannion JE, Robinson JM. Morphology of the maxillary lateral incisor in cases of unilateral impaction of the maxillary canine. Journal of Orthodontics. 1989;16: 9-16.
4. Santa Cecilia, Mauricio. The palato-gingival groove: A cause of failure in root canal treatment. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics. 1998;85:94-8.
5. Shaju JP. Palatogingival developmental groove. Quintessence Int. 2001;32:349.

MULTIPLE CHOICE QUESTIONS

1. Which of the following teeth shows great variation in development and form:
   a. Permanent maxillary lateral incisor
   b. Permanent third molars
   c. Both a and b
   d. Permanent maxillary molars
2. The permanent maxillary lateral incisor is smaller than the maxillary permanent central incisor in all dimensions except:
   a. Crown length
   b. Root length
   c. Both a and b
   d. None of the above
3. Distal outline of maxillary permanent lateral incisor is:
   a. Shorter than mesial outline
   b. Larger than mesial outline
   c. Similar to that of mesial
   d. None of the above
4. In comparison to maxillary permanent central incisor, the labial surface of maxillary permanent lateral incisor is:
   a. More convex
   b. Less convex
   c. More concave
   d. Less concave
5. When present, the developmental groove crossing the distal side of the cingulum extending on the root of maxillary permanent lateral incisor is called as:
   a. Palatogingival groove
   b. Palatoradicular groove
   c. Palatocervical groove
   d. Both a and b
6. The geometric shape of maxillary permanent lateral incisor from the mesial aspect is:
   a. Triangular
   b. Trapezoidal
   c. Cuboidal
   d. Rectangular

7. Mesial contact area of permanent maxillary lateral incisor is located at:
   a. Junction of middle and cervical third
   b. Center of middle third
   c. Junction of incisal and middle third
   d. Center of incisal third
8. Distal contact area of permanent maxillary lateral incisor is located at:
   a. At the middle third
   b. At the cervical third
   c. At the incisal third
   d. None of the above
9. Which of the following statements is false regarding the root of the permanent maxillary lateral incisor?
   a. Has single root
   b. Root is about one and a half times the length of the crown
   c. Root length is greater in proportion to the crown length when compared to central incisor
   d. Apical third of root usually shows no curvature
10. Cross-section of the maxillary permanent lateral incisor root at cervix is:
    a. Triangular
    b. Oval
    c. Circular
    d. Diamond shaped

Answers

1. c	2. b	3. a	4. a	5. d	6. a	7. c	8. a	9. d	10. b

CHAPTER

8

The Permanent Mandibular Incisors

There are four mandibular incisors; two central and two lateral. Mandibular incisors are the first permanent teeth to erupt. They have smaller mesiodistal dimensions than all other teeth. Among mandibular incisors, the lateral is larger than the central. It can be remembered that in the maxillary arch, the central incisor is larger than the lateral incisor. The crowns of these teeth exhibit lingual inclination over the root base which can be appreciated from proximal aspects. These are the teeth that show very few developmental grooves and lines.

PERMANENT MANDIBULAR CENTRAL INCISOR

- Mandibular central incisors are the smallest teeth in the permanent dentition
- They are also among the first permanent teeth to erupt into the oral cavity along with the 1st molars around 6 to 7 years of age
- The mandibular central incisors have their mesial surfaces in contact with each other just like their maxillary counterparts.

DETAILED DESCRIPTION OF MANDIBULAR CENTRAL INCISOR FROM ALL ASPECTS

The chronology and measurement of the mandibular central incisor is given in **Table 8.1**. **Figures 8.1 to 8.3** show mandibular central incisor from various aspects.

Table 8.1 Mandibular central incisor—chronology and dimensions

Chronology	
First evidence of calcification	3–4 months
Enamel completed	4–5 years
Eruption	6–7 years
Roots completed	9 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervicoincisal length of crown	9.5
Length of root	12.5
Mesiodistal diameter of crown	5.0
Mesiodistal diameter of crown at cervix	3.5
Labiolingual diameter of crown	6.0
Labiolingual diameter of crown at cervix	5.3
Curvature of cervical line—mesial	3.0
Curvature of cervical line—distal	2.0

CROWN

Labial Aspect (Fig. 8.4)

Geometric shape: *Trapezoidal* from labial and lingual aspects with shortest of the uneven sides towards cervix.

Crown Outlines

- *Mesial and distal outlines* taper evenly from mesioincisal and distoincisal angles to the narrow cervix. Heights of contour of mesial and distal outlines are at incisal third. This places *both the contact areas at the same level.*
- *Incisal outline,* formed by the incisal ridge is straight and at right angles to the long axis of the crown. A newly erupted tooth shows *mamelons* on the incisal ridge (**Fig. 8.5**).
- The *cervical line* on labial aspect is convex pointing apically.

Labial Surface within the Outlines

- Labial surface is narrow and *bilaterally symmetrical.*
- The surface is smooth, convex in the cervical third and flattened in the incisal third.
- Both mesioincisal and distoincisal angles are sharp and at right angles.
- Both mesial and distal contact areas are at the same level—at the incisal third of crown near the mesial and distal incisal angles.

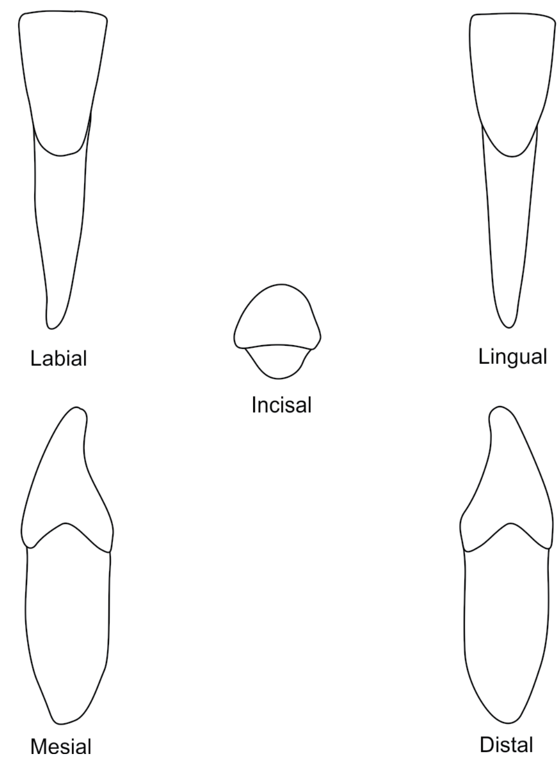


Figure 8.1 Mandibular central incisor—line drawings

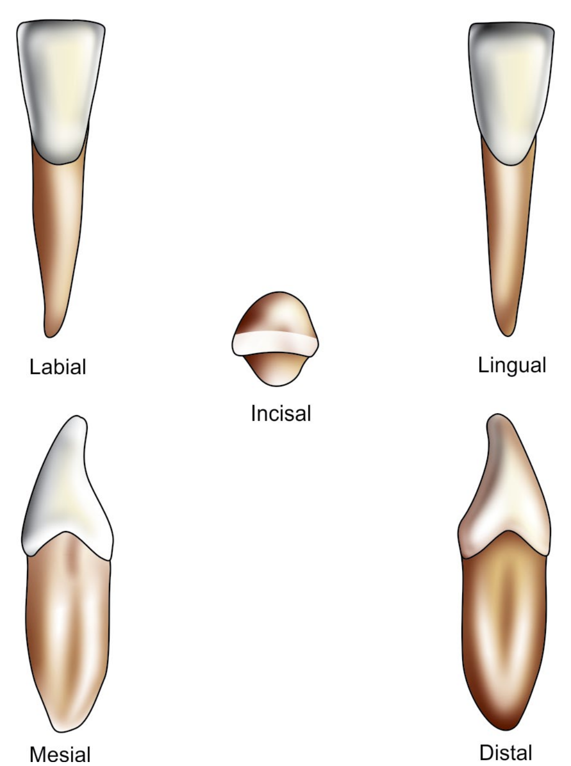


Figure 8.2 Mandibular central incisor—graphic illustration

Lingual Aspect (Fig. 8.6)

Geometric shape: *Trapezoidal*

- Mesial outline
- Distal outline
- Incisal outline
- Cervical outline

} are similar to the labial aspect

Lingual Surface within the Outlines

- The lingual surface is narrower than the labial surface because of lingual convergence of the crown
- The surface is smooth, flat in the incisal third and convex in the cervical portion near cingulum
- The marginal ridges are ill defined
- The lingual fossa between marginal ridges and cingulum is a smooth shallow concavity devoid of developmental grooves.

Mesial Aspect (Fig. 8.7)

Geometric shape: *Triangular*

Crown Outlines

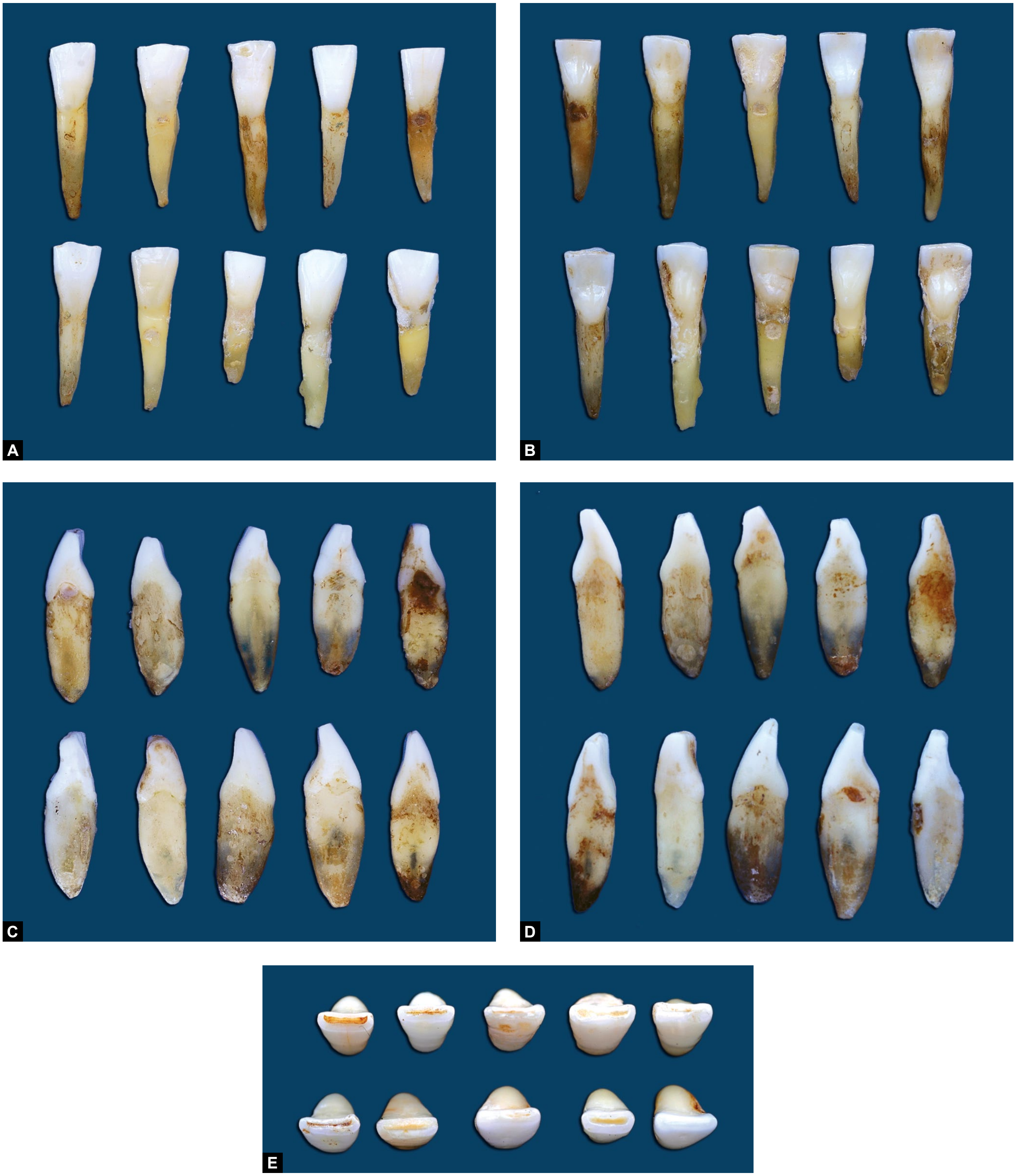
- *Labial outline* is straight except at the cervical third, where it is convex. Height of contour of labial outline is at the cervical third
- *Lingual outline* is concave incisally and is convex in the cervical region. Its height of contour is at cervical third on the cingulum
- *Incisal outline* is a small arc formed by the rounded incisal ridge. In a tooth with occlusal wear, there is a flat *incisal edge* sloping labially. Incisal surface of mandibular incisors have a labial slope and occlude with lingually sloping incisal edges of the maxillary incisors during mastication (**Fig. 8.8**)
- *Cervical line* on the mesial aspect shows a marked curvature towards incisal ridge.

Mesial Surface within the Outlines

- The mesial surface is convex in the incisal third and becomes flat towards the middle third
- The tooth may exhibit a concavity in the cervical third above the cervical line
- The crown appears to be inclined lingually. The incisal ridge is placed lingual to a vertical line drawn through the center of the tooth
- The lingual inclination of crown is a feature mandibular teeth to facilitate normal overjet
- The *mesial contact area* is at incisal third of the crown.

Distal Aspect (Fig. 8.9)

Distal aspect is similar to mesial aspect except that the extent of curvature of cervical line on distal aspect is 1 mm less than on the mesial.



Figures 8.3A to E Mandibular central incisor—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

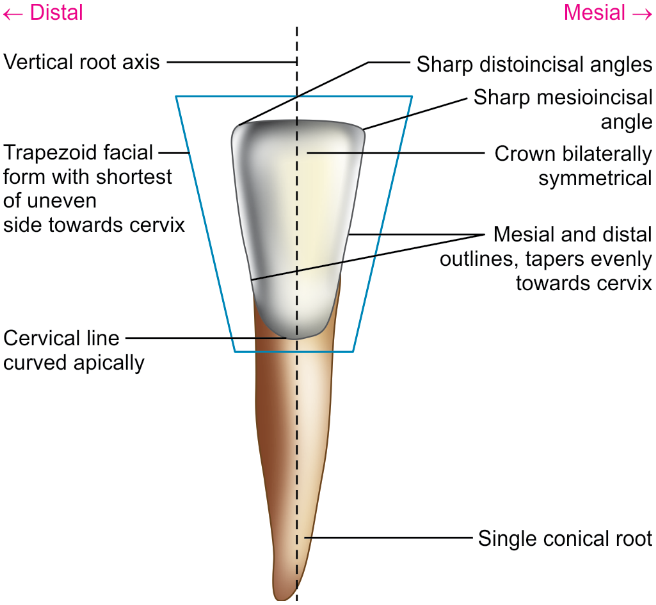


Figure 8.4 Mandibular central incisor—labial aspect

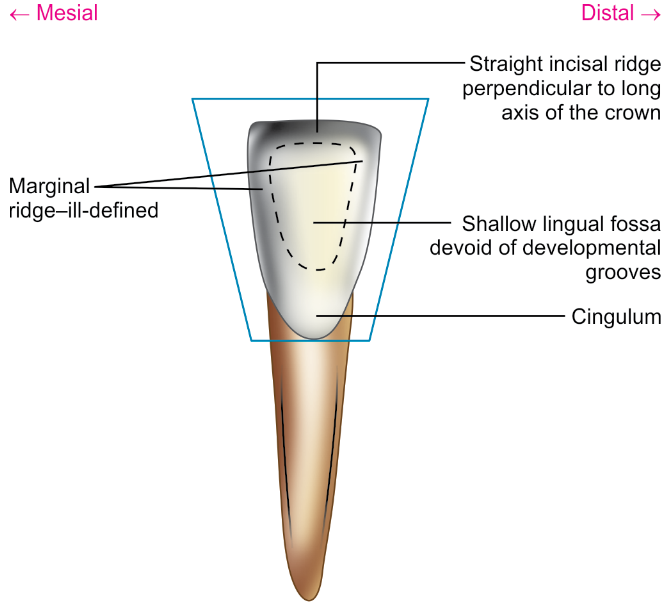


Figure 8.6 Mandibular central incisor—lingual aspect

Figure 8.5 Mamelons on erupting mandibular incisors

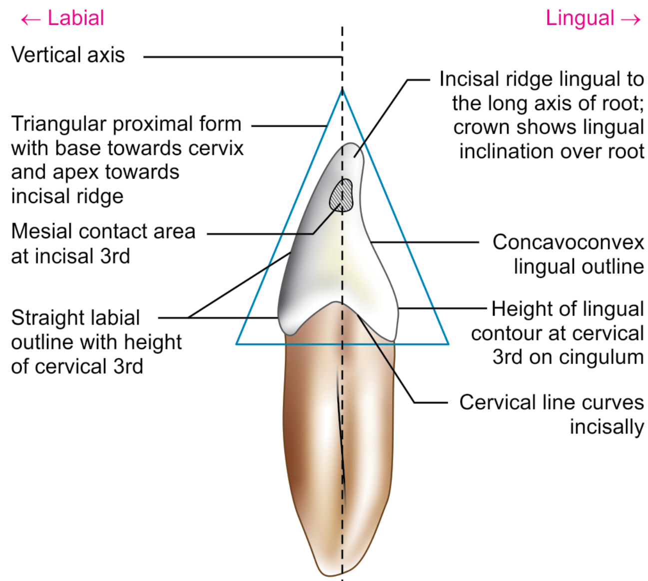


Figure 8.7 Mandibular central incisor—mesial aspect

Incisal Aspect (Fig. 8.10)

Geometric shape: It is *oval* labiolingually.

Relative Dimensions

Labiolingual dimension is always greater than mesiodistal dimension. Bilateral symmetry of this tooth is easily appreciated from this aspect. Mesial half of the crown is equal to distal half. From this aspect, more of labial surface is seen than of the lingual surface because of lingual inclination of the crown. Labial surface is wider than lingual surface. The labial surface of crown at incisal third is convex, whereas the lingual surface of the crown at incisal third is concave.

Identification Features

- When viewed occlusally, *incisal ridge is at the right angles to the line bisecting the crown labiolingually.*
- This characteristic feature of central incisor helps in differentiating it from similarly looking mandibular lateral incisor. The incisal ridge of the mandibular lateral incisor is at an angle with the labiolingual bisecting line, curves distally.

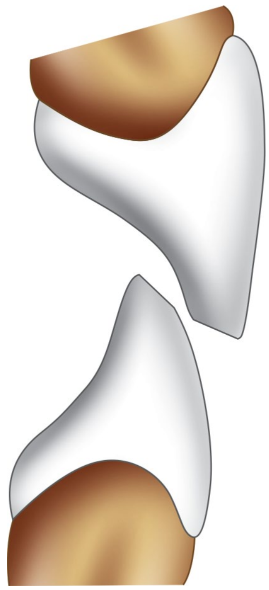


Figure 8.8 Incisal edge—slopes lingually on maxillary incisors and slopes labially on mandibular incisors

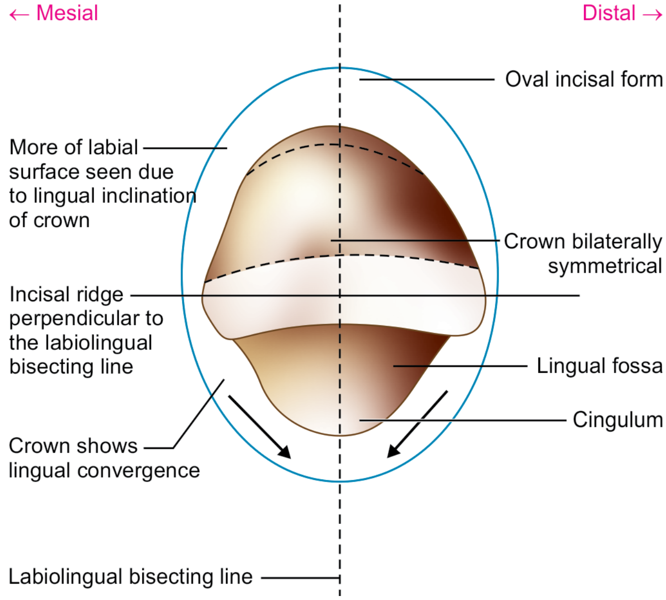


Figure 8.10 Mandibular central incisor—incisal aspect

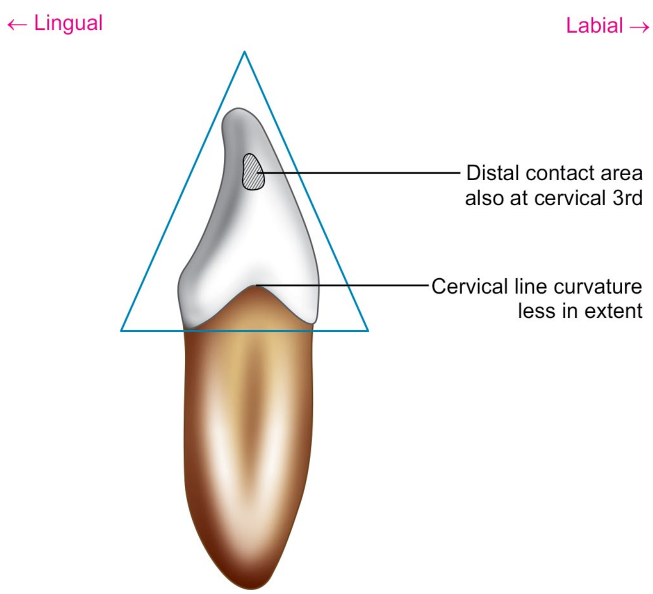


Figure 8.9 Mandibular central incisor—distal aspect

ROOT

Number

Single root.

Form

- The root is straight from cervix to middle third
- Outlines of root are straight from cervix up to middle third
- From this level the root tapers apically
- Root is convex mesiodistally and flattened labiolingually
- Developmental grooves are seen on both mesial and distal surfaces of root and the groove is deeper on the distal surface.

Apex

The root has a pointed apex.

Curvature of Root

- Apical third of root usually is straight
- Sometimes, the root exhibits distal curvature.

VARIATIONS (FIG. 8.11)

- Small tooth
- Short root
- Bifurcation of root.

DEVELOPMENTAL ANOMALIES

- Talon's cusp
- Fusion between mandibular, central and lateral incisors.

Flow charts 8.1 and 8.2 give a brief summary of mandibular central incisor anatomy. **Box 8.1** gives the tooth's identification features.

PERMANENT MANDIBULAR LATERAL INCISORS

- Mandibular lateral incisor is very similar to the mandibular central in form as the two teeth function as a team

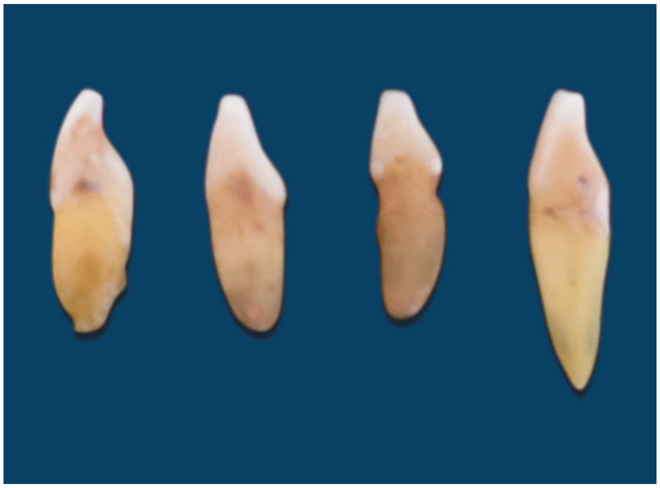
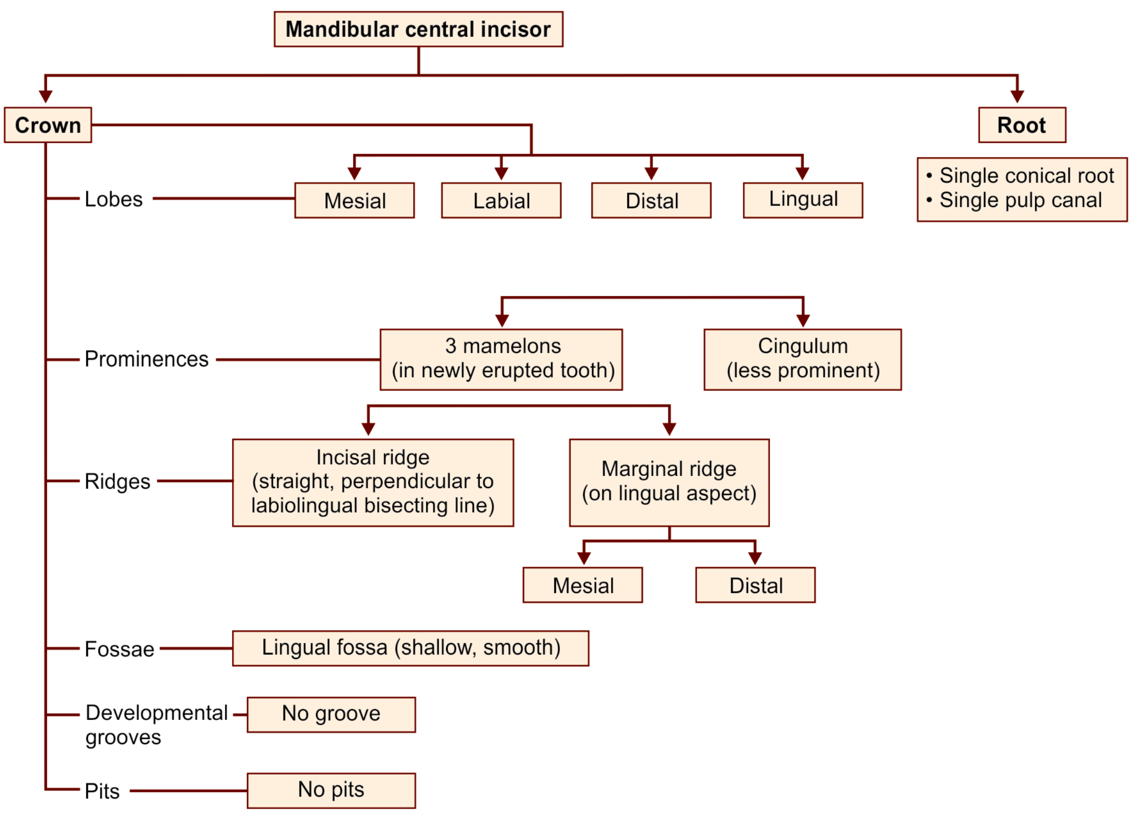


Figure 8.11 Mandibular central incisor—variations

Flow chart 8.1 Mandibular central incisor—major anatomic landmarks



Flow chart 8.2 Mandibular central incisor—summary

Mandibular central incisor

Crown

Labial aspect

Geometric shape
- Trapezoidal

Mesial and distal outlines
- Mesial
- Distal

Taper evenly from incisal angles to narrow cervix

Incisal angles
- Sharp and right angled

Incisal ridge
- Straight, perpendicular to long axis of crown
- Mamelons in newly erupted tooth

Crown symmetry
- Bilaterally symmetrical

Labial surface
- Smooth, convex, flattened incisally

Contact areas
- Both mesial and distal contact areas at same level—incisal 3rd near incisal angles

Lingual aspect
- Trapezoidal

Lingual convergene
- Crown narrower on lingual

Cingulum
- Small, not prominent

Lingual fossa
- Shallow concavity
- Smooth, devoid and any developmental grooves

Marginal ridge
- Ill defined

Incisal edge
- Slopes labially

Mesial aspect
- Triangular/wedge

Labial and lingual outlines
- Labial—straight, convex at cervical 3rd
- Lingual—concavoconvex

Incisal ridge location
- Placed lingual to the root axis line (crown inclined lingually)

Lingual inclination of crown
- Crown inclined lingually on root base
- True for all mandibular teeth, facilitates normal overjet

Distal aspect
- Triangular/wedge

Similar to mesial aspect except that
- Cervical line curvature less in extent by 1 mm

Incisal aspect
- Oval labiolingually

Relative dimensions
- Crown wider labiolingually than mesiodistally

Symmetry
- Crown bilaterally symmetrical
- Equal mesial and distal halves
- More labial surface seen

Incisal ridge
- The incisal ridge/edge in at right angles to the labiolingual bisecting line

Root

Number
- Single root

Pulp canal
- Single canal

Size
- Long root

Form
- Conical
- Convex mesiodistally and flattened labiolingually

Apical curvature
- Usually straight
- Sometimes distal curvature

Apex
- Pointed

Box 8.1 Mandibular central incisor—identification features

Identification features of mandibular central incisor
- Smallest tooth in permanent dentition
- The crown and root narrow mesiodistally and wider labiolingually
- The crown is bilaterally symmetrical
- Mesial and distal incisal angles are sharp
- Mesial and distal contact areas are at same level near mesial and distal incisal angles
- Viewed incisally, the incisal ridge is perpendicular to the line bisecting the crown labiolingually.

Side identification
- Difficult to differentiate left and right mandibular central incisors since the tooth is bilaterally symmetrical
- Developmental depression on root is deeper on distal surface
- The root may show a distal curvature at the apex.

- It is slightly larger than the mandibular central incisor (unlike the case of maxillary incisors where the lateral is smaller than the central incisor)
- The crown of this tooth is twisted on its root base to conform to the convexity of the mandibular arch.

DETAILED DESCRIPTION OF MANDIBULAR LATERAL INCISOR FROM ALL ASPECTS

The chronology and measurement of the mandibular lateral incisor is given in **Table 8.2**. **Figures 8.12 to 8.14** show mandibular lateral incisor from various aspects.

CROWN

Labial Aspect (Fig. 8.15)

Geometric shape: The crown is trapezoidal from labial aspect.

Crown Outlines

- *Mesial outline* is almost straight, in line with mesial outline of the root. It is longer than the distal outline. The maximum convexity of the mesial outline (mesial contact area) is at incisal third of crown.
- *Distal outline* is straight near cervix and become slightly convex as it reaches the distoincisal angle. Its height maximum convexity is also within incisal third

Table 8.2 Mandibular lateral incisor

Chronology	
First evidence of calcification	3–4 months
Enamel completed	4–5 years
Eruption	7–8 years
Roots completed	10 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervicoincisal length of crown	9.5
Length of the root	14.0
Mesiodistal diameter of crown	5.5
Mesiodistal diameter of crown at cervix	4.0
Labiolingual diameter of crown	6.5
Labiolingual diameter of crown at cervix	5.8
Curvature of cervical line—mesial	3.0
Curvature of cervical line—distal	2.0

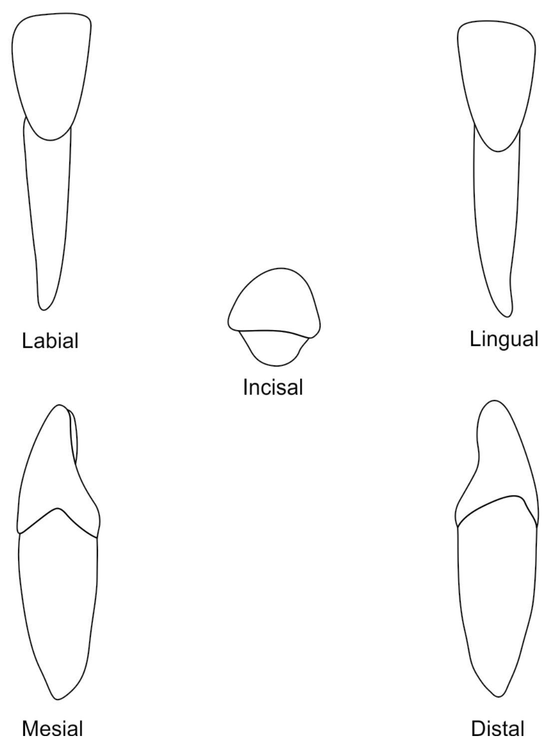


Figure 8.12 Mandibular lateral incisor—line drawings

- Incisal outline formed by the incisal ridge is straight but has a tendency to slope cervically in a distal direction. A newly erupted tooth may show mamelons (**Fig. 8.5**)
- The *cervical line* is curved apically.

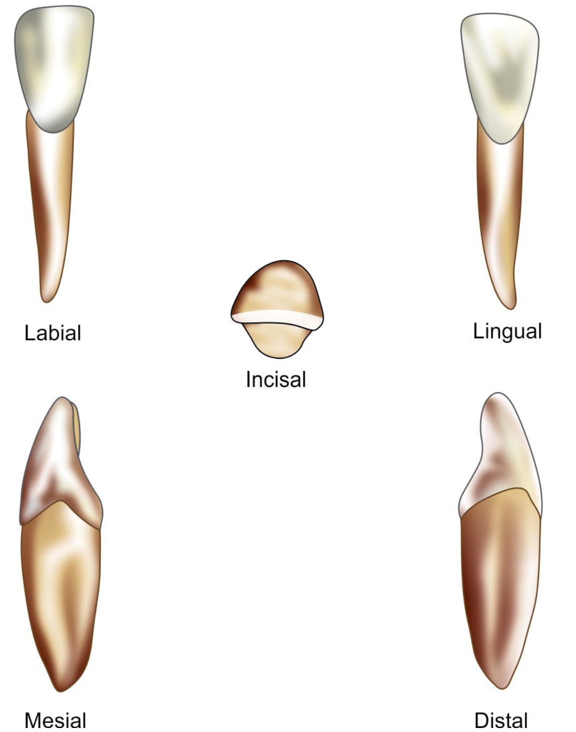


Figure 8.13 Mandibular lateral incisor—graphic illustration

Labial Surface within the Outlines

- The crown is not bilaterally symmetrical. Distal half of the crown is slightly larger
- The mesiodistal width of crown is approximately 1 mm more than that of mandibular central incisor
- Mesioincisal angle forms a right angles but the distoincisal angle is more rounded
- Labial surface is smooth, convex cervically and flattened incisally.

Lingual Aspect (Fig. 8.16)

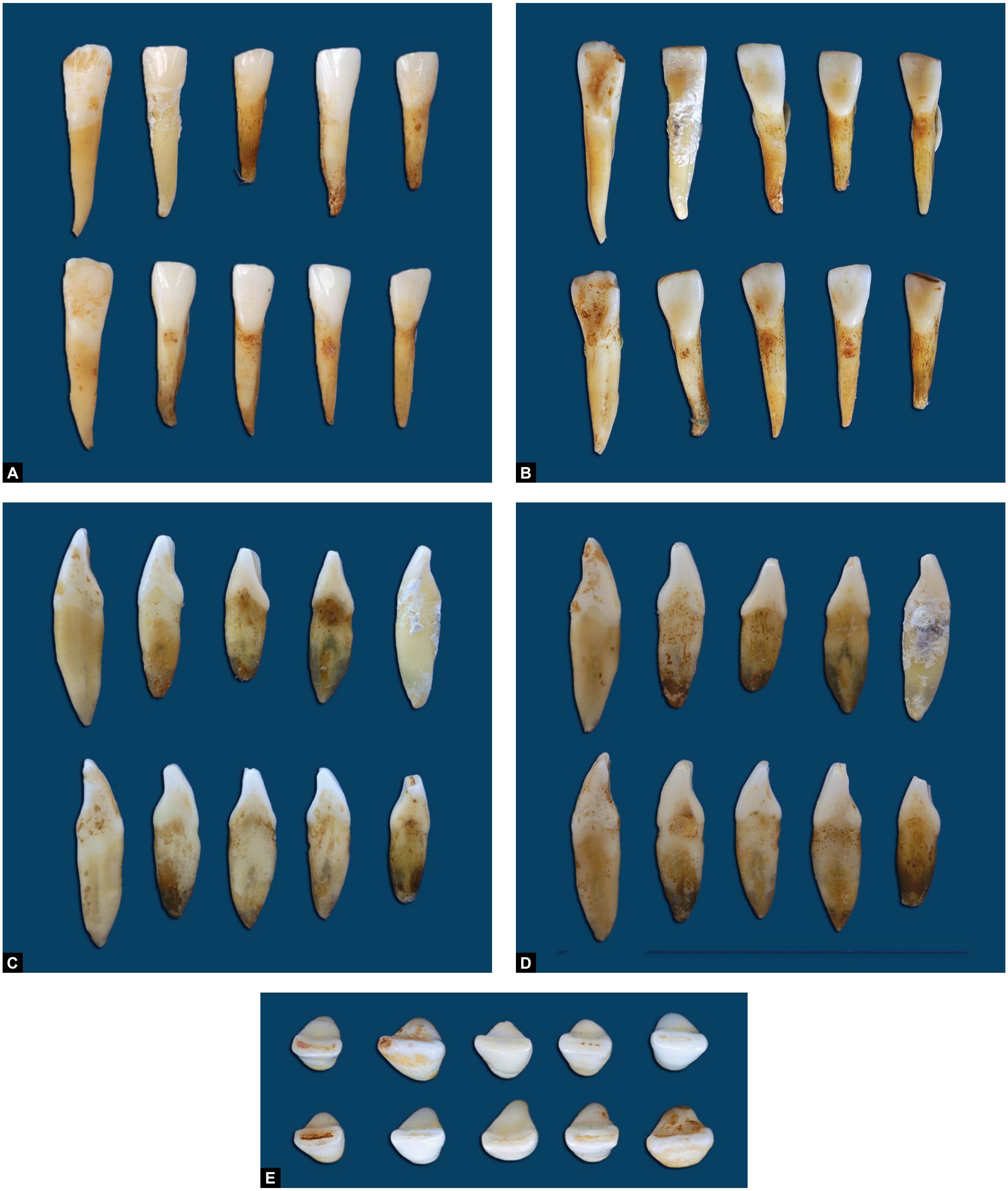
Geometric shape: It is *trapezoidal* like labial aspect.

Crown Outlines

Mesial, distal, incisal and cervical outlines on lingual aspect are similar to that of labial aspect.

Lingual Surface within the Outlines

- Lingual surface is similar to that of mandibular central incisor but is wider mesiodistally
- The crown tapers lingually making the lingual surface narrower than the labial surface
- The lingual surface is smooth devoid of developmental grooves, and is convex near cingulum



Figures 8.14A to E Mandibular lateral incisor—typical specimen from all aspects: (A) Labial; (B) Lingual; (C) Mesial; (D) Distal; (E) Incisal

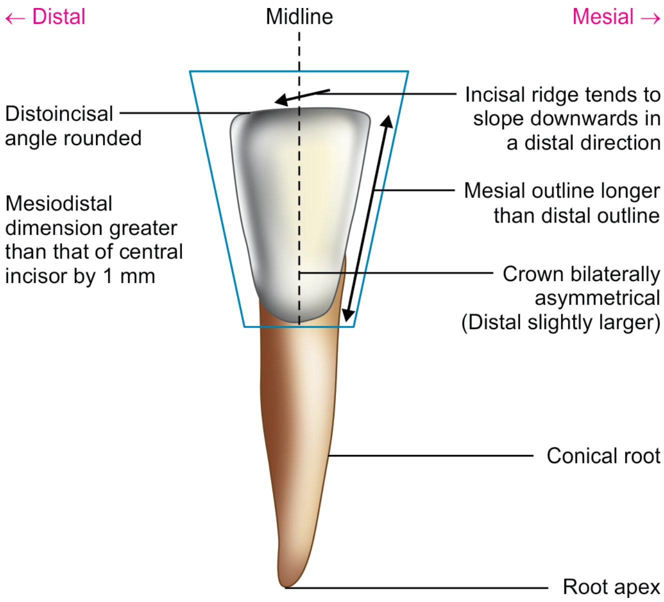


Figure 8.15 Mandibular lateral incisor—labial aspect

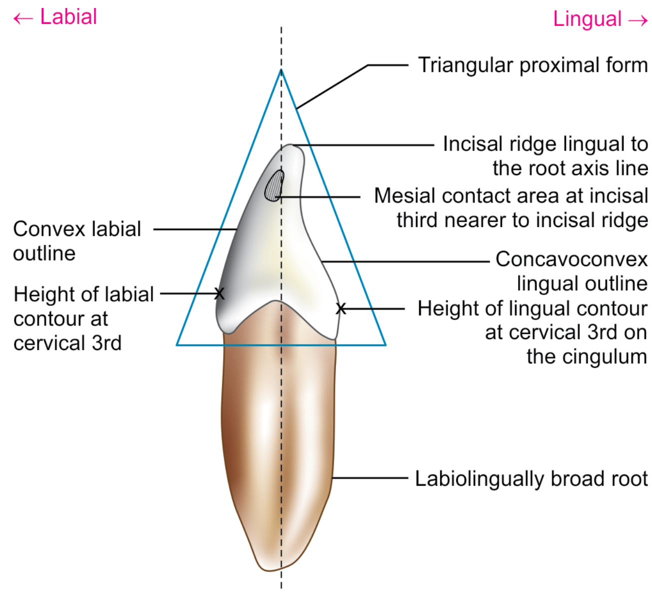


Figure 8.17 Mandibular lateral incisor—mesial aspect

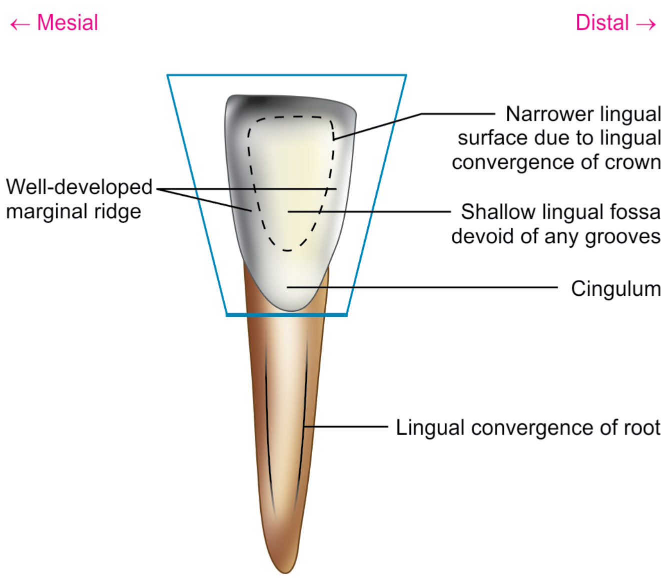


Figure 8.16 Mandibular lateral incisor—lingual aspect

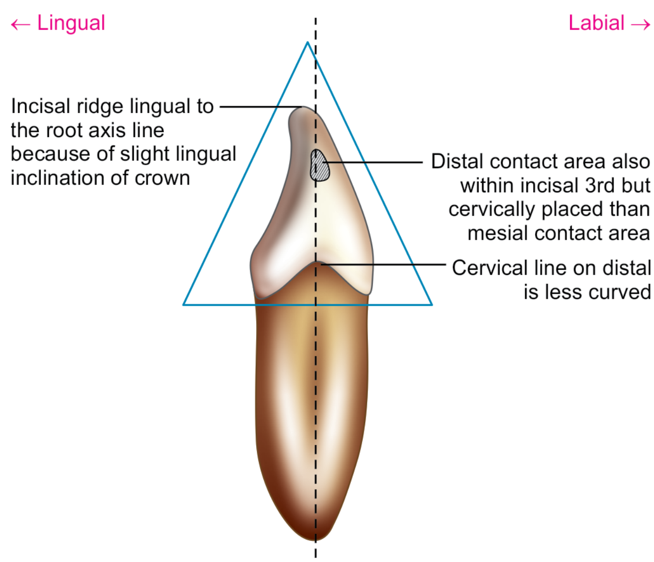


Figure 8.18 Mandibular lateral incisor—distal aspect

- Lingual fossa is shallow and marginal ridges are relatively well-formed
- Sometimes the tooth may show deep cervicoincisal groove especially in Mongoloid race group.

Mesial Aspect (Fig. 8.17)

Geometric shape: Mesial aspect is *triangular*.

Crown Outlines

- *Labial outline* is convex near cervical line and is straight from its height of contour up to incisal ridge. Height of labial contour is at cervical third.
- *Lingual outline* is straight in the incisal third, slightly concave in middle third and is convex at cervical third. Height of contour on lingual outline is also at cervical third on the cingulum.

- *Incisal outline* is formed by incisal ridge which is lingual to the root axis line. In a worn tooth, an incisal edge with a labial slope is seen.
- The *cervical line* is convex pointing incisally.

Mesial Surface within the Outlines

- Mandibular lateral incisor is broader buccolingually than the mandibular central incisor.
- It is convex and smooth.
- The mesial surface is longer than the distal surface.
- *Mesial contact area* is at incisal third of the crown.

Distal Aspect (Fig. 8.18)

Distal aspect is similar to mesial aspect except the following features:

- Cervical line on distal surface is less curved.
- *Distal contact area* is still within incisal third but is more cervically placed than the mesial contact area in order to reach the mesial contact area of mandibular canine.

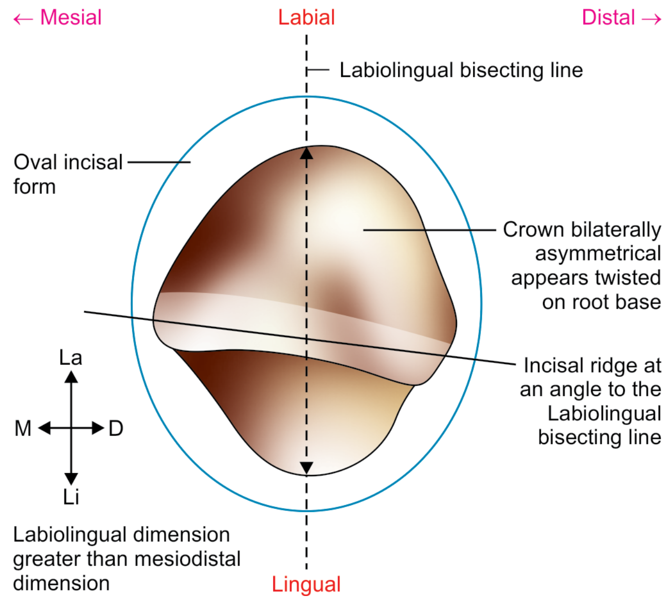
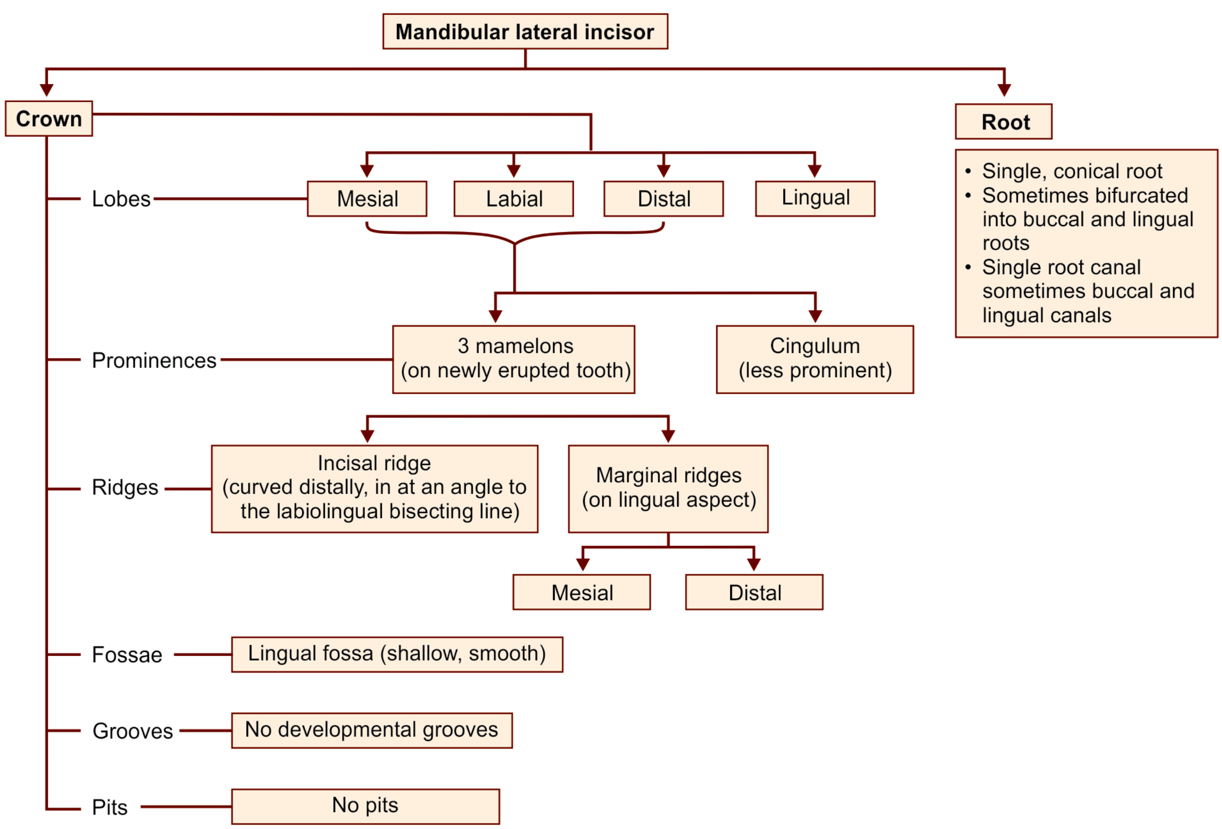


Figure 8.19 Mandibular lateral incisor—incisal aspect

Flow chart 8.3 Mandibular lateral incisor—major anatomic landmarks



Incisal Aspect (Fig. 8.19)

Geometric shape: It is *oval* labiolingually.

Relative Dimension

Labiolingual dimension is greater than mesiodistal dimension.

Symmetry

Unlike the mandibular centrals, the crown is not bilaterally symmetrical.

Incisal Form

- The incisal aspect provides the identification feature of mandibular lateral incisor.
- The *incisal ridge is at an angle to the line bisecting the tooth labiolingually* rather than being perpendicular to it.
- This arrangement allows the incisal edge to follow the curvature of mandibular arch.
- The crown of mandibular lateral incisor appears to be slightly twisted on its root base from this aspect.

ROOT

- Mandibular lateral incisor has a single root which resembles the mandibular central incisor root in every aspect but is considerably longer.
- The root may sometimes show bifurcation onto buccal and lingual divisions.

Flow charts 8.3 and 8.4 give a brief summary of mandibular central incisal. The identification features of the tooth are given in **Box 8.2**.

VARIATIONS

- Two canals in a single root
- Long root
- Small size of tooth
- Bifurcation of root into labial and lingual divisions.

Flow chart 8.4 Mandibular lateral incisor—summary

Mandibular lateral incisor

Crown

Labial aspect
- Geometric shape
  - Trapezoidal
- Crown outlines
  - Mesial
    - Straight
    - Longer than distal outline
  - Distal
    - Slightly convex
- Crown symmetry
  - Bilaterally asymmetrical
  - Distal half larger
- Incisal angles
  - Mesioincisal—right angled
  - Distoincisal—rounded
- Incisal ridge
  - Straight
  - Stopes cervically in a distal direction
  - Mamelons in newly erupted tooth
- Labial surface
  - Smooth convex
  - Flat incisally

Lingual aspect
- Trapezoidal
- Lingual convergence
  - Present lingual
- Lingual fossa
  - Shallow
  - Devoid of developmental grooves
- Marginal ridges
  - Relatively well formed

Mesial aspect
- Trapezoidal/wedge
- Crown outlines
  - Labial-straight concavoconvex
- Incisal ridge location
  - Lingual to vertical root axis
- Lingual inclination of crown
  - Crown inclined lingually over root base
- Mesial surface
  - Longer than distal surface
- Mesial contact area
  - At incisal 3rd near mesioincisal angle

Distal aspect
- Triangular/wedge
- Cervical line
  - Less curved
- Distal surface
  - Shorter than mesial surface
- Distal contact area
  - At incisal 3rd but cervical to mesial contact area

Incisal aspect
- Oval labiolingually
- Relative dimensions
  - Crown wider labiolingually than mesiodistally
- Symmetry
  - Crown bilaterally not symmetrical
- Incisal ridge
  - Not perpendicular
  - Is at an angle to labiolingual bisecting line
  - Curves distally

Root
- Number
  - Single
- Pulp canal
  - Single canal
- Size
  - Long root
- Form
  - Conical
  - Narrow mesiodistally wide and flattened labiolingually
  - Sometimes divided into buccal and lingual roots

Box 8.2 Mandibular lateral incisor—identification features

Identification features of mandibular lateral incisor
- The mandibular lateral incisor is slightly larger than the mandibular central incisor.
- The crown is bilaterally asymmetrical.
- Mesioincisal angle is sharp, distoincisal angle is slightly rounded.
- Viewed incisally, the incisal ridge is placed at an angle to the line bisecting the tooth labiolingually.

Side identification
- Mesioincisal angle is sharp
- Distoincisal angle is rounded.

DEVELOPMENTAL ANOMALIES

- Congenitally missing.
- Fusion between mandibular central and lateral incisor.

BIBLIOGRAPHY

1. Benjamin KA, Dowson J. Incidence of two canals in human mandibular incisor teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1974;38(1):122-6.
2. Brand RW, Isselhard DE. Anatomy of Orofacial Structures, 5th edn. St Louis: CV Mosby; 1994.
3. Kabak YS, Abbott PV. Endodontic treatment of mandibular incisors with two root canals: Report of two cases. Aust Endod J. 2007;33:27-31.
4. Miyashita M, Kasahara E, Yasuda E, Yamamoto A, Sekizawa T. Root canal system of the mandibular incisor. J Endod. 1997;23(8):479-84.
5. Rankine-Willson RW, Henry P. The bifurcated root canals in lower anterior teeth. J Am Dent Assoc. 1965;70:1162-5.

MULTIPLE CHOICE QUESTIONS

1. The smallest tooth in permanent dentition is:
   a. Maxillary permanent lateral incisor
   b. Mandibular permanent lateral incisor
   c. Mandibular permanent central incisor
   d. Maxillary permanent central incisor
2. Which of the following statements is true:
   a. In maxillary arch, the central incisor is larger than the lateral
   b. In mandibular arch, also the central incisor is larger than the lateral
   c. In mandibular arch, the lateral incisor is larger than the central
   d. Both a and c
3. The crown of mandibular permanent central incisor is:
   a. Bilaterally asymmetrical from labial and lingual aspects
   b. Bilaterally symmetrical from labial, lingual and incisal aspects
   c. Bilaterally symmetrical from all aspects
   d. Bilaterally asymmetrical from all aspects
4. The geometrical shape of mandibular permanent central incisor from the labial aspect is:
   a. Triangular
   b. Hexagonal
   c. Octagonal
   d. Trapezoid
5. Mesioincisal angle of mandibular permanent central incisor is:
   a. Acute angled
   b. Obtuse angled
   c. Right angled
   d. None of the above
6. Distoincisal angle of mandibular permanent central incisor is:
   a. Acute angled
   b. Right angled
   c. Obtuse angled
   d. None of the above
7. In mandibular permanent central incisor, the mesial and distal contact area are:
   a. At the same level
   b. At different levels
   c. Absent one side
   d. Absent on both the sides
8. Mesial and distal contact area of mandibular permanent central incisor is located at:
   a. Middle third
   b. Cervicsal third
   c. Incisal third
   d. None of the above
9. The differences between mesial and distal surface of mandibular permanent central incisor is:
   a. Extent of curvature of cervical line on distal aspect is 1 mm less than on the mesial
   b. Extent of curvature of cervical line on mesial aspect is 1 mm less than on the distal
   c. Extent of curvature of cervical line on distal aspect is 4 mm more than on the mesial
   d. None of the above
10. In mandibular permanent central incisor, the labiolingual dimension is:
    a. Always smaller than mesiodistal dimension
    b. Always greater than mesiodistal dimension
    c. Both are exactly same
    d. None of the above

Answers

1. a	2. d	3. b	4. d	5. c	6. b	7. a	8. c	9. a	10. b

CHAPTER

9

The Permanent Canines

There are four permanent canines: two in each dental arch and only one member of its class in each quadrant. Permanent canines develop from four lobes, three labial and one lingual. The middle labial lobe in canine is highly developed incisally to form a strong, well-formed cusp.

The name 'canine' is derived from Latin word for dog *canis,* as the corresponding teeth are very prominent members of the dentition of these animals. The canine teeth are prominent in other carnivores and also in primates (gorilla, chimpanzee, etc.). In human dentition, although canines have larger and stronger roots than other teeth, the crowns do not project much higher than the adjacent teeth. This permits wider range of side-to-side (lateral) jaw movements which is so characteristic of human dentition.

The maxillary permanent canines have other synonyms like:

- Cuspids
- Dog teeth
- Eye teeth
- Corner teeth
- Beauty teeth
- Corner stone of dental arches.

The four maxillary permanent canines are placed at the corners of the mouth; thus they sometimes are referred to as the *corner teeth* (**Fig. 9.1**). Unlike incisors that have straight incisal ridges, the canine teeth have a well-formed pointed cusp developed from their middle labial lobe. Hence, they are also called as *cuspids.* Because of their shape and position in the arches maxillary and mandibular canines assist in guiding the teeth into intercuspal position by *canine guidance*.

The canines have longest and strongest roots of all teeth. The roots have excellent anchorage in the alveolar bone with an extra length and width. Alveolar bone over the roots of maxillary permanent canine, labially, is prominent and is called *canine eminence.* Maxillary and mandibular permanent canines help to establish normal facial expression at the corners of the mouth—with their position, form of canine eminence, and thus they are of high esthetic value. Facial profile changes when canines are lost due to some reason.

Extra anchorage of the long roots and self cleansing convex surfaces of their crowns make the permanent canines highly stable teeth in the mouth. They are often the last ones to go. When one considers their longevity, crucial position in the arches, importance in establishment of occlusion and facial expression, the term *corner stone* of dental arches seems justified.

FUNCTIONS

- The canines assist the permanent incisors and premolars in mastication
- They are mainly used for tearing food
- Help in seizing, slicing and chewing food
- In carnivores, the canines act as important tools during hunting and self-defense. They are used for prehension (seizing) of their prey
- Canine teeth exhibit prominent sexual dimorphism, especially in lower animals (e.g. wild bear, etc.). The canine teeth are noticeably larger and longer in males than females in these animals.

COMMON CHARACTERISTICS (CLASS TRAITS) OF PERMANENT CANINES

- The canines develop from four lobes: Three labial and one lingual
- They are wider buccolingually than mesiodistally

Figure 9.1 Being at the corners of the mouth, the canines are sometimes referred to as the *corner teeth*

- Their middle labial lobe is highly developed into well-formed cusp
- Their labial surfaces have a labial ridge extending from the cusp tip to the cervical line
- Lingual aspect shows well-formed cingulum and a lingual fossa, which may be divided by a lingual ridge into two small fossae
- Their distal cusp slope is longer than the mesial cusp slope
- The canines typically have their contact areas at different levels cervico-occlusally. This is because the adjacent teeth of canines, with which they make contact, are of different classes lateral incisor mesially and the 1st premolar distally
- They have single root, longest and strongest of all teeth providing the best anchorage among anteriors.

PERMANENT MAXILLARY CANINE

Maxillary permanent canine is the longest tooth of all and exhibit some of the characteristics of permanent maxillary incisors and some features of premolars. In many ways, it acts like a transition between anterior and posterior segments of the dental arch. In all mammals, the maxillary canine is the first tooth situated in the maxilla immediately behind the premaxillary suture. The chronology and measurement of the maxillary canine is given in **Table 9.1**.

DETAILED DESCRIPTION OF MAXILLARY CANINE FROM ALL ASPECTS

Crown and root of maxillary permanent canines are explained separately. **Figures 9.2 to 9.4** show maxillary canine from various aspects.

Table 9.1 Maxillary canine—chronology and dimensions

Chronology	
First evidence of calcification	4–5 months
Enamel completed	6–7 years
Eruption	11–12 years
Roots completed	13–15 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervicoincisal length of crown	10.0
Length of root	17.0
Mesiodistal diameter of crown	7.5
Mesiodistal diameter of crown at cervix	5.5
Labiolingual diameter of crown	8.0
Labiolingual diameter of crown at cervix	7.0
Curvature of cervical line—mesial	2.5
Curvature of cervical line—distal	1.5

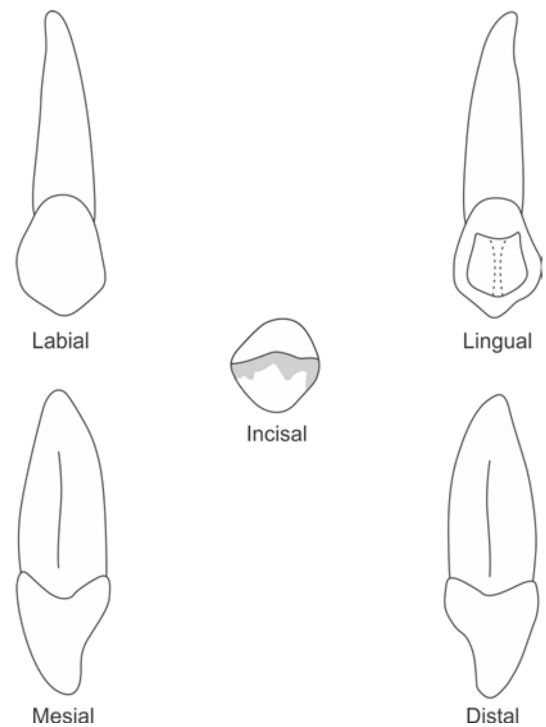


Figure 9.2 Maxillary right canine—line drawings

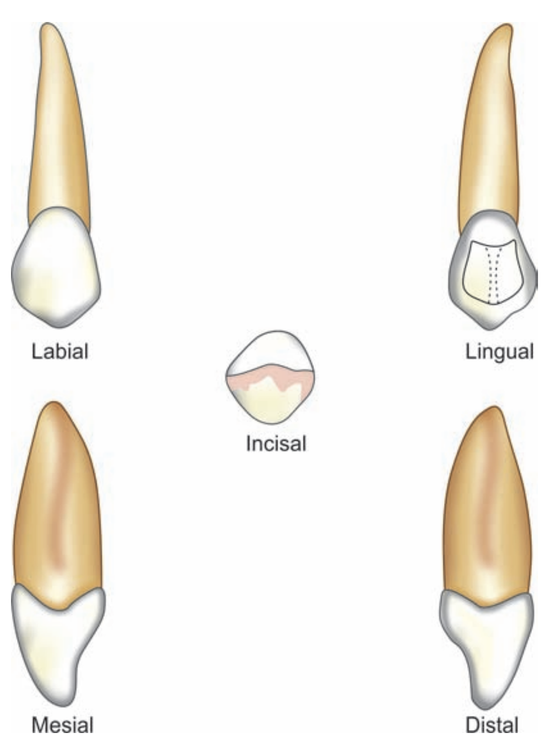
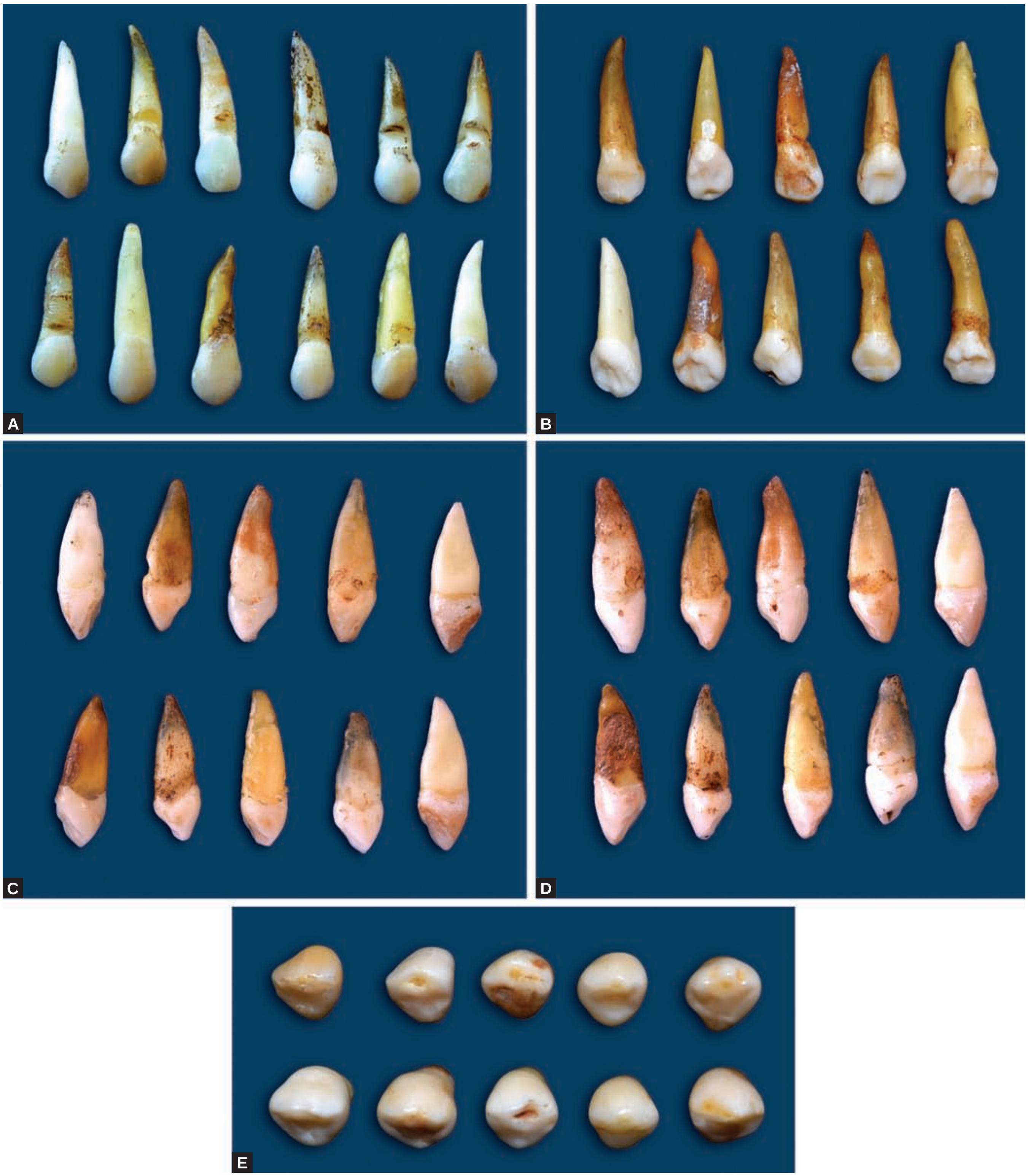


Figure 9.3 Maxillary right canine—graphic illustration



Figures 9.4A to E Maxillary canine—typical specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

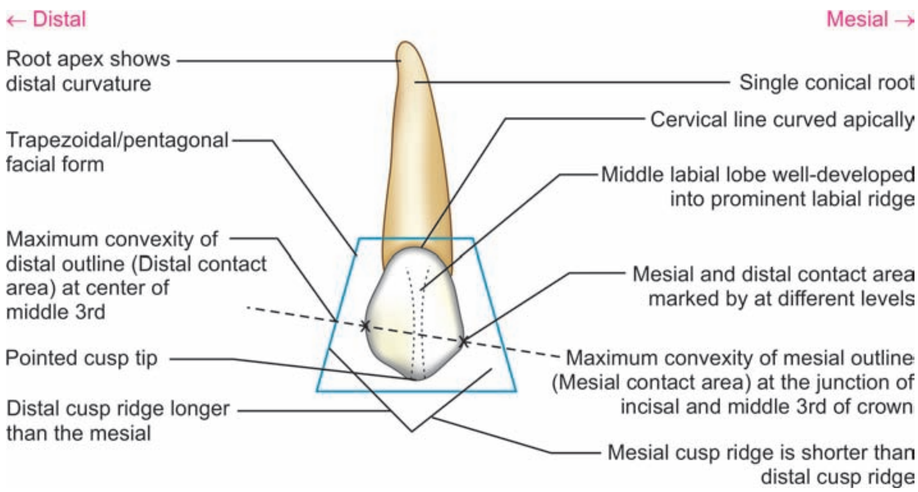


Figure 9.5 Maxillary canine—labial aspect

CROWN

Labial Aspect (Fig. 9.5)

Geometric shape: General shape of the crown from labial aspect is that of a *trapezoidal or pentagonal* form. The shorter uneven side of trapezoid is towards the cervical line.

Crown Outlines

- *Mesial outline* is a convex arc from cervix to the area where it joins the mesial cusp slope. Maximum convexity of the mesial outline (*mesial contact area*) is at the junction of incisal and middle third of the crown.
- *Distal outline* is convex for most of its part except near cervix, where it is concave. Maximum convexity of the distal outline (*distal contact area*) is at the center of middle third of the crown.
- *Incisal outline* is formed by two slopes extending downwards from mesial and distal contact areas to meet the cusp tip at midline. These slopes are called as *mesial and distal cusp ridges.* The distal cusp ridge is longer and is slightly rounded, whereas the mesial cusp ridge is usually concave. The pointed cusp becomes flat over the time due to wearing away.
- The *cervical line* on the labial surface is smoothly convex pointing apically.

Labial Surface within the Outlines

- From labial aspect the maxillary permanent canine resembles a premolar
- The crown is narrower than the maxillary central incisor mesiodistally by 1 mm and much narrower at cervix

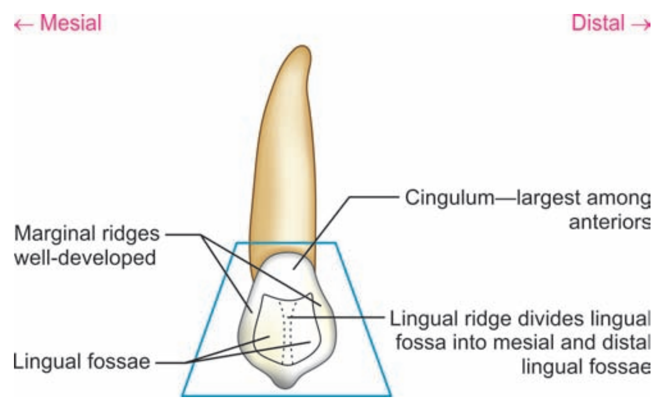


Figure 9.6 Maxillary canine—lingual aspect

- The middle labial lobe is well-developed than other lobes and forms a linear elevation extending from cervical line to the cusp tip. This feature is called as *labial ridge*
- The mesial and distal contact areas are noticeably at different levels in maxillary canine and this can be easily appreciated from labial view
- The labial surface is generally smooth and convex except for the shallow depressions on either side of the labial ridge
- In a newly erupted tooth, two shallow developmental grooves separating the three labial lobes can be seen.

Lingual Aspect (Fig. 9.6)

Geometric shape: It is *trapezoidal/pentagonal* similar to that of the labial aspect.

Crown Outlines

- The *mesial, distal and incisal outlines* on lingual aspect are similar to that of the labial aspect
- The *cervical line* on lingual aspect, is more convex and points apically.

Lingual Surface within the Outlines

- The lingual surface of maxillary permanent canine is narrower than the labial surface because of lingually converging proximal walls.
- The cervical portion of lingual surface is occupied by a large, smooth, well-developed cingulum. The cingulum of maxillary canine is largest of all anteriors and sometimes it is pointed like a small cusp.
- The marginal ridges are strongly developed and along with cingulum they form the boundaries of lingual fossa.
- The lingual fossa is more concave and may be divided by a lingual ridge into two small concavities called *mesial* and *distal lingual fossae.*
- The lingual fossa is usually devoid of any developmental grooves.
- Height of contour is on cingulum at cervical 3rd.

Mesial Aspect (Fig. 9.7)

Geometric shape: The maxillary permanent canines appear *triangular or wedge-shaped* from proximal view like incisors but with more labiolingual bulk.

Crown Outlines

- The *labial outline* of maxillary permanent canine is more convex than that of maxillary permanent central incisor due to the presence of prominent labial ridge from cervical line to cusp tip. *Height of labial contour* is within cervical third but is placed more incisally than that of the maxillary permanent central incisor.
- The *lingual outline* is 'S' shaped, follows the convexity of cingulum at the cervical third, concavity of lingual fossa in the center, and becomes convex again towards the incisal third. It is more convex in the cervical portion because of large cingulum. *Height of contour lingually* is at the cervical third, located on cingulum and is incisally placed than that of the maxillary central incisor.
- *Incisal outline* forms a small arc representing the cusp tip. Pointed cusp tip may become flat due to occlusal wear.
- *Cervical line* on the mesial aspect is convex pointing towards the cusp tip.

Mesial Surface within the Outlines

- Maxillary permanent canine has the greatest labiolingual width amongst anteriors. Thus, the tooth appears more bulkier from proximal aspects.
- The mesial surface is generally convex except for a small concavity in the cervical portion above the contact area.
- Unlike the incisal ridge of maxillary incisors, the cusp tip of maxillary canine is not centered over the root. It is placed labial to the vertical root axis.
- *Mesial contact area:* The mesial contact area is at the junction of incisal and middle third of the crown cervicoincisally, and is at the center labiolingually.

Distal Aspect (Fig. 9.8)

The distal aspect of maxillary permanent canine is similar to the mesial aspect except for the following features:

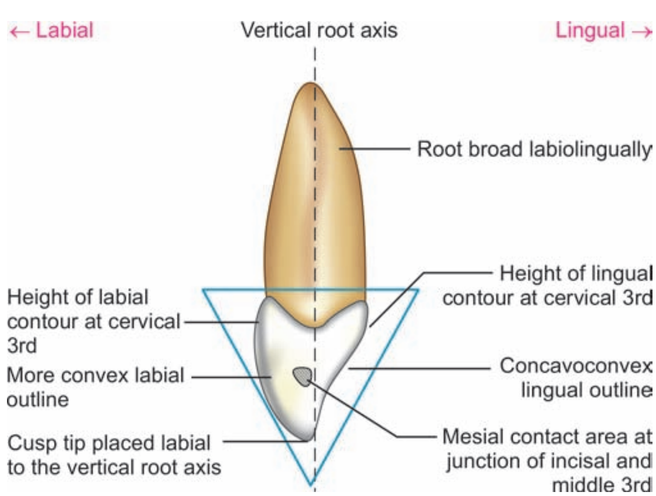


Figure 9.7 Maxillary canine—mesial aspect

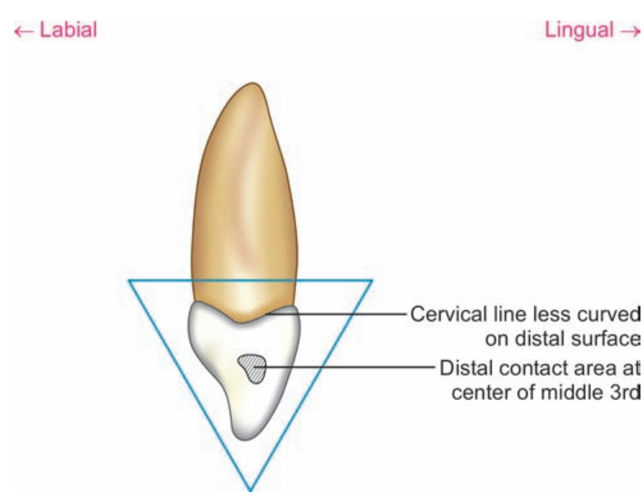


Figure 9.8 Maxillary canine–distal aspect

- The cervical line is less curved on the distal surface
- The distal marginal ridge is strongly developed than the mesial
- The distal surface shows more concavity apical to the distal contact area
- The *distal contact area* is at the center of middle 3rd of the crown.

Incisal Aspect (Fig. 9.9)

Geometric shape: Viewed incisally the maxillary canine appears *diamond shaped*.

From incisal aspect the following features are noted:
- *Relative dimensions*: The labiolingual dimension of the crown of maxillary permanent canine is greater than the mesiodistal dimension.
- *Symmetry*: The crown is *asymmetrical* with distal half of the crown larger than the mesial half.
- *Position of cusp tip*: The cusp tip is located labial to the center of the crown labiolingually, and mesial to the center mesiodistally.

Labially

- The cervical portion of labial face is convex
- The labial ridge appears prominent from incisal view, which is more convex at cervical third and gets flattened towards incisal third.

Lingually

- The cingulum forms a shorter convex arc at the cervical portion of lingual face

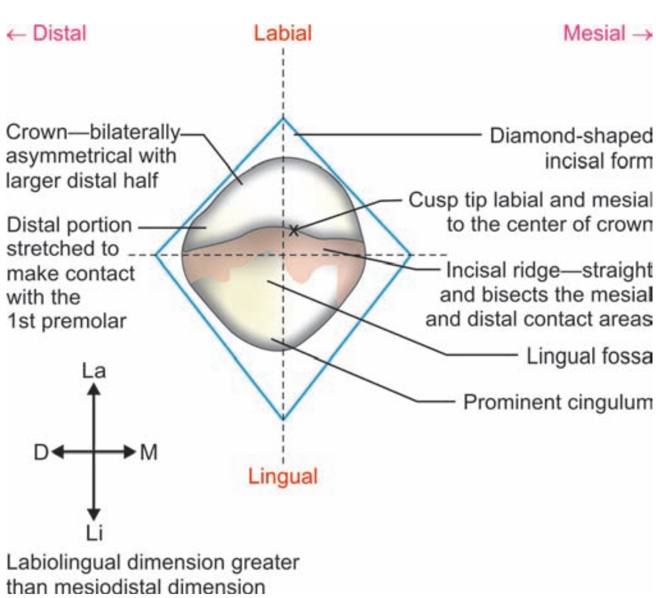


Figure 9.9 Maxillary canine—incisal aspect

- The lingual fossa, the lingual ridge and the marginal ridges bordering the lingual fossa can be seen.

Mesial and Distal Contact Areas

- Short arcs present mesially and distally represent the mesial and distal contact areas. The mesial contact area is broader than the distal
- The distal portion of the crown appears to be stretched to make contact with the 1st premolar
- The cusp ridges form a straight line mesiodistally which bisects the contact areas.

ROOT

Morphology of the root can be described under the following headings:

Number : Single root

Size : Maxillary permanent canine has the longest root of all teeth and its labiolingual thickness is greater than that of incisors.

Form :
- The root is conical in shape, narrower mesiodistally and wider labiolingually.
- Similar to the crown, the root also exhibits lingual convergence.
- The labial and lingual surfaces are smoothly convex.
- The mesial and distal surfaces are flattened and exhibit *developmental depressions* for major part of the root.
- Developmental depression on the distal surface is deeper. These developmental depressions help to reinforce anchorage in alveolar bone.

Curvature : Apical third of the root usually shows distal curvature.

Apex : Apex of the root is relatively blunt.

Cross-section : The cross-section of the root at cervix is oval.

VARIATIONS (FIG. 9.10)

Variations of maxillary permanent canine are listed below:
- Very long crown or long root
- Short crown or root

DEVELOPMENTAL ANOMALIES

- Ectopic eruption
- Transposition (**Fig. 9.11**).

CLINICAL CONSIDERATIONS

- Maxillary canines are the most commonly impacted teeth after the 3rd molars (**Fig. 9.12A**).

Figure 9.10 Maxillary canine—variations

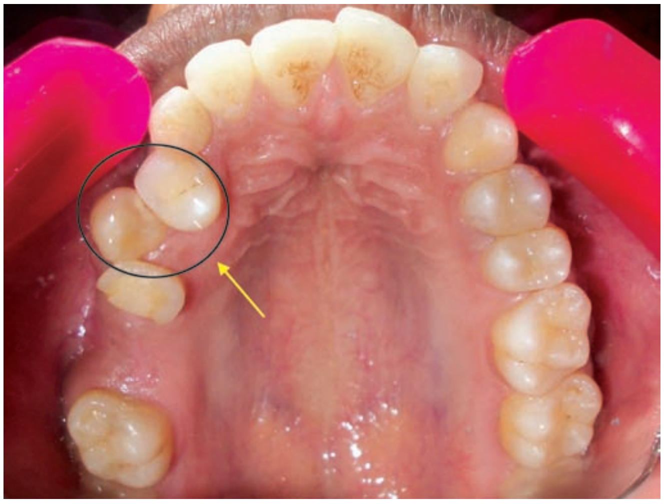


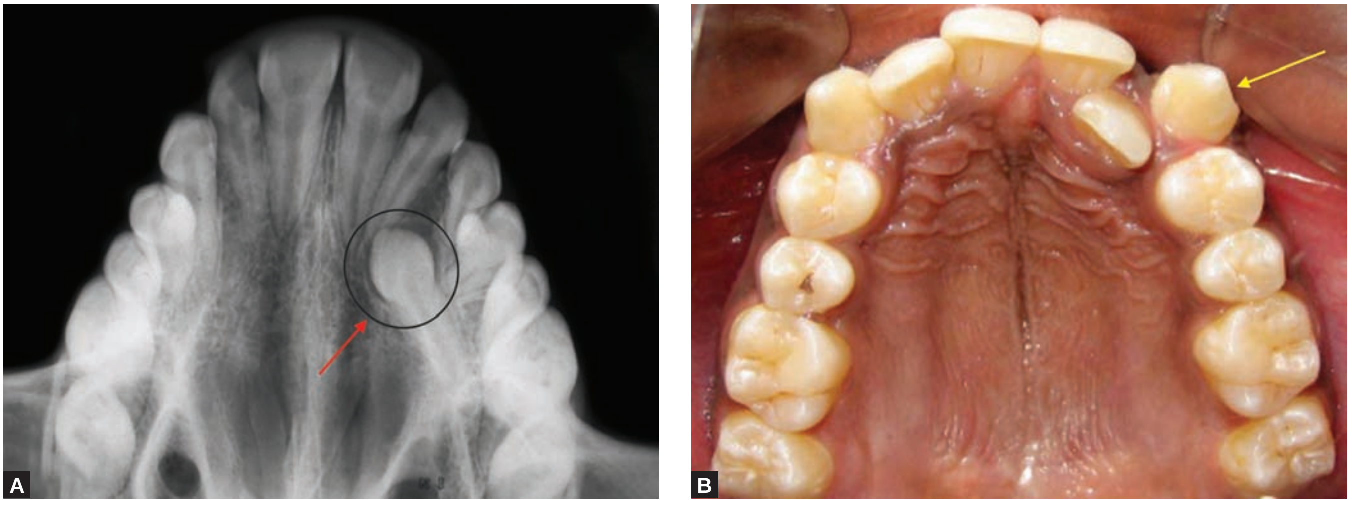
Figure 9.11 Transposition of maxillary canine and 1st premolar

- In the maxillary arch, the permanent canines erupt after the eruption of one or both the premolars. Hence, if space is not maintained until their eruption the maxillary permanent canines often erupt labially out of the arch causing malocclusion (**Fig. 9.12B**).
- Canine guidance is important in establishment of occlusion.
- Maxillary permanent canine to mandibular canine relationship is observed for classifying malocclusions especially when the 1st molars are missing.
- Inter-canine distance is often used as a gender trait in dental anthropology.
- Maxillary permanent canines provide good support when utilized as abutments in prosthetic replacement of missing teeth.
- Deep concavity on the maxilla, posterior to the canine eminence is called canine fossa. During surgical procedures, the maxillary sinus is often entered by an incision through canine fossa as the wall of the sinus is thin there.

A brief summary of maxillary canine is given in **Flow charts 9.1 and 9.2**. **Box 9.1** gives the identification features of maxillary canine.

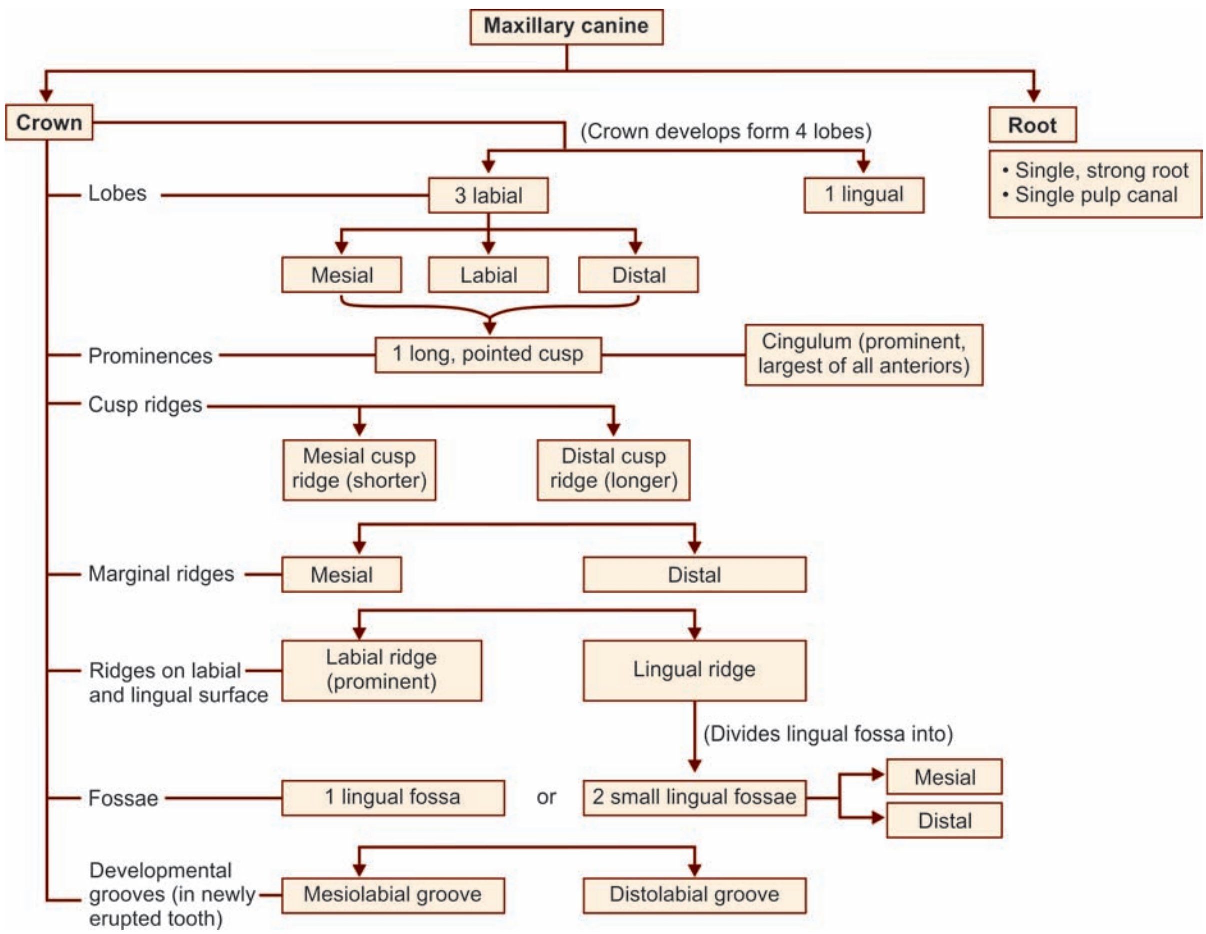
PERMANENT MANDIBULAR CANINE

The mandibular canine closely resembles the maxillary canine. In comparison to its maxillary counterpart, the mandibular canine has a long narrow crown, shorter root, poorly developed cingulum and less prominent cusp. The mandibular canine erupts prior to mandibular premolars and well before maxillary canine. The chronology and measurement of the mandibular canine is given in **Table 9.2**.



Figures 9.12A and B (A) Occlusal radiograph showing impacted maxillary canine; (B) Labially erupted upper canines causing malocclusion

Flow chart 9.1 Maxillary canine—major anatomic landmarks



DETAILED DESCRIPTION OF MANDIBULAR CANINE FROM ALL ASPECTS

Figures 9.13 to 9.15 show mandibular canine from various aspects.

CROWN

Labial Aspect (Fig. 9.16)

Geometric shape: The labial aspect of mandibular canine is *trapezoidal or pentagonal* like that of the maxillary canine.

Crown Outlines

The labial aspect reveals the major differences between the maxillary and mandibular canines.

- The *mesial outline* is almost straight, in line with the mesial outline of the root and it joins the mesial cusp. The maximum convexity of the mesial outline *(The mesial contact area)* is near the mesioincisal angle.
- *Distal outline* is less convex than that of maxillary canine. The *distal contact area* is more incisally located than that of maxillary canine.
- *Incisal outline:* The cusp tip is on line with vertical root axis. Cusp ridges are straight and the distal cusp ridge is longer than the mesial as in case of maxillary canine.
- *Cervical outline:* The cervical line on the labial surface curves apically.

Labial Surface within the Outlines

- Crown of mandibular canine appears longer, not only because of its extra length of 1 mm, but also due to its narrow mesiodistal width and more incisally placed contact areas.
- Mesioincisal and distoincisal angles are well-defined

Flow chart 9.2 Maxillary canine—summary

Maxillary canine

- **Crown**
  - **Labial aspect**
  - **Lingual aspect**
  - **Mesial aspect**
  - **Distal aspect**
  - **Incisal aspect**
- **Root**

Labial aspect

Geometric form
- Trapezoidal/ pentagonal

Crown outlines
- Mesial—convex
- Distal—more convex

Height of mesial and distal contours/ contact areas
- Markedly at different levels
- Mesial—junction of middle and incisal 3rd
- Distal—at center of middle 3rd

Cusp ridges/slopes
- Mesial—short, concave
- Distal—longer

Cusp
- Single well—developed cusp with pointed tip

Labial ridge
- Middle labial lobe well-developed to form labial ridge running from cervix to cusp tip

Labial surface
- Convex
- Shallow depressions on either side of labial ridge

Lingual aspect

- Trapezoidal/ pentagonal

Lingual convergence
- Marked

Cingulum
- Largest among the anteriors
- Well-developed sometimes like a small cusp

Marginal ridges
- Strongly developed

Lingual fossa
- May be divided into mesial and distal lingual fossae by the lingual ridge
- Usually no developmental grooves

Mesial aspect

- Triangular/wedge

Dimensions
- Crown bulkier labiolingually
- Labiolingual dimension greatest of all anteriors
- Thicker at incisal portion than incisors

Outlines
- Labial—more convex
- Lingual—concavoconvex

Height of labial contour
- At cervical 3rd

Cusp tip location
- Placed labial to the vertical root axis

Mesial surface
- Convex except a small concavity in cervical portion

Mesial contact area
- At the junction of incisal middle 3rd cervicoincisally
- Centered labio-lingually

Distal aspect

- Triangular/ wedge

Similar to mesial surface except
- Cervical line—less curved
- Preconcavity apical to contact area

Distal contact area
- At middle 3rd of crown

Incisal aspect

- Diamond-shaped

Relative dimensions
- Labiolingual dimension greater than the mesio-distal

Symmetry
- Crown is asymmetric with mesial half larger than distal half
- Distal portion is stretched to make contact with 8th premolar

Positions of cusp tip
- Cusp tip located labial to crown center labiolingually and mesial to the center mesio-distally

Cusp ridges
- Form straight line mesiodistally and bisect the contact areas

Root

Number
- Single root canal

Pulp canals
- Single canal

Size
- Longest root of all teeth
- Thicker labiolingually

Form
- Conical-shaped root
- Narrow mesiodistally, wider labiolingually

Cross-section at cervix
- Oval

Developmental depressions
- On both mesial and distal surfaces root
- Deeper on distal surface

Apical curvature
- Distal curvature at apical 3rd

Apex
- Blunt

Box 9.1 Maxillary canine—identification features

Identification features of maxillary canine
- It has long crown with a single cusp
- It has a large cingulum giving the tooth more bulk at the cervical portion when viewed proximally
- The crown is pentagonal, narrower at cervix and wider at contact areas
- The root is longest of all teeth, and is also wider labiolingually

Side identification
- Distal cusp slope is longer than the mesial
- Root apex often show a distal curvature
- Developmental depression of the root is deeper on the distal surface

- The labial ridge running from cervix to the cusp tip is less prominent than that of the maxillary canine
- The crown appears to be tilted distally on the root base because of its straight mesial outline and curved distal outline
- When cusp tip is worn off, the tooth appears like a lateral incisor from labial aspect.

Lingual Aspect (Fig. 9.17)

Geometric shape: It is trapezoidal like that of the labial aspect.

Crown outlines: Crown outlines of labial surface are similar to that of the labial aspect.

Lingual Surface within the Outlines

- The lingual surface is narrower than the labial surface as the crown tapers lingually
- The lingual surface is less concave and more flattened similar to that of mandibular lateral incisor. The lingual fossa is shallow. When lingual ridge is present, there are

Table 9.2 Mandibular canine—chronology and measurements

Chronology	
First evidence of calcification	4–5 years
Enamel completed	6–7 years
Eruption	9–10 years
Roots completed	12–14 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervicoincisal length of crown	10.5
Length of root	13.0
Mesiodistal diameter of crown	8.5
Mesiodistal diameter of crown at cervix	7.0
Labiolingual diameter of crown	7.0
Labiolingual diameter of crown at cervix	6.0
Curvature of cervical line—mesial	3.5
Curvature of cervical line—distal	2.5

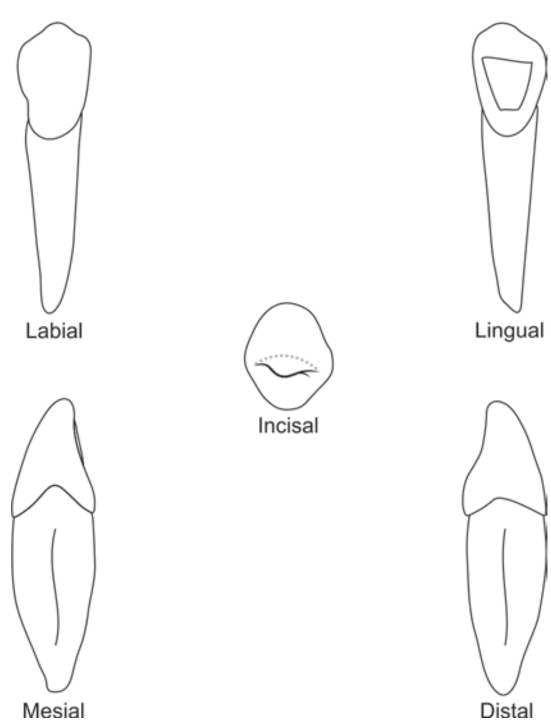


Figure 9.13 Mandibular canine—line drawings

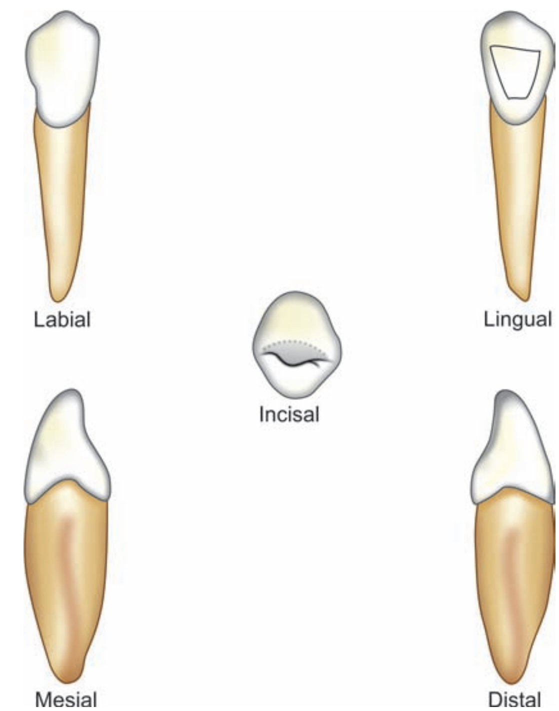


Figure 9.14 Mandibular canine—graphic illustration

two small fossae, mesial and distal lingual fossae. The lingual ridge is also less well-developed than that of the maxillary canine
- The cingulum is poorly developed.
- The marginal ridges are less prominent.

Mesial Aspect (Fig. 9.18)

Some major differences between maxillary and mandibular canines are noted from this aspect.

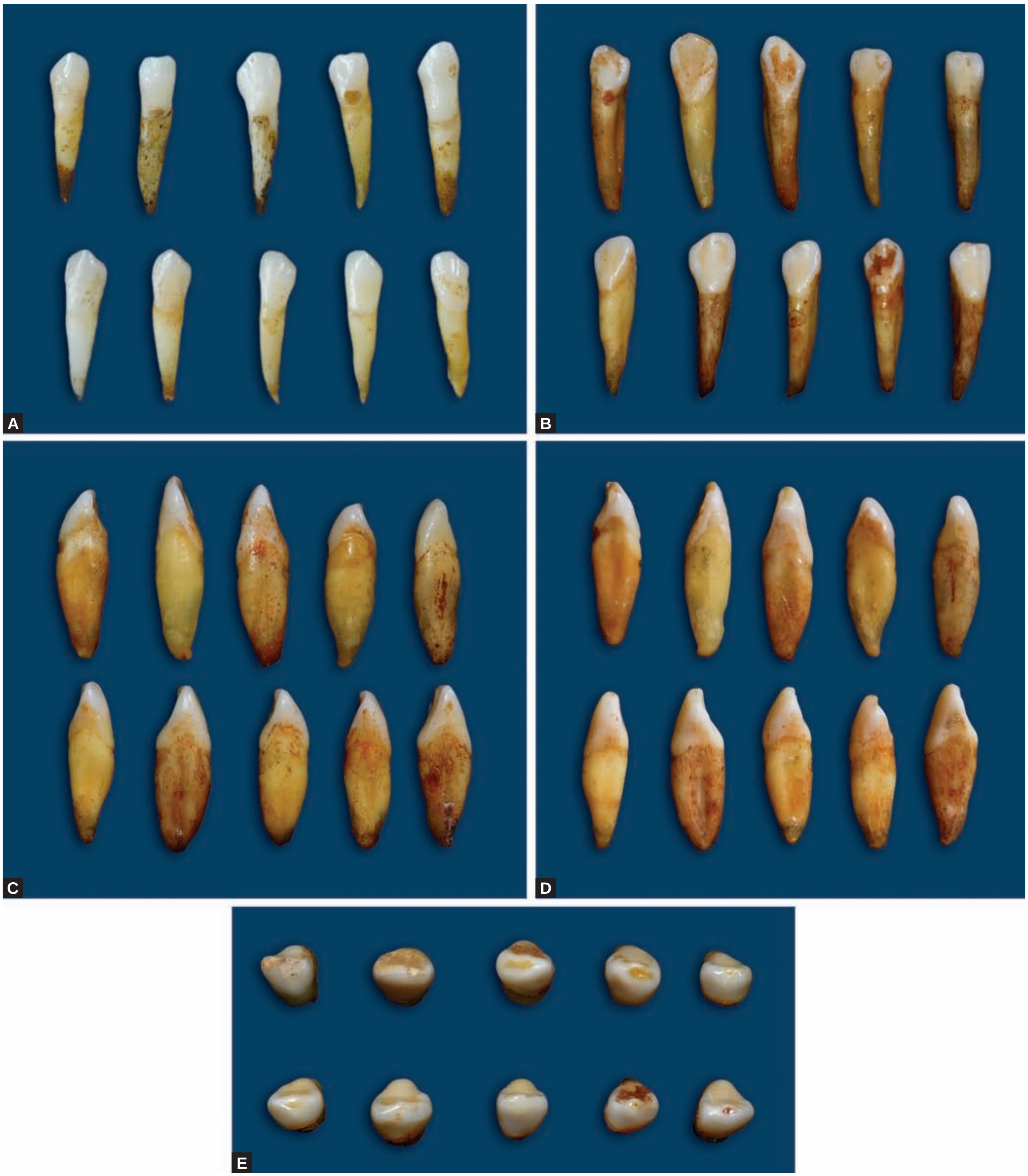
Geometric shape: The mesial aspect has a *triangular* form with its base at cervix and apex at cusp tip.

Crown Outlines

- The *labial outline* is less convex especially near the cervical line
- *Lingual outline* follows a less convex cingulum and less concave lingual fossa
- *Incisal outline*: Cusp tip is thin, pointed and cusp ridge is thin labiolingually
- *Cervical outline*: The cervical line shows more curvature incisally than that of the maxillary canine.

Mesial Surface within the Outlines

The cusp tip is in the center or lingual to the vertical root axis. It can be remembered that cusp tip of maxillary canine is



Figures 9.15A to E Mandibular canine—typical tooth specimen from all aspects: (A) Labial aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Incisal aspect

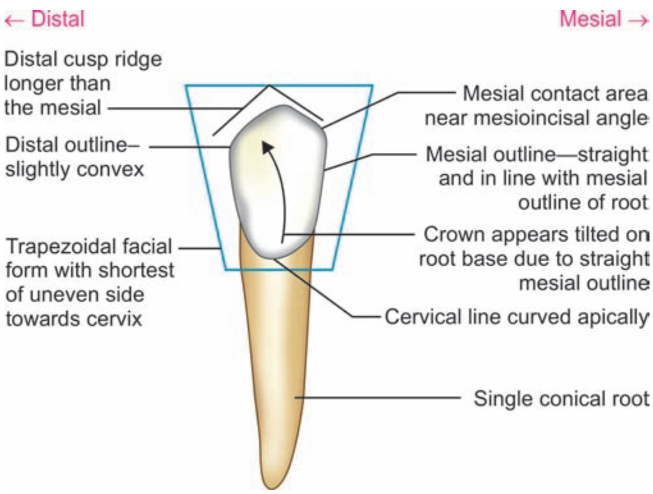


Figure 9.16 Mandibular canine—labial aspect

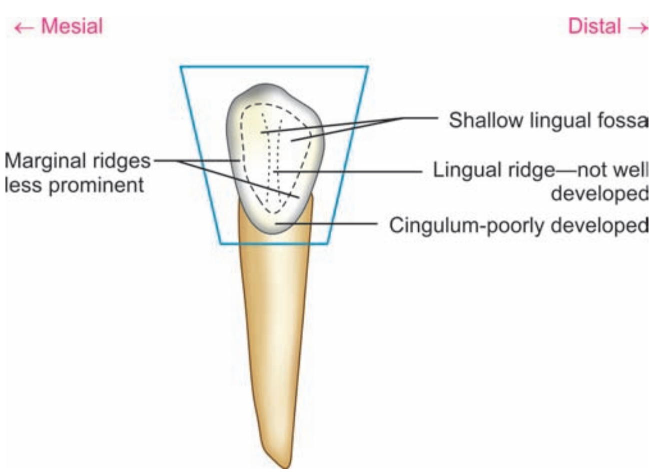


Figure 9.17 Mandibular canine—lingual aspect

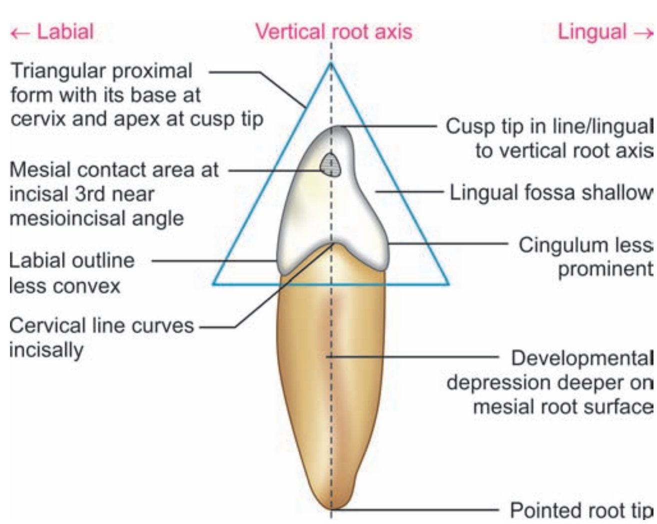


Figure 9.18 Mandibular canine—mesial aspect

labial to the vertical root axis. The lower teeth show a lingual inclination over the root base. This conforms to the general rule that the upper teeth overlap the lower teeth in occlusion.

Distal Aspect (Fig. 9.19)

It is similar to mesial aspect of mandibular canine except that: Cervical line is less curved on distal surface.

Incisal Aspect (Fig. 9.20)

Geometric shape: *Oval*

Incisal aspect is similar to that of maxillary canine except the following features:

- Mesial outline is less curved.
- Cingulum is smaller.
- Cusp tip and cusp ridges are lingually inclined. Whereas cusp ridges of maxillary canine extend straight to bisect the mesial and distal contact areas.

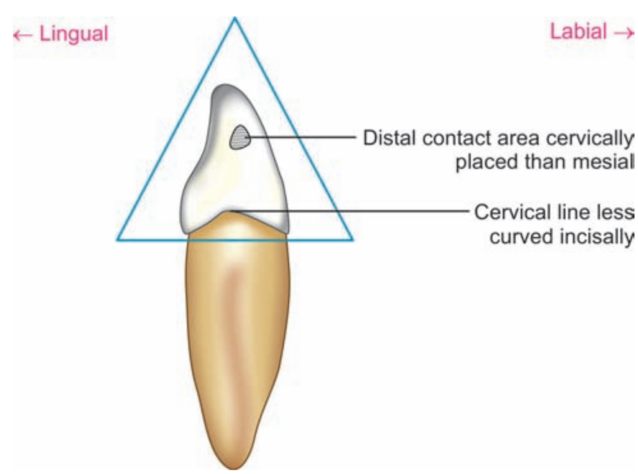


Figure 9.19 Mandibular canine—distal aspect

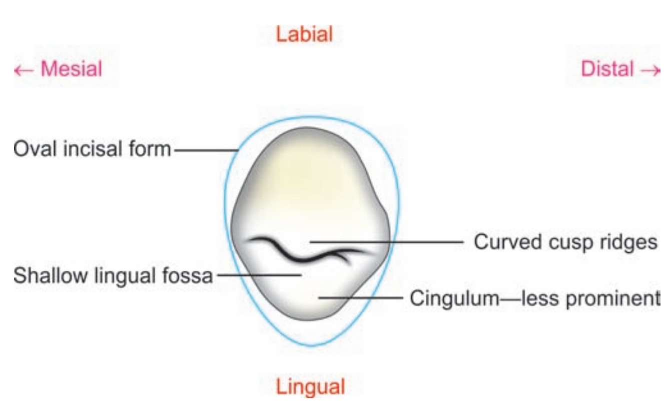


Figure 9.20 Mandibular canine—incisal aspect

ROOT

Mandibular canine root differs from the root of maxillary canine in following ways:

Number : Usually single, but bifurcated root is a common variation than the maxillary canine root

Size : It is shorter by 1 to 2 mm

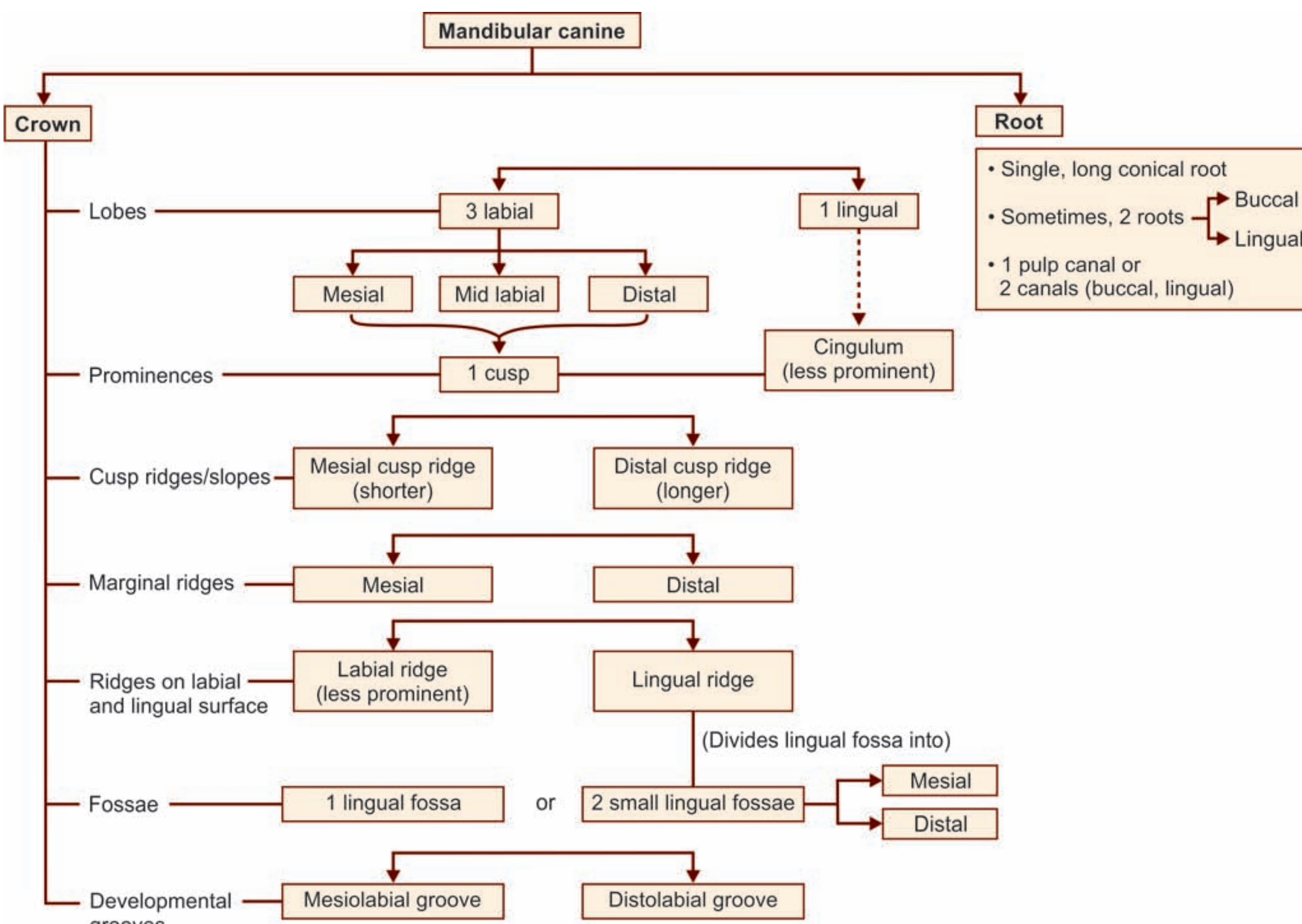
Form : The root is thinner mesiodistally and its lingual surface is more narrower than that of maxillary canine. The developmental depression is more deeper on mesial surface of the root

Apex : Mandibular canine has a more pointed root tip

Curvature : The root is usually straight and sometimes shows mesial curvature at its apical third.

Figures 9.21A to C Mandibular canine with bifurcated root

Flow chart 9.3 Mandibular canine—major anatomic landmarks



Flow chart 9.4 Mandibular canine—summary

Mandibular canine

Crown

Labial aspect

Geometric form
- Trapezoidal

Crown outlines
- Mesial—a straight line in line with mesial outline of root
- Distal—slightly convex

Height of mesial and distal contours/contact areas
- Mesial—at incisal 3rd near mesioincisal angle
- Distal—cervical to mesial contact area

Cusp ridges/slopes
- Mesial—shorter
- Distal—longer

Cusp and labial ridge
- Less prominent than maxillary canine

Labial surface
- Crown appear longer
- Crown appear tilted distally on root base due to straight mesial outline of crown and root

Lingual aspect

- Trapezoidal

Lingual convergence
- Crown tapers lingually

Cingulum
- Less prominent
- Poorly developed

Marginal ridges
- Less prominent

Lingual fossa
- Shallow
- Lingual surface less concave like that of mandibular lateral incisor

Lingual ridge
- Less prominent
- Divide lingual fossa into 2 small fossae

Mesial aspect

- Triangular/wedge

Crown outlines
- Labial—less convex
- Lingual—less concave lingual fossa and less convex cingulum

Cusp tip
- Thin, pointed

Cusp tip position
- Is in center or lingual to the vertical root axis
- Crown shows lingual inclination over root base

Mesial contact area
- At cervical 3rd near mesioincisal angle

Distal aspect

- Triangular/ wedge

Crown outlines
- Similar to mesial aspect except that
- Cervical line is less curved

Distal contact area
- Positioned cervically than the mesial

Incisal aspect

- Oval

Cingulum
- Smaller

Lingual fossa
- Shallow

Cusp ridges
- Curved lingually and not straight as in maxillary canine

Cusp tip
- Positioned lingually

Root

Number
- Single

Pulp canal
- Single

Size
- Long root

Form
- Conical, wider buccolingually

VARIATIONS (FIGS 9.21A TO C)

- Bifurcation of the root
- long root
- short root.

CLINICAL CONSIDERATIONS

- The mandibular canine along with the maxillary canine establishes *canine guidance*.
- The relationship of maxillary canine to mandibular canine is an important consideration while classifying malocclusions.
- Frequent bifurcation of roots should be considered during root canal therapy.

Box 9.2 Mandibular canine—identification features

Identification features of mandibular canine
- The mandibular permanent canine has a long and narrow crown with a sharp cusp
- The labial ridge and cingulum are less prominent
- The distal cusp slope is longer than the mesial
- The crown appears to be tilted distally on the root base
- The root is long and narrow
- When viewed proximally, the cusp tip is lingual to the root axis line

Side identification
- The distal cusp slope is longer
- Developmental depression on the mesial surface of the root is deeper
- Viewed, labially the mesial outline is straight and distal outline is rounded

Flow charts 9.3 and 9.4 give brief summary of mandibular canine morphology. **Box 9.2** lists the tooth's identification features.

BIBLIOGRAPHY

1. Babacan H, Kiliç B, Biçakçi A. Maxillary canine-1st premolar transposition in the permanent dentition. Angle Orthod. 2008;78(5):954-60.
2. Bedoya MM, Park JH. A review of the diagnosis and management of impacted maxillary canines. J Am Dent Assoc. 2009;140(12):1485-93.
3. Bishara SE. Impacted maxillary canines: A review. Am J Orthod Dentofac Orthoped 1992;101(2):159-71.
4. Peck L, Peck S, Attia Y. Maxillary canine-1st premolar transposition, associated dental anomalies and genetic basis. Angle Orthod. 1993;63(2):99-109.
5. Segura JJ, Hattab F, Ríos V. Maxillary canine transpositions in two brothers and one sister: associated dental anomalies and genetic basis. ASDC J Dent Child. 2002;69(1): 54-8,12.

MULTIPLE CHOICE QUESTIONS

1. Synonyms of maxillary permanent canine are followings, except:
   a. Beauty tooth
   b. Corner stone of dental arch
   c. Cuspids
   d. Canivos teeth
2. The maxillary permanent canines are named because they:
   a. Closely resemble the tearing teeth of carnivores, especially those of dogs
   b. Are corner stones of arches
   c. Are four in number
   d. Are having longest roots
3. The maxillary permanent canine develops from:
   a. 2 lobes
   b. 3 lobes
   c. 4 lobes
   d. 5 lobes
4. Which of the following statement is false?
   a. The maxillary permanent canine has longest and strongest roots of all teeth
   b. The maxillary permanent canines are six in number
   c. The maxillary permanent canines are also called as cuspids
   d. Roots of maxillary permanent canines have excellent anchorage in the alveolar bone with an extra length and wider labiolingual width
5. The term *canine eminence* refers to:
   a. Alveolar bone over the roots of maxillary permanent canines, labially, is prominent and or is prominent labial alveolar bone over the roots of maxillary permanent canines
   b. Prominent lingual alveolar bone over the roots of maxillary permanent canines
   c. Least prominent labial alveolar ridge/bone over the roots of maxillary permanent canines
   d. Least prominent labial alveolar ridge/bone over the roots of maxillary permanent canines
6. Following are the functions of maxillary permanent canines, except:
   a. They assist permanent incisors and premolars in mastication
   b. They are mainly used for tearing food
   c. They help in seizing, slicing and chewing food
   d. They are esthetically not important
7. The characteristics of maxillary permanent canines are:
   a. Maxillary permanent canines exhibit some of the characteristics of maxillary permanent incisors
   b. Maxillary permanent canines exhibit some of the characteristics of permanent premolars
   c. Maxillary permanent canines exhibit longest root of all
   d. All of the above
8. The shape of the crown of maxillary permanent canine from the labial aspect is:
   a. Trapezoidal
   b. Pentagonal
   c. Hexagonal
   d. Both a and b
9. The mesial outline of the crown of maxillary permanent canine from the labial aspect is:
   a. Convex arc from cervix to the area where it joins the mesial cusp slope
   b. Concave arc from cervix to the area where it joins the mesial cusp slope
   c. Straight from cervix to the area where it joins the mesial cusp slope
   d. None of the above
10. The minimum convexity of the mesial outline of maxillary permanent canine from the labial aspect lies at:
    a. The junction of cervical and middle third of the crown
    b. The junction of incisal and middle third of the crown
    c. At the cervical third
    d. Near the gingival margin.

Answers

1. d	2. a	3. c	4. b	5. a	6. d	7. d	8. d	9. a	10. c

CHAPTER

10

The Permanent Maxillary Premolars

There are four permanent premolars; four in each dental arch and two in each quadrant. The premolars are named so since they are located anterior to the molars in the permanent dentition (**Fig. 10.1**). *There are no premolars in deciduous dentition* and they *succeed deciduous molars*. Premolars along with molars occupy posterior segments of dental arches and are collectively referred to as 'posterior teeth'.

Premolars are often also called as 'bicuspids' suggestive of having two cusps. However, the mandibular 1st premolar has only one functional cusp and the mandibular 2nd premolar frequently has three cusps. Moreover, the premolar teeth in carnivorous animals exhibit varied occlusal anatomy and thus precluding the usage of 'bicuspid' term. Hence the term premolar is generally preferred in both dental and comparative anatomy.

The premolars develop from four lobes except the mandibular 2nd premolar which develops from five lobes. They have two cusps except for mandibular 2nd premolar which frequently has three cusps. They have single root except the maxillary 1st premolar which has two roots: buccal and lingual.

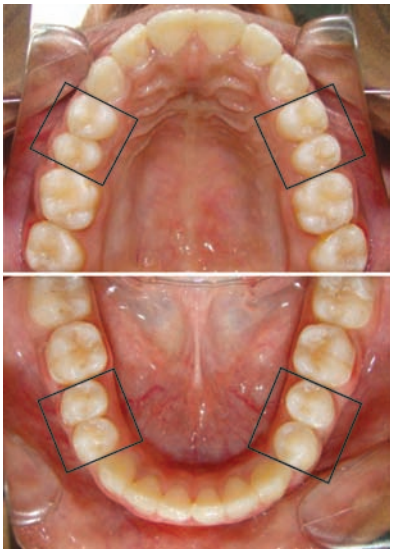


Figure 10.1 'Premolars' are situated anterior to the molars. They together with the molars form the posteriors of the dental arch

FUNCTIONS

- 1st premolars with their sharp cusps assist canines in tearing the food
- They grind the food along with molars
- Provide support to cheek near corners of mouth
- They reinforce esthetics during smiling.

COMMON CHARACTERISTICS (CLASS TRAITS) OF PREMOLARS

- The premolars develop from four lobes with an exception of the mandibular 2nd premolar which develops from five lobes
- All premolars have single root except maxillary 1st premolars which are frequently bifurcated
- They generally have two cusps, one buccal and one lingual except for mandibular 2nd premolars which often carry three cusps
- Their buccolingual dimension is greater than the mesiodistal dimension
- The contact areas are broader than that of the anterior and are placed nearly at the same level. Contact areas are buccal to center of the crowns buccolingually
- Crests of buccal and lingual contours are more occlusal than seen on anterior teeth
- Marginal ridges are at a higher level (occlusally placed) mesially than distally. Exception is in case of mandibular 1st premolar where the distal marginal ridge is more occlusally placed than mesial marginal ridge.

MAXILLARY PERMANENT 1ST PREMOLAR

The maxillary permanent 1st premolar has two cusps: buccal and lingual and frequently has two roots. Sometimes, it can have a single root with two pulp canals. The buccal cusp is longer than the lingual cusp by 1 mm. The tooth resembles maxillary permanent canine from buccal aspect, but with a shorter crown and root. The crown is angular with prominent buccal line angles.

The maxillary permanent 1st premolar develops from four lobes: three buccal lobes forming the buccal cusp and a single lingual lobe forming the lingual cusp. The chronology and measurements of the maxillary 1st premolar is given in **Table 10.1**.

DETAILED DESCRIPTION OF MAXILLARY 1ST PREMOLAR FROM ALL ASPECTS

Figures 10.2 to 10.4 show maxillary 1st premolar from various aspects.

CROWN

Buccal Aspect (Fig. 10.5A)

Geometric shape: The crown of maxillary permanent 1st premolar is *trapezoidal* from buccal aspect.

Crown Outlines

Mesial Outline

- The mesial outline is slightly concave near cervical line and becomes convex as it joins the mesial cusp slope
- Height of contour of mesial outline (*mesial contact area*) is occlusal to the center of crown cervico-occlusally.

Distal Outline

- Distal outline is more straighter and meets the distal cusp slope
- Its height of contour (*distal contact area*) is broader and slightly occlusally placed than the mesial contact area.

Table 10.1 Maxillary 1st premolar—chronology and dimensions

Chronology	
First evidence of calcification	1½–1¾ years
Enamel completed	5–6 years
Eruption	10–11 years
Roots completed	12–13 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	8.5
Length of root	14.0
Mesiodistal diameter of crown	7.0
Mesiodistal diameter of crown at cervix	5.0
Buccolingual diameter of crown	9.0
Buccolingual diameter of crown at cervix	8.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

Occlusal Outline

- Occlusal outline is formed by the cusp tip and cusp slopes of the buccal cusp
- Mesial cusp slope is straight or sometimes concave whereas distal cusp slope is more rounded

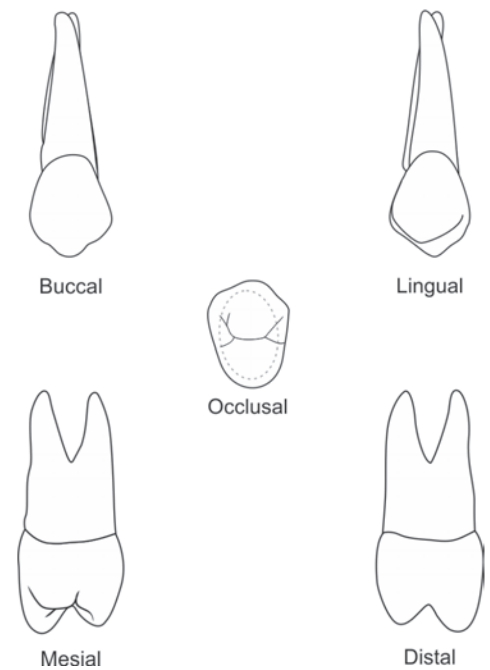


Figure 10.2 Maxillary right 1st premolar—line drawings

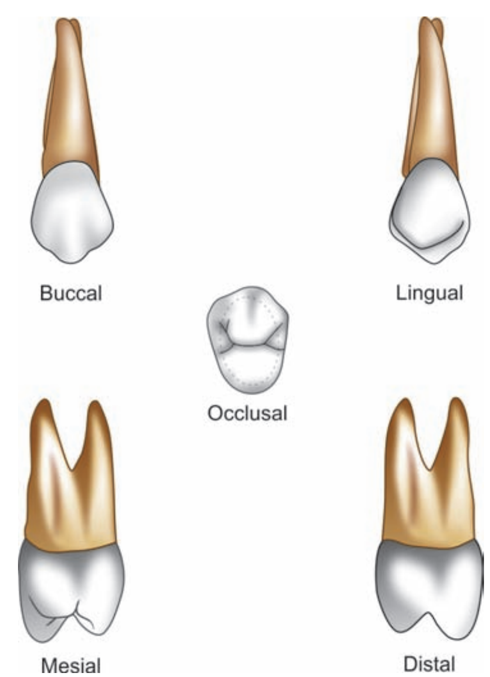
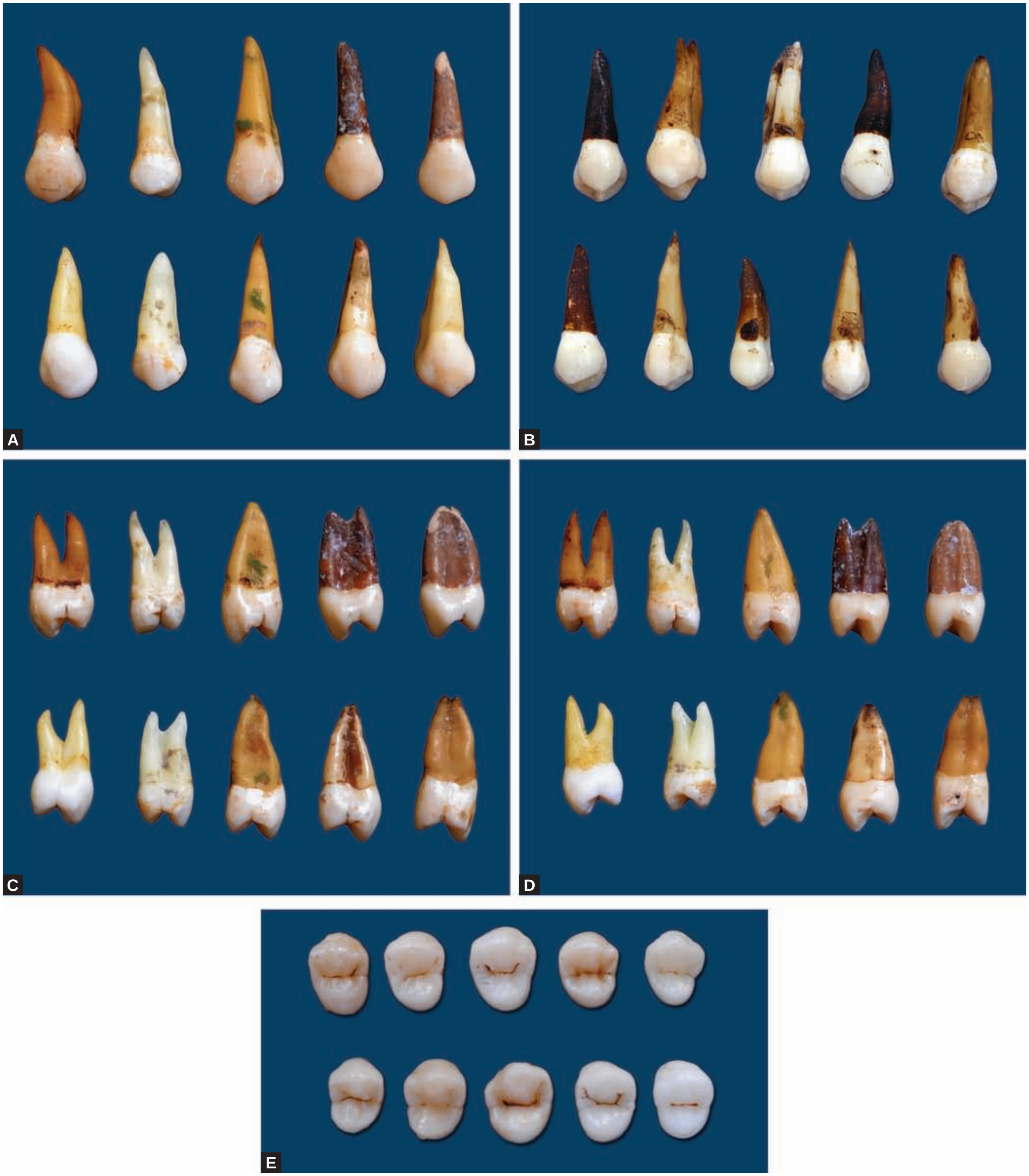
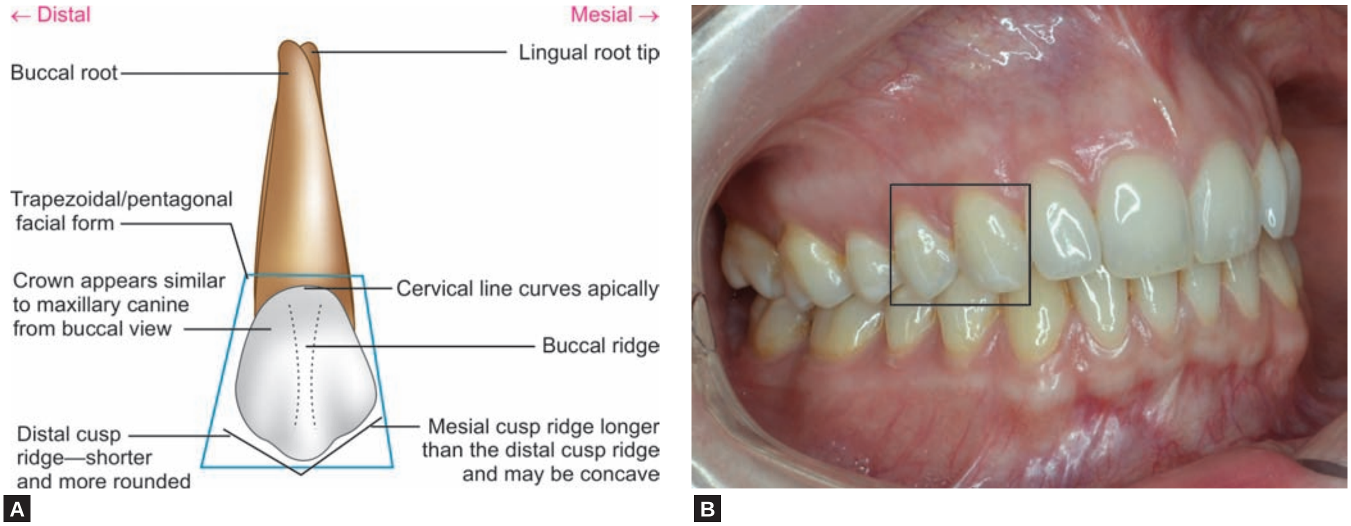


Figure 10.3 Maxillary right 1st premolar—graphic illustrations



Figures 10.4A to E Maxillary 1st premolar—typical tooth specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect



Figures 10.5A and B (A) Maxillary 1st premolar—buccal aspect; (B) Maxillary 1st premolar appears similar to the maxillary canine but with shorter and narrower crown

- Mesial slope is longer than the distal slope (It can be remembered that distal cusp slope is generally longer in other teeth).

Cervical Outline
Cervical line slightly curves towards the root apex.

Buccal Surface within the Outlines

- Tooth appears similar to maxillary canine from buccal aspect but the crown is shorter and narrower than that of maxillary canine (**Fig. 10.5B**).
- The middle buccal lobe is strongly developed than the other lobes and forms a continuous ridge from cusp tip to cervix called 'buccal ridge'.
- The buccal surface is convex except the developmental depressions on either side and buccal ridge demarcating the three lobes.

Lingual Aspect (Fig. 10.6)

Geometric shape: *Trapezoidal* like labial aspect:

Crown Outlines

- *Mesial outline*
- *Distal outline*
- *Cervical outline*

} are similar to buccal aspect

Occlusal Outline
- Lingual cusp is pointed with its cusp slopes meeting at right angles
- Buccal cusp tip with its cusp slopes are seen because of a shorter lingual cusp.

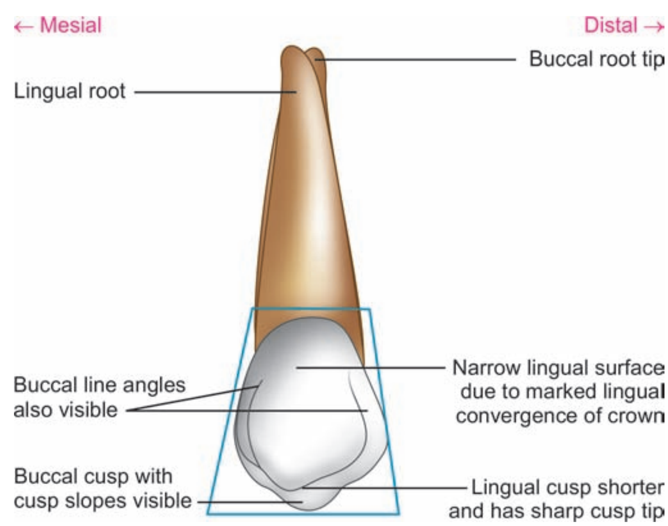


Figure 10.6 Maxillary 1st premolar—lingual aspect

Lingual Surface within the Outlines

- Lingual surface is narrower than buccal surface as the proximal walls converge towards smaller lingual cusp
- Lingual surface is smooth and more convex
- Sometimes there can be lingual ridge
- The lingual line angle are not as prominent as buccal line angles.

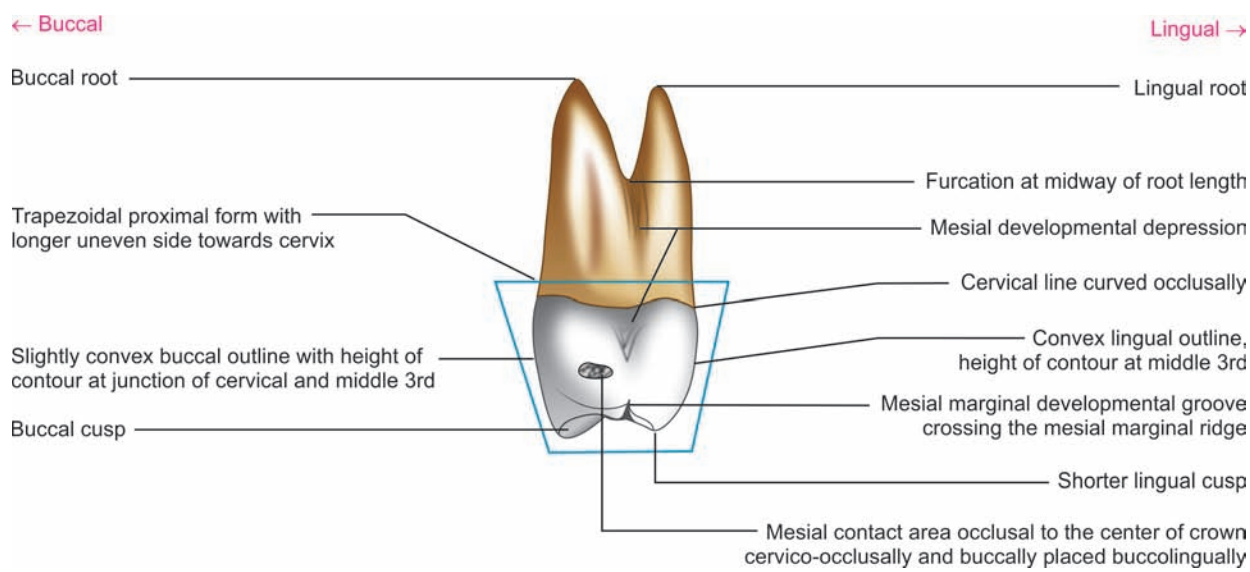


Figure 10.7 Maxillary 1st premolar—mesial aspect

Mesial Aspect (Fig. 10.7)

Geometric shape: The proximal aspects of all maxillary posteriors have a *trapezoid* outline with the longest of uneven sides towards cervical portion and shortest of uneven sides towards occlusal portion.

Crown Outlines

Buccal Outline

- Buccal outline is convex near cervix and become straight as it reaches the buccal cusp tip
- Height of contour of buccal outline is at the junction of cervical and middle third.

Lingual Outline

- Lingual outline is a more convex arc from cervical line to the tip of lingual cusp
- Its height of contour is at the center of middle third.

Occlusal Outline

- Occlusal outline is formed by mesial marginal ridge which is slightly concave
- The triangular ridges of buccal and lingual cusp are also seen converging cervically toward the center of occlusal surface.

Cervical Outline

The cervical line is slightly curved occlusally.

Mesial Surface within the Outlines

- Mesial surface shows both the cusps and the cusp tips are well within the confines of the root trunk.
- The lingual cusp is shorter than the buccal cusp by 1 mm or more.
- A marked concavity located in the center of the mesial surface, cervical to the contact area is called as *mesial developmental depression*. This concavity extends apically crossing the cervical line and joins the developmental depression between the two roots.
- There is a deep developmental groove crossing the mesial marginal ridge called *mesial marginal developmental groove*. This groove runs from occlusal surface and crosses the marginal ridge lingual to the mesial contact area to end on the mesial surface after running for a short distance.
- *Mesial marginal developmental depression and mesial developmental groove* are the identifying features of maxillary permanent 1st premolar, and help to differentiate the tooth from maxillary permanent 2nd premolar.
- The *mesial contact area* is occlusal to the center of crown cervico-occlusally and more buccally placed buccolingually.

Distal Aspect (Fig. 10.8)

Geometric shape: *Trapezoidal* like mesial aspect.

Crown Outlines

The distal aspect of maxillary permanent 1st premolar has four outlines:

- *Mesial outline*
- *Distal outline*
- *Occlusal outline*

} are similar to mesial aspect

Cervical Outline

The cervical line on the lingual surface is straight rather than curving occlusally.

Distal Surface within the Outlines

- The distal surface is generally convex
- The distal marginal ridge is smooth devoid of any grooves
- *Distal contact area* is at the same level as mesial contact area but is more broader and more buccally placed buccolingually.

Occlusal Aspect (Figs 10.9A and B)

Geometric shape: Occlusal aspect of this tooth has a *hexagonal shape with unequal sides.*

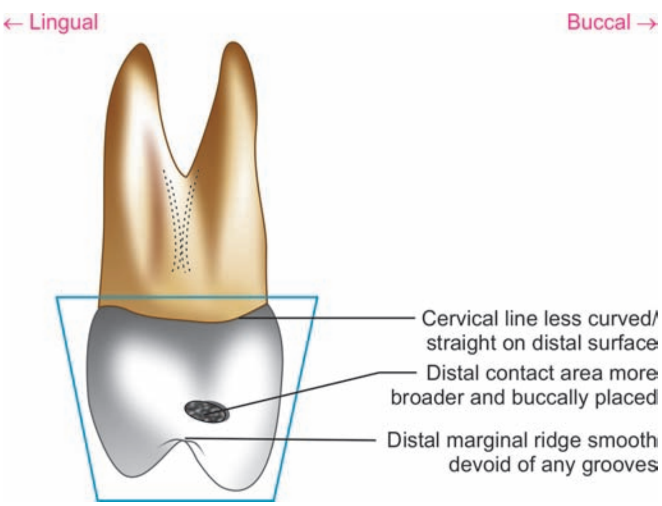


Figure 10.8 Maxillary 1st premolar—distal aspect

The six sides in clockwise direction are:
1. Mesiobuccal
2. Mesial
3. Mesiolingual
4. Distolingual
5. Distal
6. Distobuccal.

The mesiobuccal side is slightly shorter than the distobuccal side and mesiolingual side is much more shorter than the distolingual side.

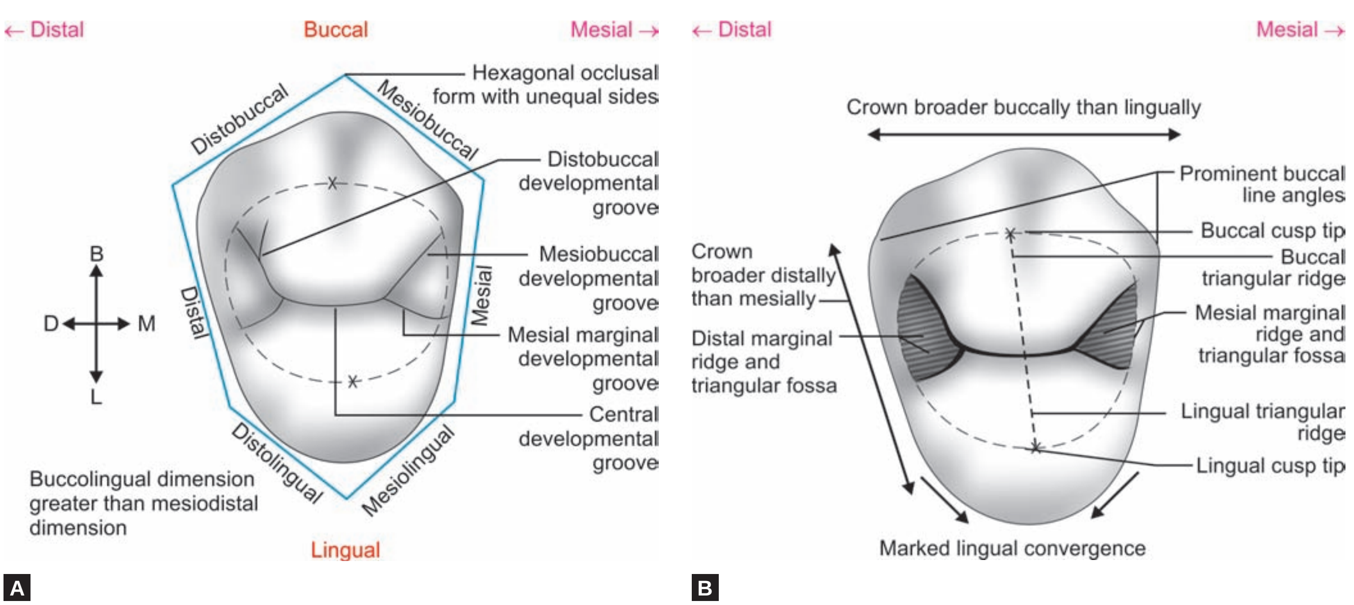
Relative Dimensions

- From occlusal aspect it is easily noted that the buccolingual dimension is greater than mesiodistal dimension.
- The crown is wider buccally than lingually.

Position of Cusp Tips and Contact Area Extensions
- The *buccal cusp* is placed slightly distal to the midline.
- The *lingual cusp* tip is located mesial to the midline.
- Distal contact area is more bucally placed than the mesial contact area.

Boundaries of Occlusal Surface

- The occlusal surface is bounded by:
  - Mesial and distal cusp ridges of buccal and lingual cusps
  - Mesial and distal marginal ridges
- Distobuccal cusp ridge is more bucally placed.
- Mesiobuccal cusp ridge meets the mesial marginal ridge at right angles whereas the angle formed by distobuccal cusp ridge with distal marginal ridge is acute.



Figures 10.9A and B Maxillary 1st premolar—occlusal aspect

- Mesial and distal marginal ridges converge towards lingual cusp.

Occlusal Surface within Boundaries
- Cusps and cusp ridges
- Grooves and pits
- Marginal ridges and fossae.

Cusps and Cusp Ridges

Buccal Cusp
- Among the two cusps, the buccal cusp is longer and well-formed
- *Mesiobuccal and distobuccal cusp ridges* are well-defined and make a relatively straight line
- *Buccal triangular ridge* is well-defined extending from buccal cusp tip lingually up to the central developmental groove in the center of the occlusal surface
- Buccal cusp has inclined planes on either side of the triangular ridge sloping towards the central groove.

Lingual Cusp
- The lingual cusp is smaller and shorter than the buccal cusp
- *Mesiolingual and distolingual cusp ridges* are more curved and form a semicircular outline merging with the marginal ridges
- A less prominent *lingual triangular ridge* extends from lingual cusp tip to the central groove
- These are inclined planes on either side of triangular ridge.

Grooves and Pits

Grooves: There are four major grooves:
1. Central groove.
2. Mesiobuccal groove.
3. Distobuccal groove.
4. Mesial marginal developmental groove.

- The *central developmental groove* running in a mesiodistal direction divides the occlusal surface evenly. This groove is at the bottom of central sulcus.
- Two small grooves join the central groove near mesial and distal marginal ridge buccally. These are called *mesiobuccal* and *distobuccal developmental grooves.*
- The *mesial marginal developmental groove* extends from the central groove mesially and crosses the mesial marginal ridge to reach the mesial surface. This is the important identifying feature of maxillary 1st premolar.

Pits: There are two pits:
1. Mesial
2. Distal.

- *Mesial pit* is formed by convergence of:
  - Central developmental groove
  - Mesiobuccal developmental groove
  - Mesial marginal developmental groove.
- *Distal pit* is formed by convergence of:
  - Central developmental groove
  - Distobuccal developmental groove.

Marginal Ridges and Fossae

Marginal Ridges
- There are two marginal ridges.
  1. Mesial
  2. Distal.
- *Mesial marginal ridge* is notched by mesial marginal developmental groove
- *Distal marginal ridge* is smooth.

Fossae

There are two triangular fossae:
- *Mesial triangular fossa* is a small triangular depression with mesial marginal ridge forming the base and mesial pit forming the apex of the triangle
- Mesial marginal groove runs across mesial triangular fossa
- *Distal triangular fossa* is a shallower triangular depression with distal marginal ridge forming the base and distal pit forming the apex of the triangle.

ROOT

- *Number*: Maxillary 2nd premolar is the only premolar which generally has two roots, buccal and lingual. Not uncommonly, premolar can also have a single root but with two pulp canals.
- *Size*: The root is shorter than that of maxillary canine and of same length as maxillary molar roots. Both buccal and lingual roots are of nearly same length.

Root Form

Two Root Form

- Bifurcated root has a root trunk (undivided part of the root) and two branches: buccal and lingual.
- The root is narrow and convex mesiodistally broader and flattened buccolingually.
- The root is bifurcated for half its length and its bifurcation point is more nearer to cervical line on mesial aspect
- From bifurcation point, the two roots diverge outwards and later their apical ends converge to face each other.
- Developmental depression and groove is prominent on the mesial surface of the root.

Single root form: The single root often shows deep developmental grooves and has two pulp canals

Apex: Buccal root apex is sharp and distal root has a blunt apex

Curvature: The roots may show distal curvature at their apical ends.

VARIATIONS (FIG. 10.10A)

Maxillary permanent 1st premolar may shows following variations:

- Single root (commonly seen)
- Short root
- Long root.

DEVELOPMENTAL ANOMALIES (FIG. 10.10B)

Dens evaginatus/Leong's premolar.

CLINICAL CONSIDERATIONS

- Maxillary and mandibular 1st premolars are the most common teeth to undergo therapeutic extraction for orthodontic treatment purposes.
- Transposition of teeth often involves maxillary canine and maxillary premolar.

Anatomy of maxillary 1st premolar is summarized in **Flow charts 10.1 and 10.2**. **Box 10.1** gives the identification features of the tooth.

MAXILLARY PERMANENT 2ND PREMOLAR

The maxillary 2nd premolar closely resembles maxillary 2nd premolar and assists the latter in function. When compared to maxillary 2nd premolar, it is less angular, exhibits a more rounded appearance and has two cusps of nearly same size (**Fig. 10.11**).

The maxillary permanent 2nd premolar is more variable in its size and has a single root. However, average dimensions of both the premolars are same (**Table 10.2**).

DETAILED DESCRIPTION OF MAXILLARY 2ND PREMOLAR FROM ALL ASPECTS

Figures 10.12 to 10.14 show maxillary 2nd premolar from various aspects.

CROWN

The crown of maxillary permanent 2nd premolar has five aspects:

1. Buccal
2. Lingual
3. Mesial
4. Distal
5. Occlusal

Buccal Aspect (Fig. 10.15)

Geometric shape: Buccal aspect of maxillary permanent 2nd premolar has a *trapezoidal* form, with shorter uneven side towards the cervix.

Crown Outlines

The maxillary permanent 2nd premolar is similar to that of maxillary permanent 1st premolar except some features.

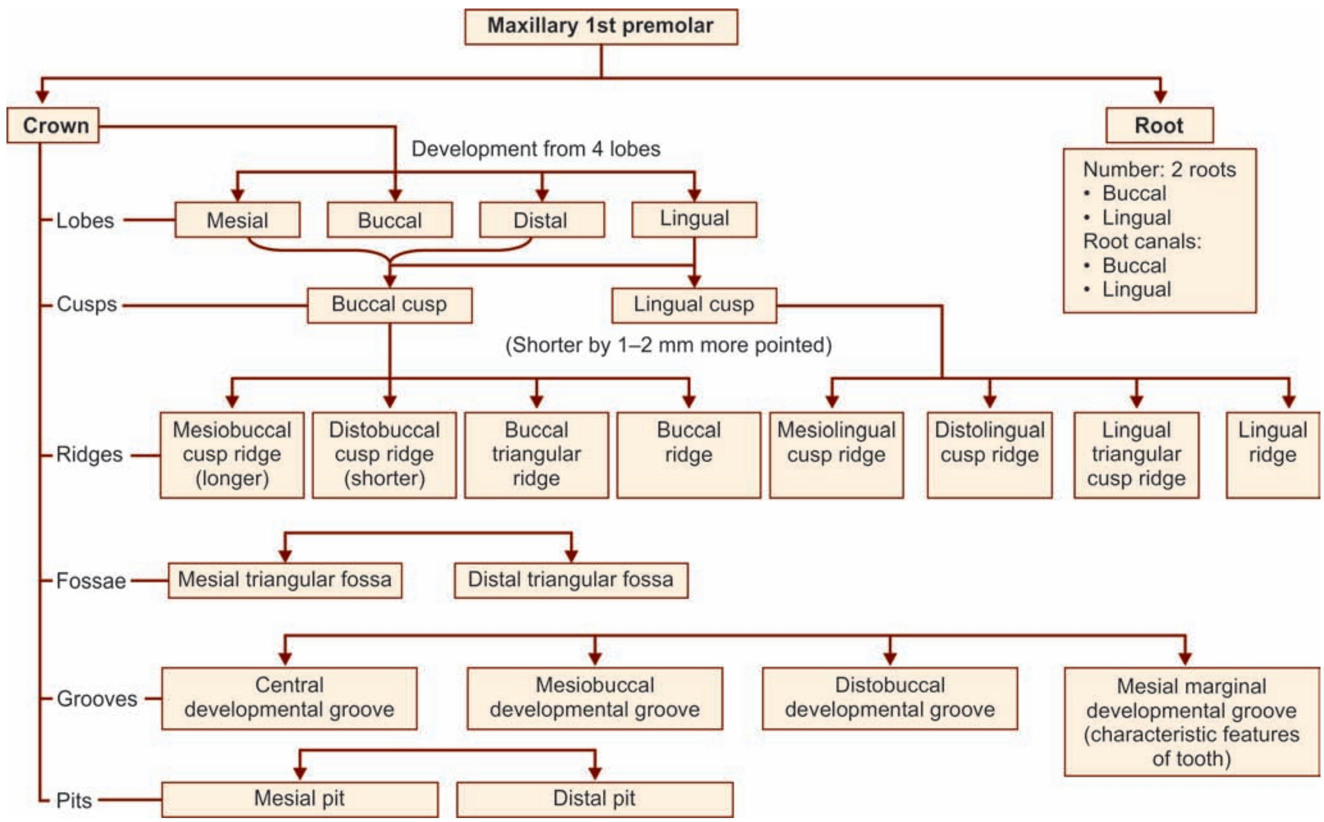
Mesial outline: It is slightly convex from cervix to the point where it joins the mesial slope of the buccal cusp.

Distal outline: It is more convex than the mesial outline.

Cervical outline: On buccal aspect it is slightly convex and curves in an apical direction.

Figures 10.10A and B (A) Maxillary 1st premolar—variations; (B) Dens evaginatus/Leong's premolar

Flow chart 10.1 Maxillary 1st premolar—major anatomic landmarks



Occlusal Outline

- The tip of the buccal cusp is less pointed than that of maxillary permanent 1st premolar
- Distal slope of buccal cusp is longer than the mesial slope. This feature is similar in all the permanent canines and premolars. One exception is maxillary 1st premolar in which the mesial slope is longer than the distal slope.

Buccal Surface within the Outlines

- The tooth is thicker at cervical portion than the maxillary permanent 1st premolar
- Its buccal ridge is not as prominent as that of maxillary permanent 1st premolar
- The buccal surface is generally convex.

Lingual Aspect (Fig. 10.16)

Geometric shape: *Trapezoidal* like buccal aspect.

Crown Outlines

- *Mesial and distal outlines* are similar to that seen from buccal aspect.
- *Cervical outline*—the cervical line is less curves apically on lingual aspect.

Occlusal Outline

- Lingual cusp tip and its cusp slopes form the occlusal outline
- As the lingual is nearly as long as the buccal cusp, only a part of buccal profile may be seen.

Lingual Surface within the Outlines

Lingual surface appears broader and longer than that of maxillary permanent 1st premolar.

Mesial Aspect (Fig. 10.17)

Geometric shape: Mesial aspect has *trapezoidal* form with longest of the uneven sides towards cervical portion and shortest of uneven sides towards occlusal portion.

Crown Outlines

Buccal and lingual outlines are convex from cervix to the respective cusp tips.

Flow chart 10.2 Maxillary 1st premolar—summary

Maxillary 1st premolar

Crown

Buccal aspect

Geometric shape
- Trapezoidal with shorter uneven side towards cervix

Crown outlines
- Mesial—concave near cervix
- Distal—straight/convex

Height of mesial and distal contours/contact areas
- Mesial—at center of crown
- Distal—occlusally placed than mesial

Cusp ridges/slopes
- Mesial cusp ridge—longer and concave
- Distal cusp ridge—shorter and rounded

Buccal cusp
- Well-developed

Buccal ridge
- Prominent
- Runs from cervix to cusp tip

Buccal surface
- Smooth, convex
- Developmental of depressions on either side of buccal ridge

Lingual aspect

- Trapezoidal like buccal aspect

Lingual convergence
- Crown tapers markedly towards smaller lingual cusp

Lingual cusp
- Shorter
- Smaller

Buccal cusp visibility
- Buccal cusp tip and slopes also seen due to shorter lingual cusp

Lingual ridge
- Sometimes seen
- Less prominent

Lingual surface
- Narrower
- Smooth, more convex

Mesial aspect

- Trapezoidal with shorter of uneven sides towards occlusal surface

Cusps seen
- Both cusps visible

Crown outlines
- Buccal—convex
- Lingual—more convex

Height of contours
- Buccal—at cervical and middle 3rd
- Lingual—at center of middle 3rd

Mesial surface
- Cusp tips within confines of root trunk
- Marked concavity present, extending onto root trunk

Mesial developmental depression
- Marked depression cervical to contact area

Mesial marginal developmental groove
- Unique identifying feature
- Crosses mesial marginal ridge to run onto mesial surface

Distal aspect

- Trapezoidal like mesial aspect

Distal marginal ridge
- Smooth
- Devoid of developmental grooves

Distal contact area
- More buccally placed buccolingually
- Broader

Cervical line
- Straight rather than curved

Occlusal aspect

- Hexagonal with uneven sides

Relative dimensions
- Crown wider buccolingually than mesiodistally

Line angles
- Crown very angular
- Buccal line angles very prominent

Cusps
- Buccal—larger
- Lingual—smaller shorter by 1 mm

Cusp ridges
- Mesio–and disto–buccal —Well-defined, make straight line

Grooves
- Central groove
- Mesiobuccal groove
- Distobuccal groove
- Mesial marginal developmental groove

Pits
- Mesial
- Distal

Fossae
- Mesial triangular

Root

Number
- Two roots—buccal and lingual
- May be single, fused

Size
- Shorter than that of canine
- Both roots of same length

Form
- Root trunk divided for half length
- Narrow mesio-distally and broad buccolingually

Developmental depression and groove
- Deeper on mesial surface of root

Apical root curvature
- Curvature—distal

Apex
- Buccal root—sharp
- Lingual root—blunt

Box 10.1 Maxillary 1st premolar—identification features

Identification features of maxillary 1st premolar
- Tooth has two cusps, lingual cusp is shorter
- It frequently has two roots and sometimes single root with deep developmental grooves
- Mesial developmental depression on mesial surface of crown which may extend onto root surface
- Mesial marginal developmental groove is the distinguishing feature of maxillary second permanent premolar

Side identification
- Presence of mesial marginal developmental groove on the mesial side
- Deep developmental depression on mesial surface of the root

Figure 10.11 Compared to maxillary 1st premolar, the maxillary 2nd premolar is less angular with oval occlusal form, two cusps of equal size and a single root

Table 10.2 Maxillary 2nd premolar—chronology and measurements

Chronology	
First evidence of calcification	2 years
Enamel completed	6 to 7 years
Eruption	10 to12 years
Roots completed	12 to 14 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	8.5
Length of root	14.0
Mesiodistal diameter of crown	7.0
Mesiodistal diameter of crown at cervix	5.0
Buccolingual diameter of crown	9.0
Buccolingual diameter of crown at cervix	8.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

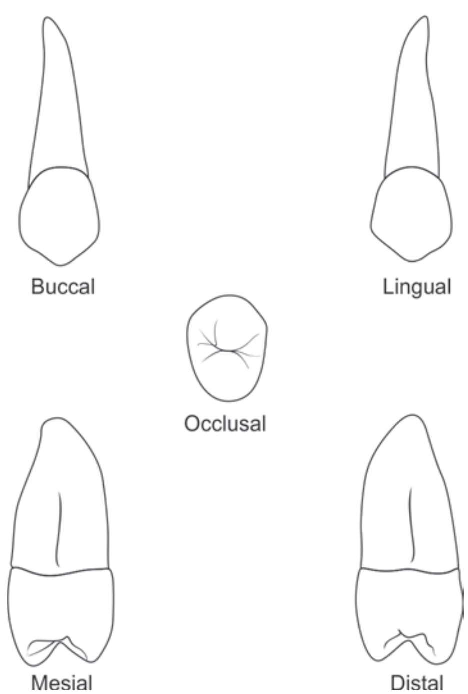


Figure 10.12 Maxillary 2nd premolar—line drawings

Occlusal Outline

- The mesial marginal ridge is horizontal to the long axis of tooth
- Buccal and lingual triangular ridges are seen inclining towards the center of occlusal surface.

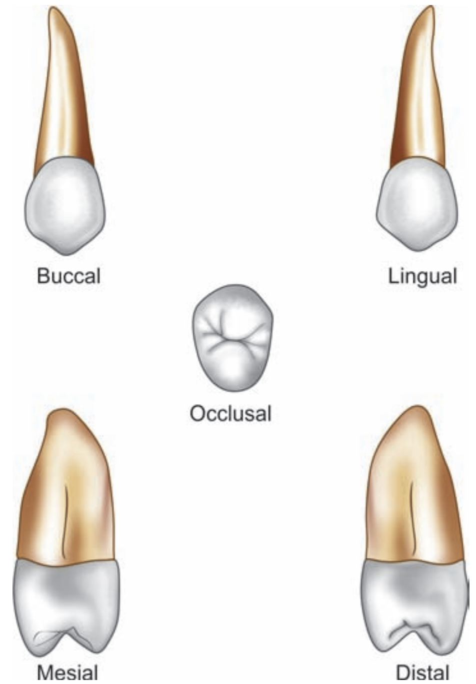


Figure 10.13 Maxillary 2nd premolar—graphic illustrations

Cervical Outline

The cervical outline is slightly curved occlusally.

Mesial Surface within the Outlines

- From mesial aspect it is noted that both buccal and lingual cusps are of the same length
- The distance between the cusp tips is wider than seen in maxillary permanent 1st premolar
- The mesial surface is smoothly convex and there is no developmental groove crossing the mesial marginal ridge
- *Mesial contact area* is broader than that of the maxillary permanent 1st premolar though located at the same level.

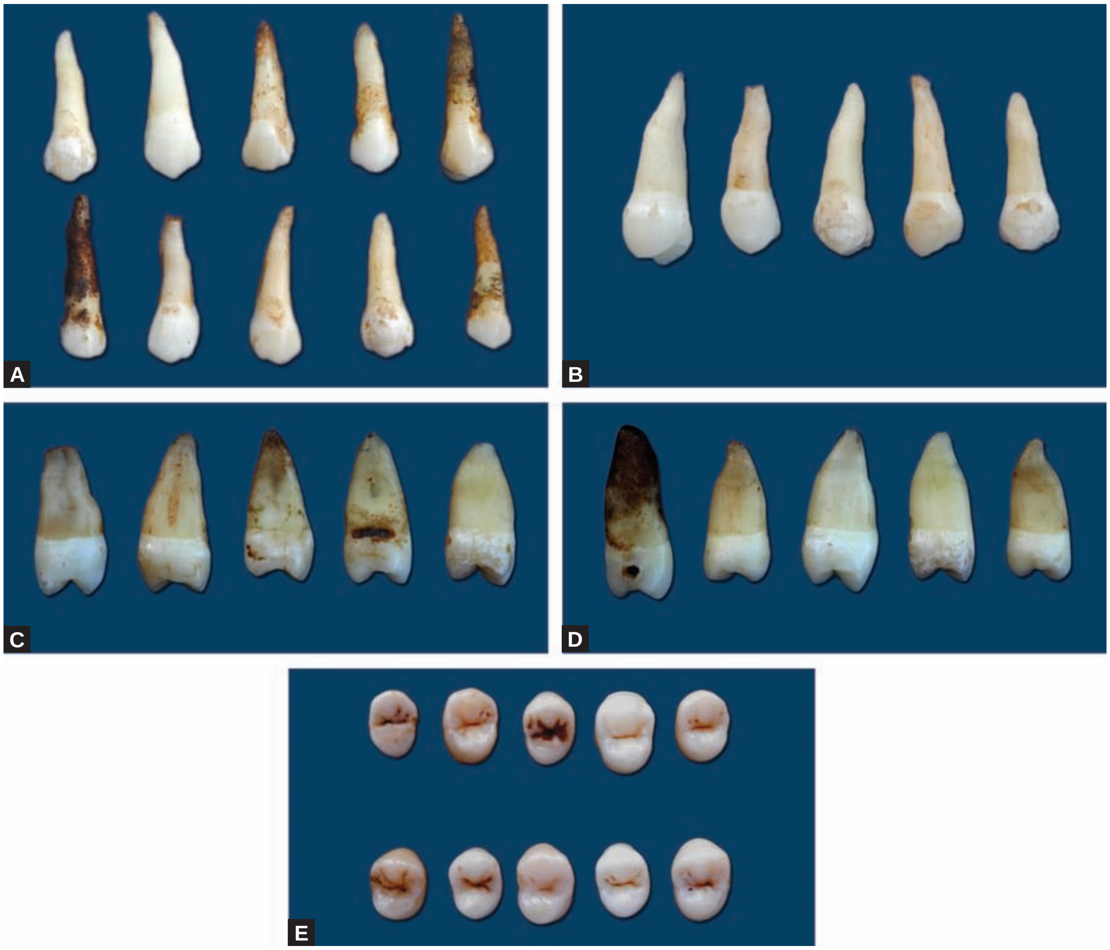
Distal Aspect (Fig. 10.18)

Distal aspect of maxillary permanent 2nd premolar is similar to mesial aspect except that the cervical line is rather straight than curved.

Occlusal Aspect (Fig. 10.19)

Geometric Shape

- The crown appears oval rather than hexagonal from occlusal aspect.
- The crown is less angular and more rounded with less prominent buccal line angles.



Figures 10.14A to E Maxillary 2nd premolar—typical tooth specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

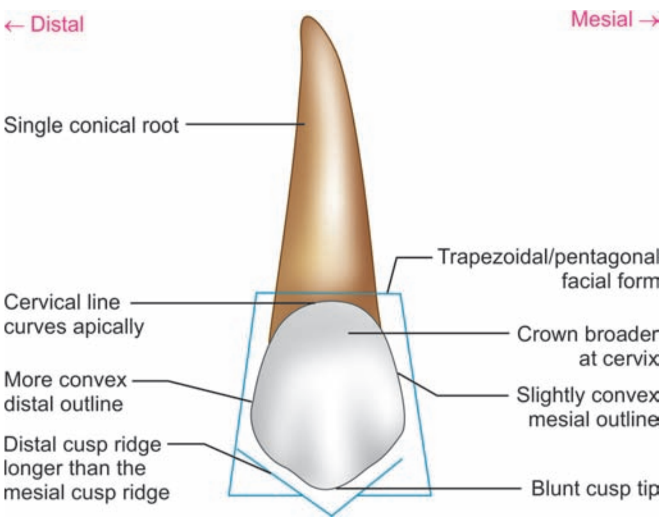


Figure 10.15 Maxillary 2nd premolar—buccal aspect

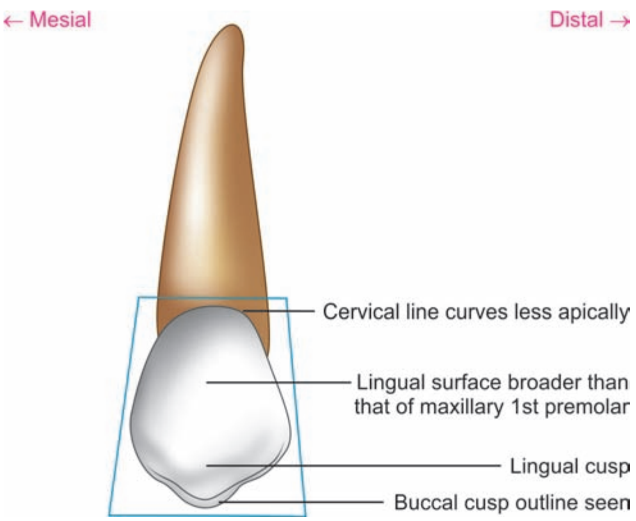


Figure 10.16 Maxillary 2nd premolar—lingual aspect

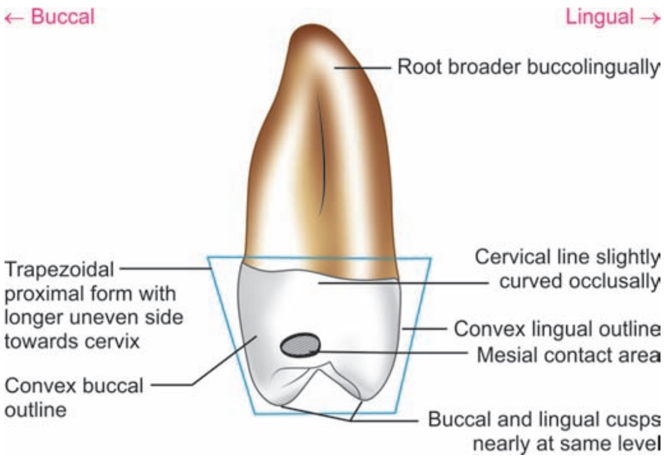


Figure 10.17 Maxillary 2nd premolar—mesial aspect

- The crown tapers lingually to a lesser extent than the maxillary permanent 1st premolar, since both buccal and lingual cusps are of similar size.

Cusps and Ridges

- Lingual cusp is as large as buccal cusp and their tips are less pointed than that of maxillary permanent 1st premolar cusps.
- Mesial and distal cusp ridges of both the cusps are less well-defined.

Grooves and Pits

Grooves

- The *central developmental groove* is shorter and irregular
- *Multiple supplementary grooves* radiate from the central developmental groove giving a *wrinkled appearance* to the occlusal surface.

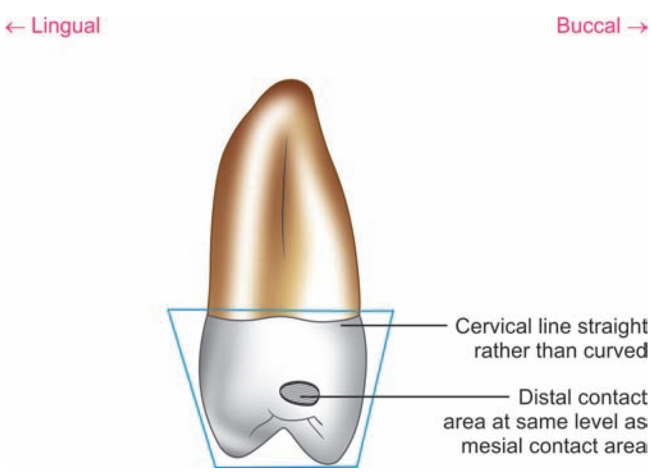


Figure 10.18 Maxillary 2nd premolar—distal aspect

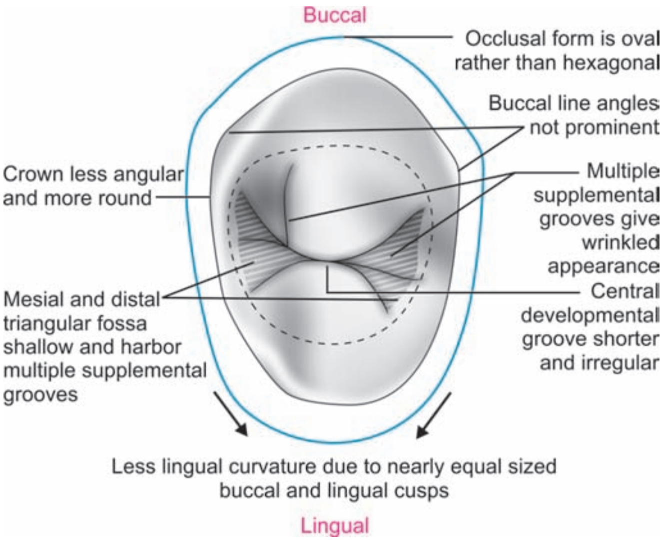
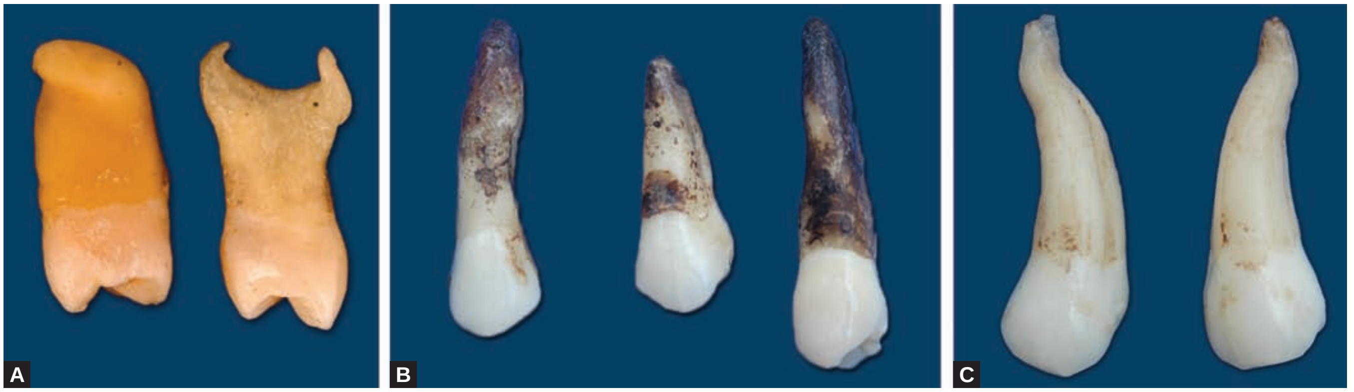


Figure 10.19 Maxillary 2nd premolar—occlusal aspect



Figures 10.20A to C Maxillary 2nd premolar—variations

Pits

The *mesial and distal pits* are placed less apart as the central developmental groove is shorter.

Marginal Ridges and Fossae

- Both mesial and distal marginal ridges are strong and well-developed.
- Mesial and distal triangular fossae are shallow and harbor supplemental grooves.

ROOT

- *Number*: Maxillary permanent 2nd premolar has a single root with a single pulp canal.
- *Size*: The root is of the same length or a little longer than maxillary permanent 2nd premolar root.
- *Form*: The root is narrow mesiodistally and broader buccolingually. It tapers evenly from cervix to the apex when viewed from buccal and lingual aspects. When viewed from proximal aspects, the apical half of the root appears to taper buccally.
- *Developmental depressions*: Developmental depression is deeper on distal surface of the root. Whereas in maxillary permanent 1st premolar the developmental depression is deeper on the mesial surface.
- *Apex*: Apex is relatively blunt
- *Curvature*: Apical third of the root may show a distal curvature.

VARIATIONS (FIGS 10.20A TO C)

- The tooth varies in its size; the crown of maxillary 2nd premolar may be smaller or bigger than the maxillary 1st premolar.
- Root may be bifurcated at its apex having two canals and two apical foramina.

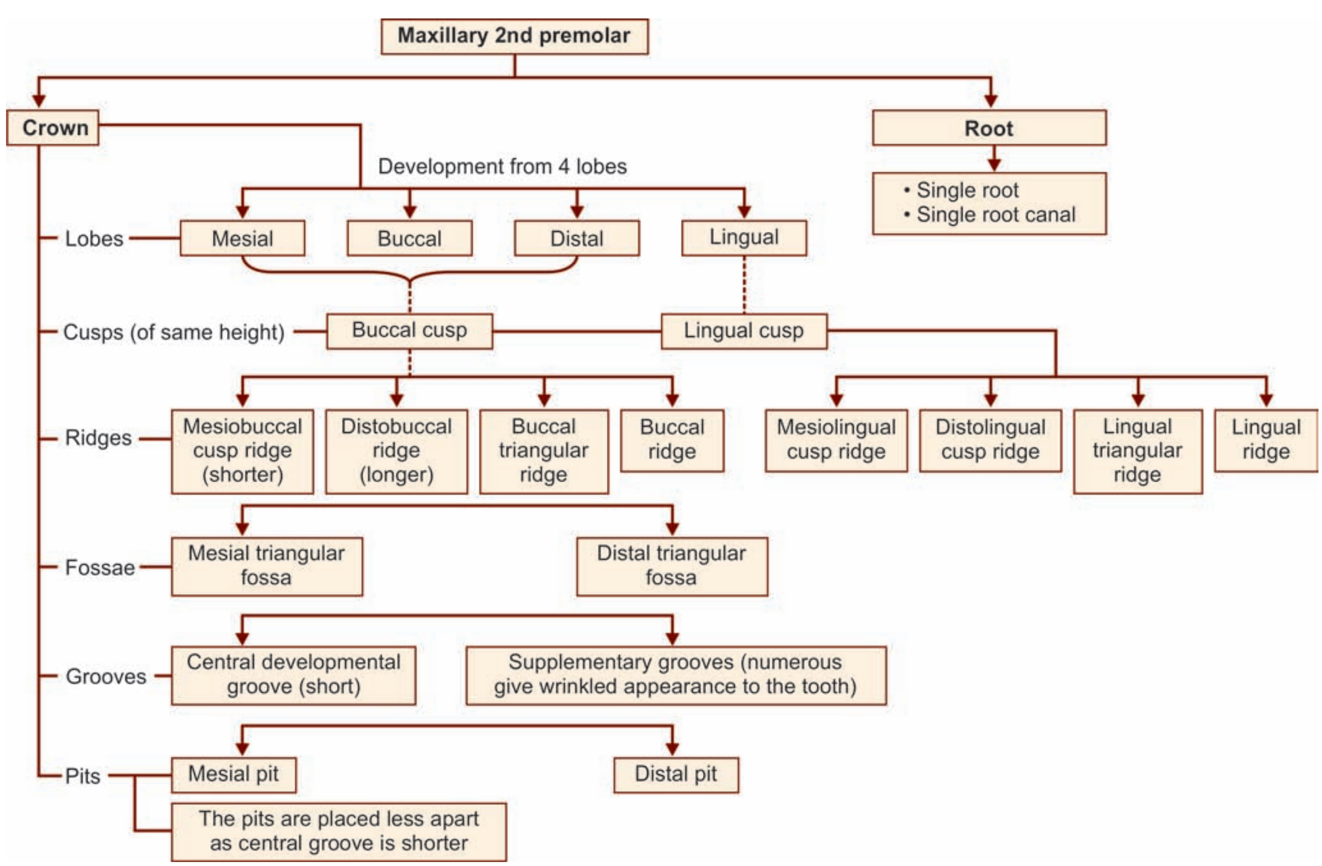
DEVELOPMENTAL ANOMALIES

- Parapremolars
- Dens evaginatus.

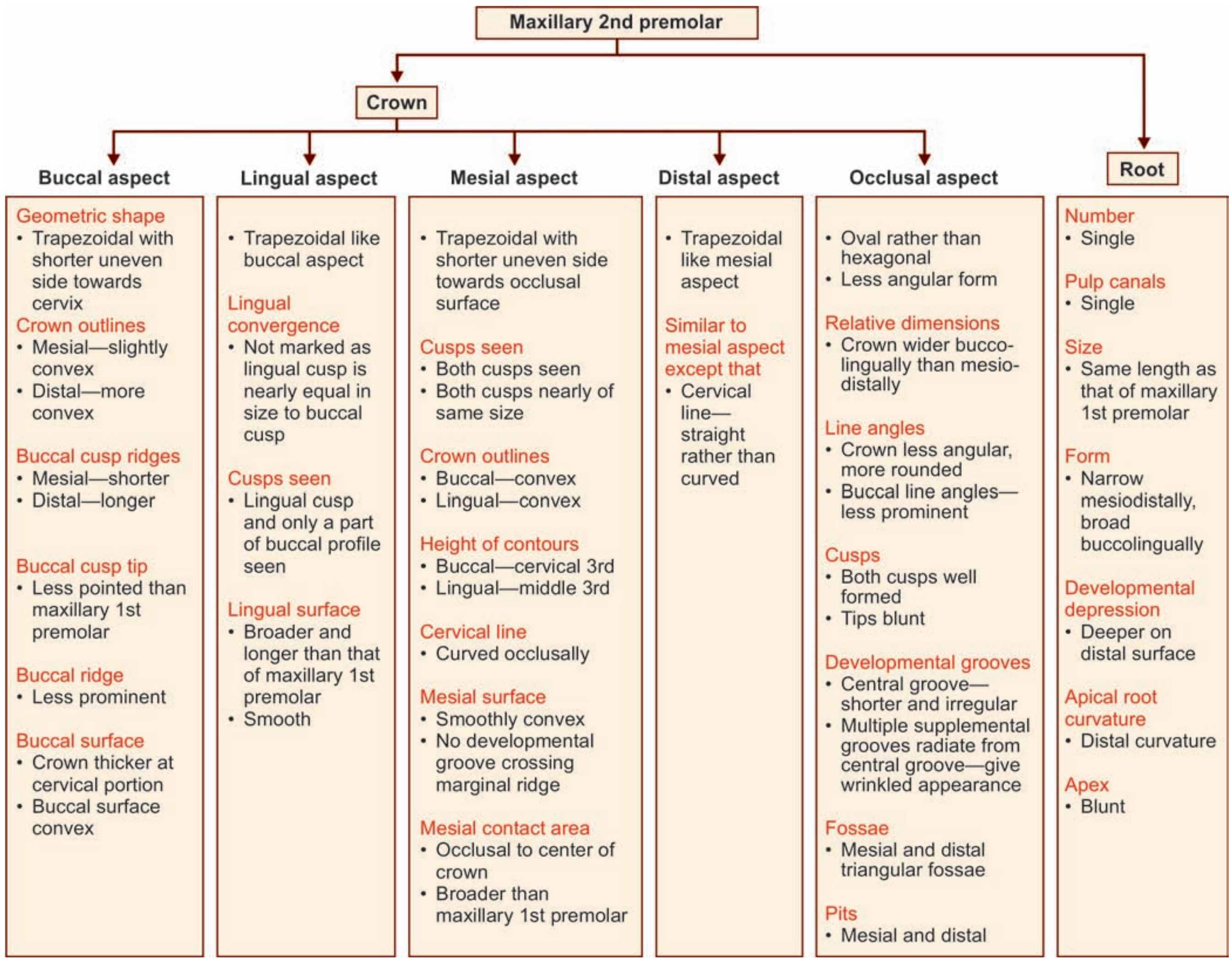
CLINICAL CONSIDERATIONS

Maxillary and mandibular 2nd premolars are sometimes therapeutically extracted during orthodontic treatment and malocclusions.

Flow chart 10.3 Maxillary 2nd premolar—major anatomic landmarks



Flow chart 10.4 Maxillary 2nd premolar—summary



Box 10.2 Maxillary 2nd premolar—identification features

Identification features of maxillary 2nd premolar

- Both the cusps are of almost equal size and the crown is not inclined on its root base
- Tooth has a single root
- The crown is less angular and more rounded from occlusal view
- There are no developmental grooves crossing the marginal ridges
- Central developmental groove is shorter and occlusal surface has a wrinkled appearance because of multiple supplementary grooves.

Side identifications

- Distal slope/cusp ridge of buccal cusp is longer than that of mesial
- Root may show distal curvature at its apical third
- Developmental depression deeper on distal surface of root.

Anatomy of maxillary 2nd premolar is summarized in **Flow charts 10.3 and 10.4**. **Box 10.2** gives identification features of the tooth.

BIBLIOGRAPHY

1. Kartal N, Ozçelik B, Cimilli H. Root canal morphology of maxillary premolars. J Endod. 1998;24(6):417-9.
2. Pécora JD, Saquy PC, Sousa Neto MD, Woelfel JB. Root form and canal anatomy of maxillary 1st premolars. Braz Dent J. 1992;2(2):87-94.
3. Peck L, Peck S, Attia Y. Maxillary canine first premolar transposition, associated dental anomalies and genetic basis. Angle Orthod. 1993;63:99-109.

MULTIPLE CHOICE QUESTIONS

1. Which of the following statement is false regarding the maxillary premolars:
   a. There are eight premolars, four in each and two in each quadrant
   b. There are no premolars in deciduous dentition and they succeed deciduous molars
   c. Premolars along with molars occupy posterior segment of dental arches and are collectively referred to as posterior teeth
   d. Premolars are often also called as tricuspids
2. Which of the following premolar has only one functional cusp?
   a. Mandibular 1st premolar
   b. Mandibular 2nd premolar
   c. Maxillary 1st premolar
   d. Maxillary 2nd premolar
3. Which of the following premolar can have three cusps?
   a. Mandibular 1st premolar
   b. Mandibular 2nd premolar
   c. Maxillary 1st premolar
   d. Maxillary 2nd premolar
4. Generally premolars develop from four lobes, except:
   a. Mandibular 1st premolar
   b. Mandibular 2nd premolar
   c. Maxillary 1st premolar
   d. Maxillary 2nd premolar
5. Which of the following premolar develops from five lobes?
   a. Mandibular 1st premolar
   b. Mandibular 2nd premolar
   c. Maxillary 1st premolar
   d. Maxillary 2nd premolar
6. Which of the following premolar generally has two roots?
   a. Mandibular 1st premolar
   b. Mandibular 2nd premolar
   c. Maxillary 1st premolar
   d. Maxillary 2nd premolar
7. Which of the following premolar has a single root?
   a. Mandibular 1st premolar
   b. Mandibular 2nd premolar
   c. Maxillary 2nd premolar
   d. All of the above
8. The following are the functions of premolar except:
   a. They grind the food along with molar
   b. They provide support to check near corner of mouth
   c. They reinforce esthetics during smiling
   d. None of the above
9. Which of the following statements is false regarding maxillary 1st premolar?
   a. The maxillary 1st premolar has two cusps and frequently has one root with one pulp canal
   b. The maxillary 1st premolar has two cusps and two roots; buccal and lingual
   c. Sometimes they can have a single root with two plup chamber
   d. The buccal cusp is longer than the lingual cusp by 1 mm
   e. The crown is angular with prominent buccal line angle
10. In maxillary permanent 1st premolar?
    a. The buccal cusp is longer than the lingual cusp by 1–2 mm
    b. The lingual cusp is longer than the buccal cusp
    c. Both the cusps are equal sized
    d. Either a or b

Answers

1. d	2. a	3. b	4. b	5. b	6. c	7. d	8. d	9. a	10. a

CHAPTER

11

The Permanent Mandibular Premolars

The mandibular premolars differ from each other in their development and form. Among mandibular premolars, the 1st premolar is always smaller developing from four lobes, whereas the 2nd premolar is larger developing from five lobes (**Fig. 11.1**). The crowns of both the teeth are inclined lingually on their root bases. They have single root.

PERMANENT MANDIBULAR 1ST PREMOLAR

The mandibular 1st premolar develops from four lobes: Mesial, distal, buccal and lingual; and has two cusps; buccal and lingual. The buccal cusp is well developed and is the only functional cusp occluding with the maxillary teeth. The lingual cusp is very small and non-functional. The chronology and measurements of the mandibular 1st premolar is given in **Table 11.1**.

The mandibular 1st premolar shows resemblance to both of its neighboring teeth; the mandibular canine and 2nd premolar.

The features that resemble those of the mandibular canine are:

- Viewed buccally, the buccal cusp is long and sharp. It is the only functional cusp
- From the proximal view, the buccolingual measurement is similar to that of the canine
- The occlusal surface slopes dramatically lingually in a cervical direction. This is because, the lingual cusp is very small
- Viewed occlusally, the occlusal outline of the crown resembles the incisal outline form of the mandibular canine.

The characteristics that resemble those of the second mandibular premolar are as follows:

- The tooth has two cusps like the 2nd premolar
- Viewed buccally, the crown and root form resembles that of the 2nd premolar
- Both the contact areas on mesial and distal surfaces are at the same level. This feature is common to all posteriors
- The curvature of cervical line mesially and distally is similar.

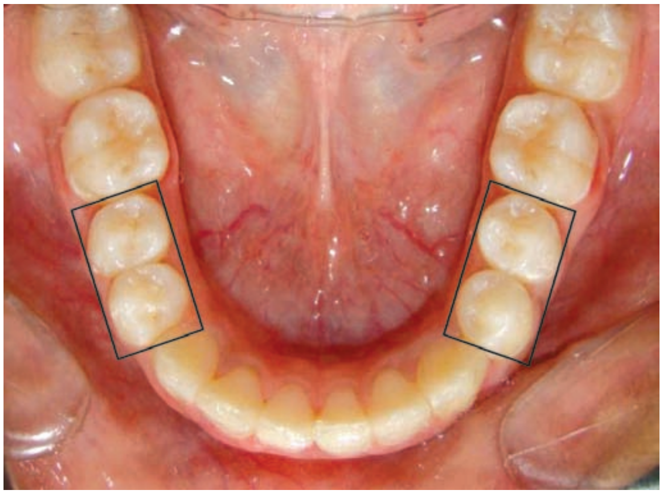


Figure 11.1 Among mandibular premolars, 1st premolar is smaller than the 2nd premolar

Table 11.1 Mandibular 1st premolar—chronology and dimensions

Chronology	
First evidence of calcification	1¾–2 years
Enamel completed	5–6 years
Eruption	10–12 years
Roots completed	12–13 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	8.5
Length of root	14.0
Mesiodistal diameter of crown	7.0
Mesiodistal diameter of crown at cervix	5.0
Buccolingual diameter of crown	7.5
Buccolingual diameter of crown at cervix	6.5
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

DETAILED DESCRIPTION OF MANDIBULAR 1ST PREMOLAR FROM ALL ASPECTS

Figures 11.2 to 11.4 show mandibular 1st premolar from various aspects.

CROWN

Buccal Aspect (Fig. 11.5)

Geometric shape: Crown is *trapezoidal* from buccal aspect and appears bilaterally symmetrical.

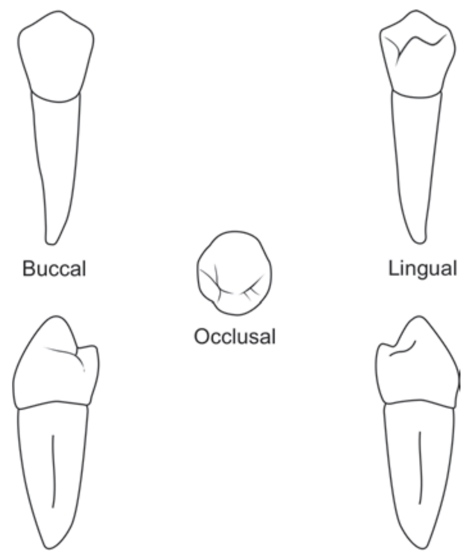


Figure 11.2 Mandibular 1st premolar—line drawings

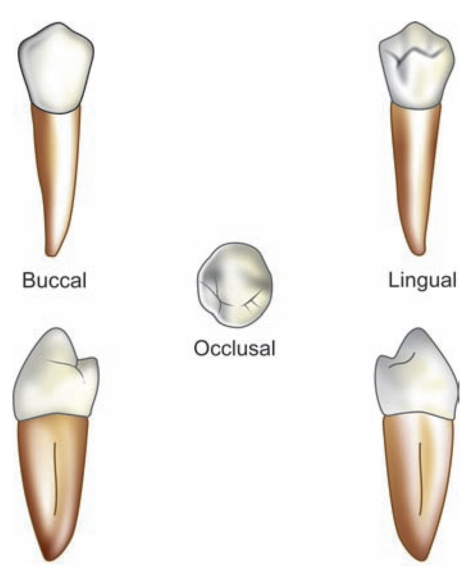


Figure 11.3 Mandibular right 1st premolar—graphic illustrations

Crown Outlines

Mesial Outline
- Mesial outline is convex except near the cervical line where it is slightly concave
- Height of contour (representing the *mesial contact area*) is just occlusal to the center of the crown cervico-occlusally.

Distal Outline
- It is concave near the cervix and becomes convex as it joins the occlusal outline
- The *distal contact area* is broader and is at the same level as the mesial contact area.

Occlusal Outline
- The buccal cusp tip is sharp and the mesiobuccal and distobuccal cusp ridges are slightly concave on unworn premolar
- Distal cusp ridge is longer than the mesial cusp ridge.

Cervical Outline
The cervical line on buccal surface is curved apically.

Buccal Surface within the Outlines

- The crown appears broader with a narrow cervix
- The middle buccal lobe is well developed into a long buccal cusp and prominent buccal ridge
- The buccal cusp tip is pointed and is placed slightly mesial to the center of the crown
- The buccal surface is convex.

Lingual Aspect (Fig. 11.6)

Geometric shape: It is *trapezoidal* like that of buccal aspect.

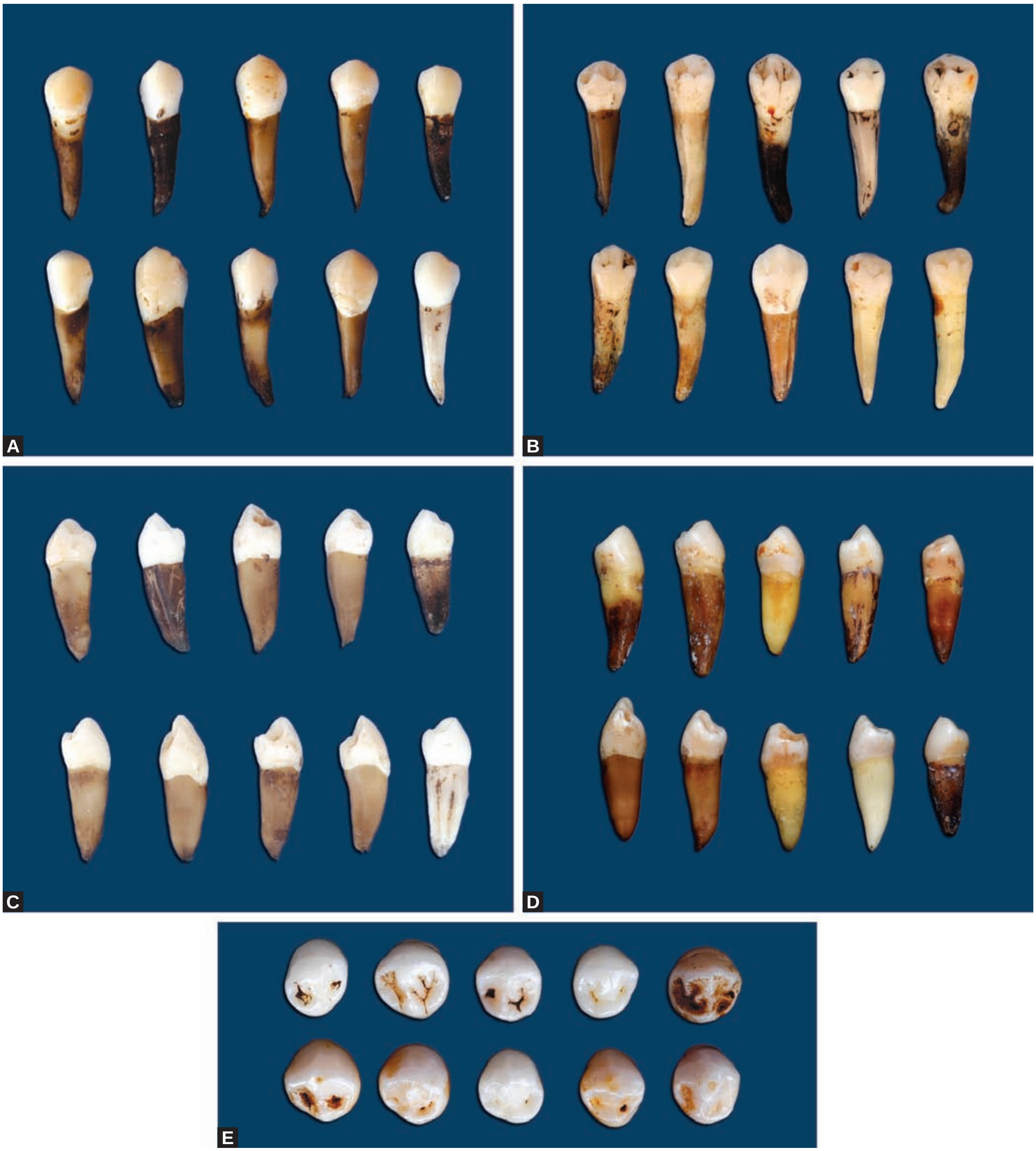
Crown Outlines

Mesial, distal, cervical outlines are similar to that of buccal aspect.

Occlusal Outline
- Occlusal limit of lingual surface is formed by the cusp tip and cusp ridges of the lingual cusp.
- The occlusal outline is notched by a groove passing between mesial marginal ridge and mesiolingual cusp ridge
- Because of a much shorter lingual cusp, buccal cusp tip and cusp ridges are visible from lingual aspect.

Lingual Surface within the Outlines

- There is marked lingual convergence of the crown resulting in a much narrower lingual surface
- Consequently, most of the mesial and distal surfaces can be seen from lingual aspect
- Occlusal surface slopes lingually because of shorter lingual cusp. Thus, most of the occlusal surface, including



Figures 11.4A to E Mandibular 1st premolar—typical tooth specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

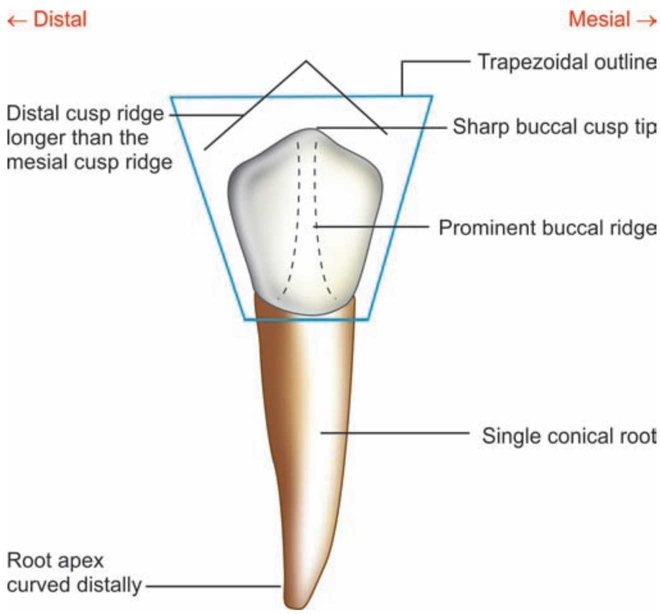


Figure 11.5 Mandibular 1st premolar—buccal aspect

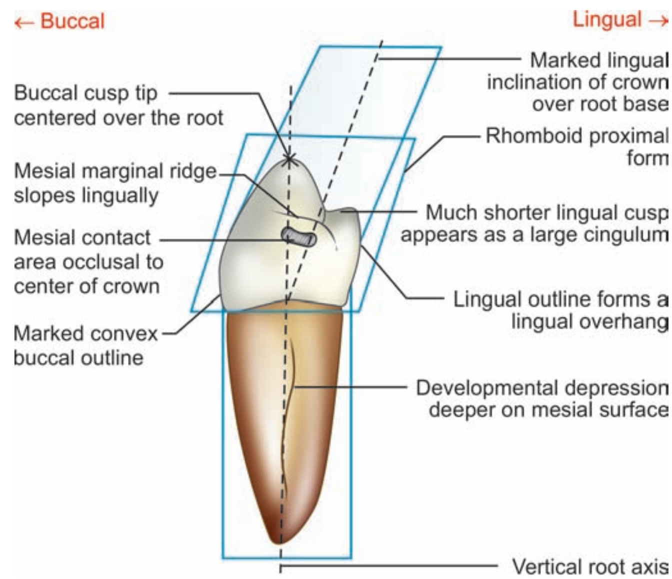


Figure 11.7 Mandibular 1st premolar—mesial aspect

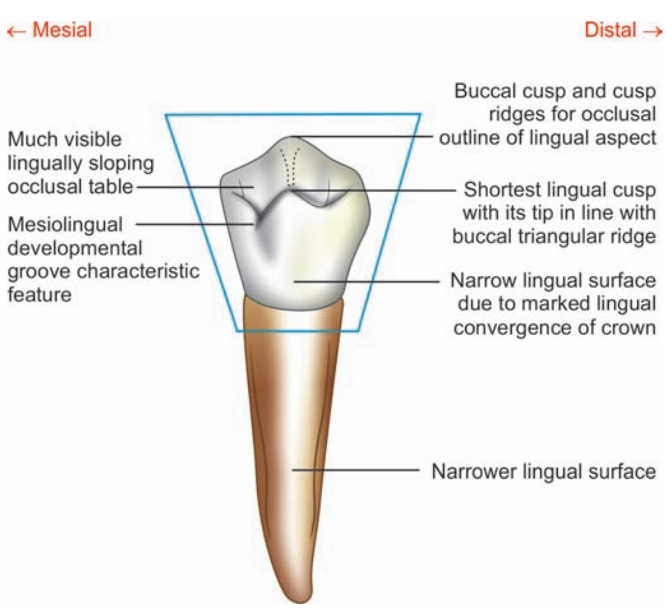


Figure 11.6 Mandibular 1st premolar—lingual aspect

buccal triangular ridge, marginal ridge, inclined planes of buccal cusp, mesial and distal fossae is visible.

- The lingual cusp tip is pointed and is in line with the buccal triangular ridge which is clearly seen from this aspect
- The characteristic feature of mandibular 1st premolar is the *mesiolingual developmental groove* extending from mesial developmental groove of occlusal surface onto the lingual surface mesially.

Mesial Aspect (Fig. 11.7)

Geometric shape: Crown appears rhomboidal which is true for proximal aspect of all mandibular posterior teeth.

Crown Outlines

Buccal Outline

- The buccal outline is marked by convex from cervix to buccal cusp tip
- Height of buccal contour is at the cervical third of the crown.

Lingual Outline

- Lingual outline is convex stretching out of the confines of the root and thus, creating an overhang above the root trunk lingually
- Its height of contour is at the middle third of crown, near to lingual cusp tip.

Occlusal Outline

- Occlusal outline is a concave arc sloping lingually
- The mesial marginal ridge slopes prominently in lingual direction.

Cervical Outline

The cervical line curves slightly in occlusal direction.

Mesial Surface within the Outlines

- Mesial surface is smoothly convex except for the mesiolingual developmental groove and a concavity just above the cervical line

- The buccal cusp tip is centered over the root base. In other words, it is in line with the vertical root axis
- Lingual cusp tip is in line with lingual outline of root
- The mesial marginal ridge slopes prominently in a lingual direction
- Some part of occlusal surface with buccal and lingual triangular ridges can be seen from mesial aspect
- *Mesial contact area:* It is occlusal to the center of crown, and is in line with the buccal cusp tip.

Distal Aspect (Fig. 11.8)

Geometric shape: *Rhomboidal* like mesial aspect.

Crown Outlines

Buccal and lingual outlines are similar to that of mesial aspect.

Occlusal Outline
- Distal marginal ridge is perpendicular to the long axis of tooth rather than sloping lingually
- It is placed at a higher level than mesial marginal ridge from the cervix.

Cervical Outline
The cervical line on the distal surface is nearly a straight line.

Distal Surface within the Outlines

- The distal surface is smooth except for a small linear concavity just above the cervical line
- The *distal contact area* is at the same level but broader than the mesial contact area.

Occlusal Aspect (Fig. 11.9)

Geometric shape: Diamond-shaped or circular.

Relative Dimensions

- Buccolingual dimension is only 0.5 mm greater than mesiodistal dimension, thus the crown appears circular rather than oval
- Because of lingual inclination of the crown, most of the buccal surface and very little of lingual surface can be seen from occlusal aspect.

Cusp and Cusp Ridges

- Buccal cusp is larger making the major bulk of the crown and the lingual cusp is much smaller. The crown converges sharply towards lingual surface
- Mesiobuccal and distobuccal cusp ridges are stronger than the mesiolingual and distolingual cusp ridges
- Buccal triangular ridge is strong and well developed whereas the lingual triangular ridge is less defined
- There are inclined planes on either side of triangular ridges.

Fossae

- *Mandibular 1st premolar has two fossae*: The *mesial* and the *distal*
- The fossae near marginal ridges are irregular rather than triangular and thus named as *mesial and distal fossae*.

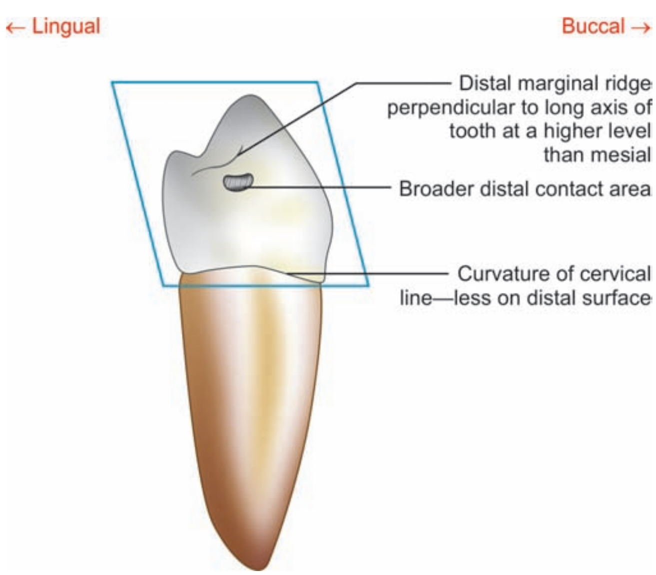


Figure 11.8 Mandibular 1st premolar—distal aspect

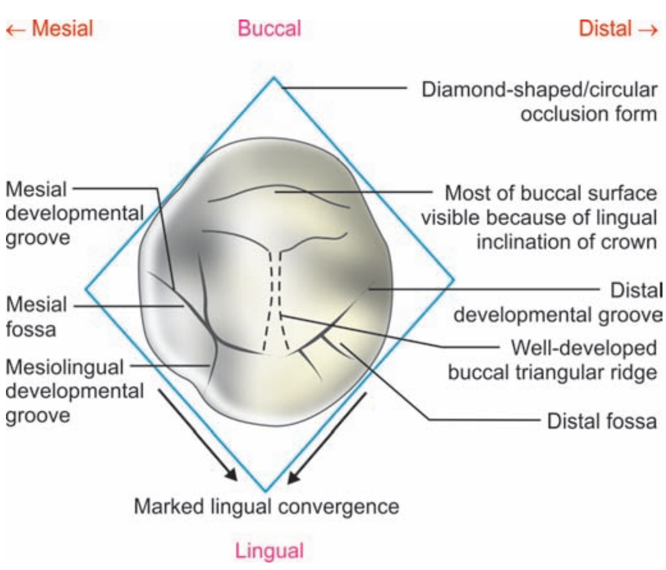


Figure 11.9 Mandibular 1st premolar—occlusal aspect

Grooves and Pits

Grooves

It has three grooves:

1. *Mesial developmental groove*: It is located in the mesial fossa; is short and extends buccolingually
2. *Distal developmental groove*: It is in the distal fossa is longer
3. *Mesiolingual developmental groove*: It is continuous from mesial groove and it extends between mesial marginal ridge and mesiolingual cusp ridge onto the lingual surface mesially. This groove is the characteristic feature of mandibular 1st premolar.

Pit

The distal fossa may have a pit in its center.

Marginal Ridges

- Mesial marginal ridge is shorter and is constricted because of mesiolingual developmental groove. It slopes sharply lingually in a cervical direction.
- The distal marginal ridge is confluent with the distolingual cusp ridge.

ROOT

- *Number*: The mandibular premolar has a single root
- *Size*: It is slightly shorter than the mandibular 2nd premolar root and 3 to 4 mm shorter than that of mandibular canine
- *Form*: It is conical in shape, tapering evenly from cervix to apex.
- The root is wider buccolingually than mesiodistally
- Buccal and lingual surfaces are convex and proximal surfaces are flat
- The root tapers acutely towards lingual surface
- Lingual convergence of the root is exaggerated.

Developmental Groove and Depressions

Developmental depression on the mesial surface of the root is deeper than on the distal surface. A deep developmental groove is often present on the mesial surface of root running longitudinally.

Apex

The root apex is pointed.

Curvature

The apical third of root is often curved distally.

VARIATIONS (FIG. 11.10)

- Bifurcation of the root into buccal and lingual divisions is a fairly common variation.
- Long root.

DEVELOPMENTAL ANOMALIES

- Supernumerary premolar in the region (**Fig. 11.11**)
- Dens evaginatus/Leong's premolar.

CLINICAL CONSIDERATIONS

- A possibility of bifurcated roots must be considered during root canal therapy.
- Lingual inclination of the crown should be kept in mind during crown preparation and access cavity opening.

Identification of permanent mandibular 1st premolar is given in **Box 11.1**.

The tooth's morphology is summarized in **Flow charts 11.1 and 11.2**.

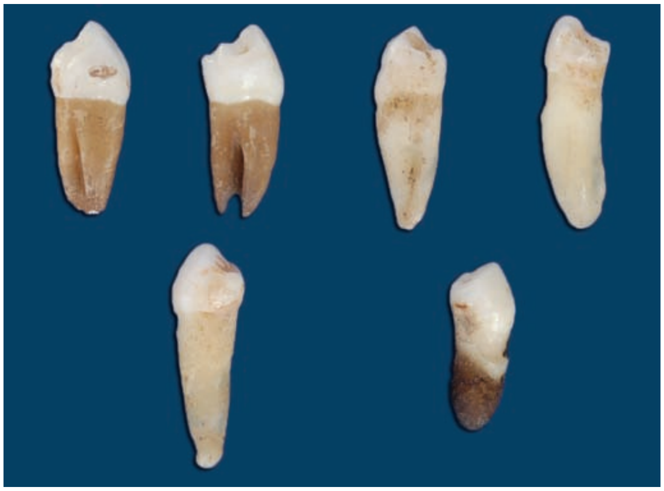


Figure 11.10 Mandibular 1st premolar—variations

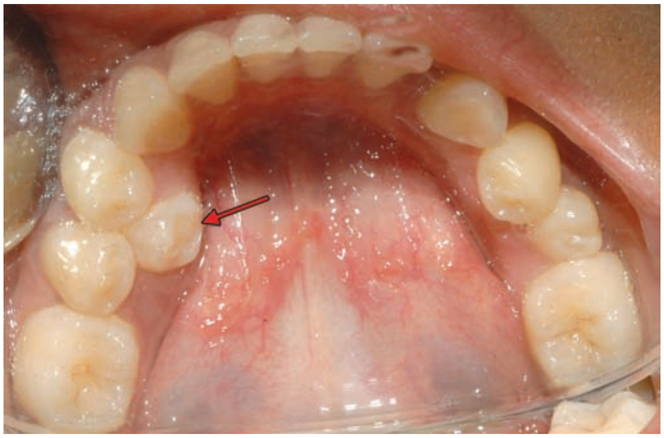


Figure 11.11 Supernumerary premolars/parapremolar

Box 11.1 Mandibular 1st premolar—identification features

Identification features of mandibular 1st premolar
- Large pointed buccal cusp and a very small lingual cusp
- Marked lingual inclination of crown on its root base as observed from proximal view
- The buccal tip is centered over the root trunk as seen from proximal view
- The lingual cusp tip is in line with the lingual outline of the root or may extend lingually out of confines of the root
- *Mesiolingual developmental groove* between mesial marginal ridge and mesiolingual cusp ridge, crossing onto the mesial portion of lingual surface is the characteristic feature of the tooth
- It has a single root.

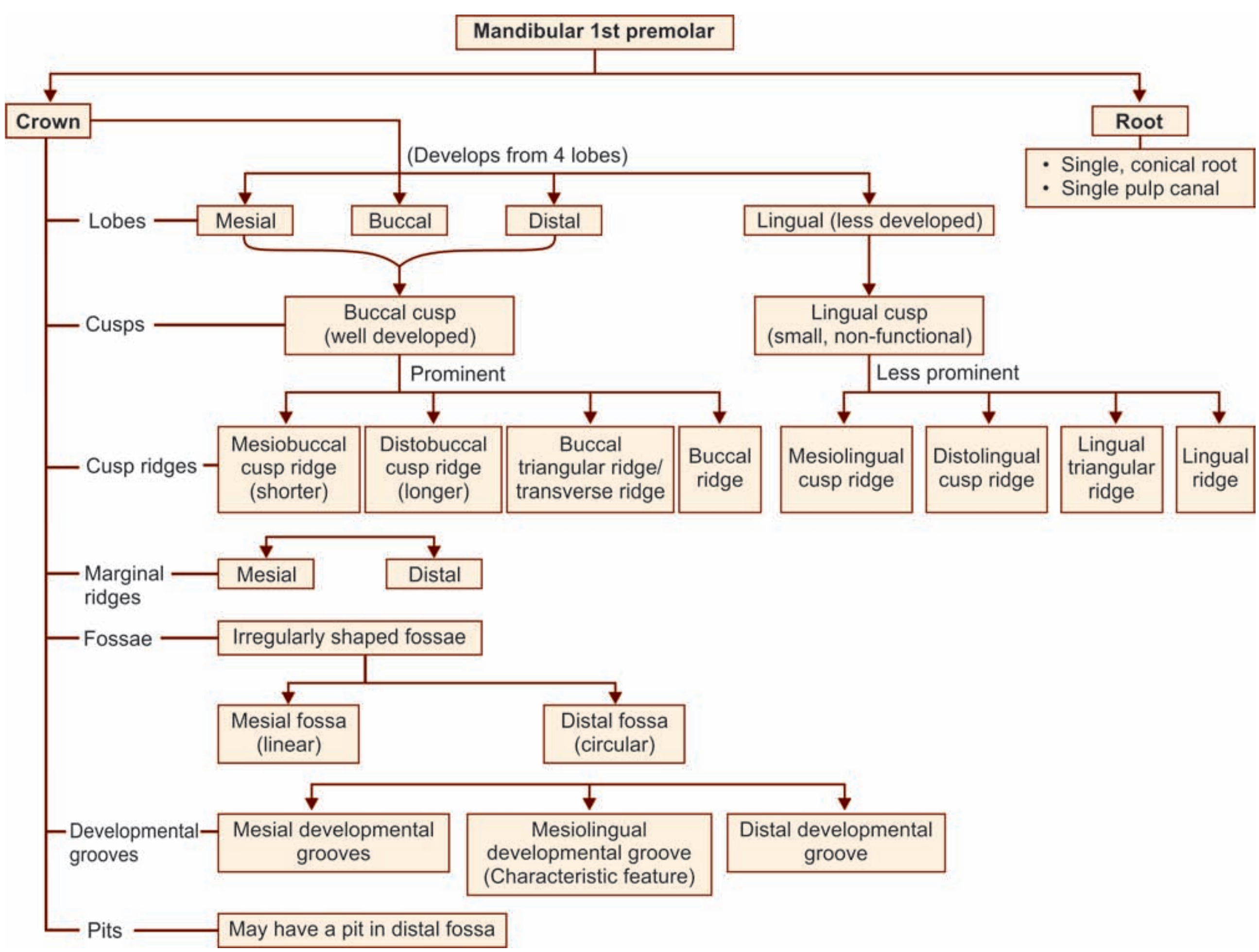
Side identification
- By locating the mesiolingual developmental groove, it is on the lingual surface towards mesial portion of the crown
- Developmental groove is deeper on the mesial surface of the root which may also have a developmental groove at its center.

PERMANENT MANDIBULAR 2ND PREMOLAR

The mandibular 2nd premolar is larger than the mandibular 1st premolar and it resembles the latter only from buccal aspect. It has a broad occlusal table and assists mandibular molars in grinding the food. The crown shows wide variation in occlusal anatomy. It has a single root that resembles the root of mandibular 1st premolar in form although it is longer. Mandibular 2nd premolar is the only premolar developing from five lobes: three buccal (mesial, buccal, distal lobes) and two lingual lobes (mesiolingual and distolingual lobes). **Table 11.2** gives the chronology and measurements of mandibular 2nd premolar.

These are two common forms of mandibular 2nd premolar (**Figs 11.12A to C**).
1. Three cusp form ('Y' groove pattern)
   – Frequently seen
2. Two cusp form ('U' and 'H' groove pattern).

Flow chart 11.1 Mandibular 1st premolar—major anatomic and landmarks



Flow chart 11.2 Mandibular 1st premolar—summary

Mandibular 1st premolar

Crown

Buccal aspect

Geometric shape
- Trapezoidal

Crown outlines
- Mesial—slightly convex
- Distal—slightly convex

Cusps seen: Only buccal

Buccal cusp ridges
- Mesial—shorter
- Distal—longer

Buccal cusp tip
- Sharp, pointed
- Placed mesial to center of crown

Buccal ridge
- Prominent

Buccal surface
- Smooth and convex
- Crown appears broader with narrow cervix

Lingual aspect

- Trapezoidal

Cusps seen
- Lingual cusp
- Most of buccal cusp with tip and ridges seen

Lingual convergence
- Crown tapers markedly towards much smaller lingual cusp

Occlusal surface visibility
- Occlusal table slopes lingually
- Most of occlusal surface seen

Lingual cusp tip
- Pointed
- In line with buccal triangular ridge

Lingual surface
- Much narrower

Mesiolingual developmental groove
- Characteristic feature
- Extends from occlusal surface onto lingual mesially

Mesial aspect

- Rhomboidal

Cusps seen
- Both cusps seen

Crown outlines
- Buccal—markedly convex
- Lingual—stretches out of confines of root

Lingual inclination
- Crown shows marked lingual inclination over root base
- Creates lingual overhang

Cusp tip location
- Buccal—centered over root base
- Lingual—in line with lingual outline of root

Mesial marginal ridge
- Slopes lingually
- Cervically placed than distal marginal ridge

Developmental groove
- Mesiolingual developmental groove

Mesial contact area
- Occlusal to center of crown
- In line with buccal cusp tip

Distal aspect

- Rhomboidal

Distal marginal ridge
- Perpendicular to long axis of tooth
- It is at higher level than mesial marginal ridge

Distal surface
- Smooth
- No developmental groove

Cervical line
- Straight line
- Not curved

Distal contact area
- Same level
- Broader

Occlusal aspect

- Diamond-shaped/ circular

Relative dimensions
- Buccolingual dimension 0.5 mm greater than mesiodistal dimension
- Therefore circular appearance

Lingual inclination
- Thus more of buccal surface seen and less of lingual surface seen

Cusps
- Buccal—larger makes bulk of crown
- Lingual—much smaller

Cusp ridges
- Buccal cusp ridges—well developed
- Lingual cusp ridges—ill defined

Grooves
- Mesial developmental groove
- Distal developmental groove
- Mesiolingual developmental groove

Fossae
- Irregular mesial and distal fossae

Pits: Distal pit

Root

Number
- Single

Pulp canal
- Single

Size
- 3–4 mm shorter than mandibular canine

Form
- Conical
- Wider buccolingually
- Markedly converges towards lingual

Developmental depression
- Deeper on mesial surface of root

Apical curvature
- Distally curved

Apex
- Pointed

DETAILED DESCRIPTION OF MANDIBULAR 2ND PREMOLAR FROM ALL ASPECTS

Figures 11.13 to 11.15 show mandibular 2nd premolar from various aspects.

CROWN

Buccal Aspect (Fig. 11.16)

Geometric shape: *Trapezoidal*

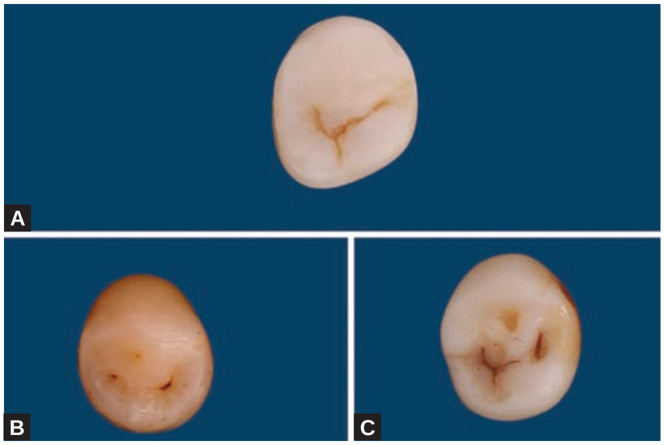
Crown Outlines

Mesial Outline
- Mesial outline is convex for a short distance near the cervical line.
- Its height of contour (*mesial contact area*) is at the middle third of the crown.

Distal Outline
- The distal outline is more convex.
- Its height of contour (*distal contact area*) is also at the middle third.

Table 11.2 Mandibular 2nd premolars—chronology and measurements

Chronology	
First evidence of calcification	2¼–2½ years
Enamel completed	6–7 years
Eruption	11–12 years
Roots completed	13–14 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	8.0
Length of root	14.5
Mesiodistal diameter of crown	7.0
Mesiodistal diameter of crown at cervix	5.0
Buccolingual diameter of crown	8.0
Buccolingual diameter of crown at cervix	7.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0



Figures 11.12A to C Mandibular 2nd premolar have diverse occlusal anatomy: (A) With 3 cusps ('Y' groove pattern); (B) With 2 cusps ('U' groove pattern); (C) With 2 cusps ('H' groove pattern)

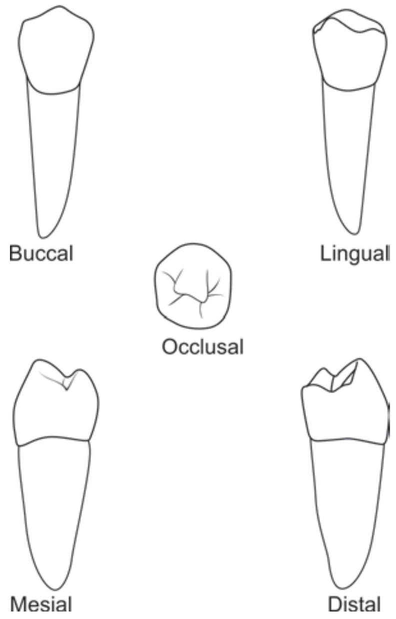


Figure 11.13 Mandibular right 2nd premolar—line drawing

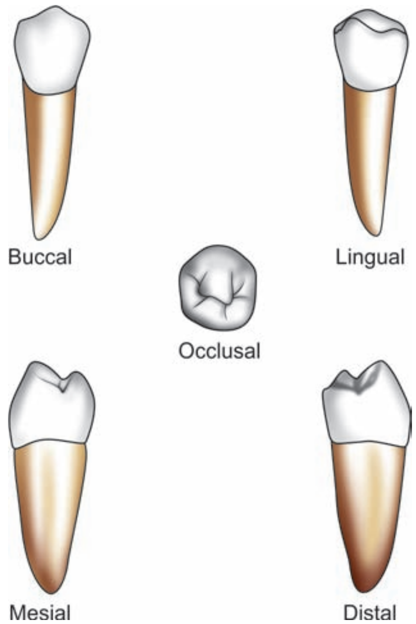


Figure 11.14 Mandibular right 2nd premolar—graphic illustrations

Occlusal Outline

Buccal cusp tip is blunt with the mesial and distal buccal cusp ridges meeting at a more obtuse angle.

Cervical Outline

The cervical line is slightly curved apically.

Buccal Surface within the Outlines

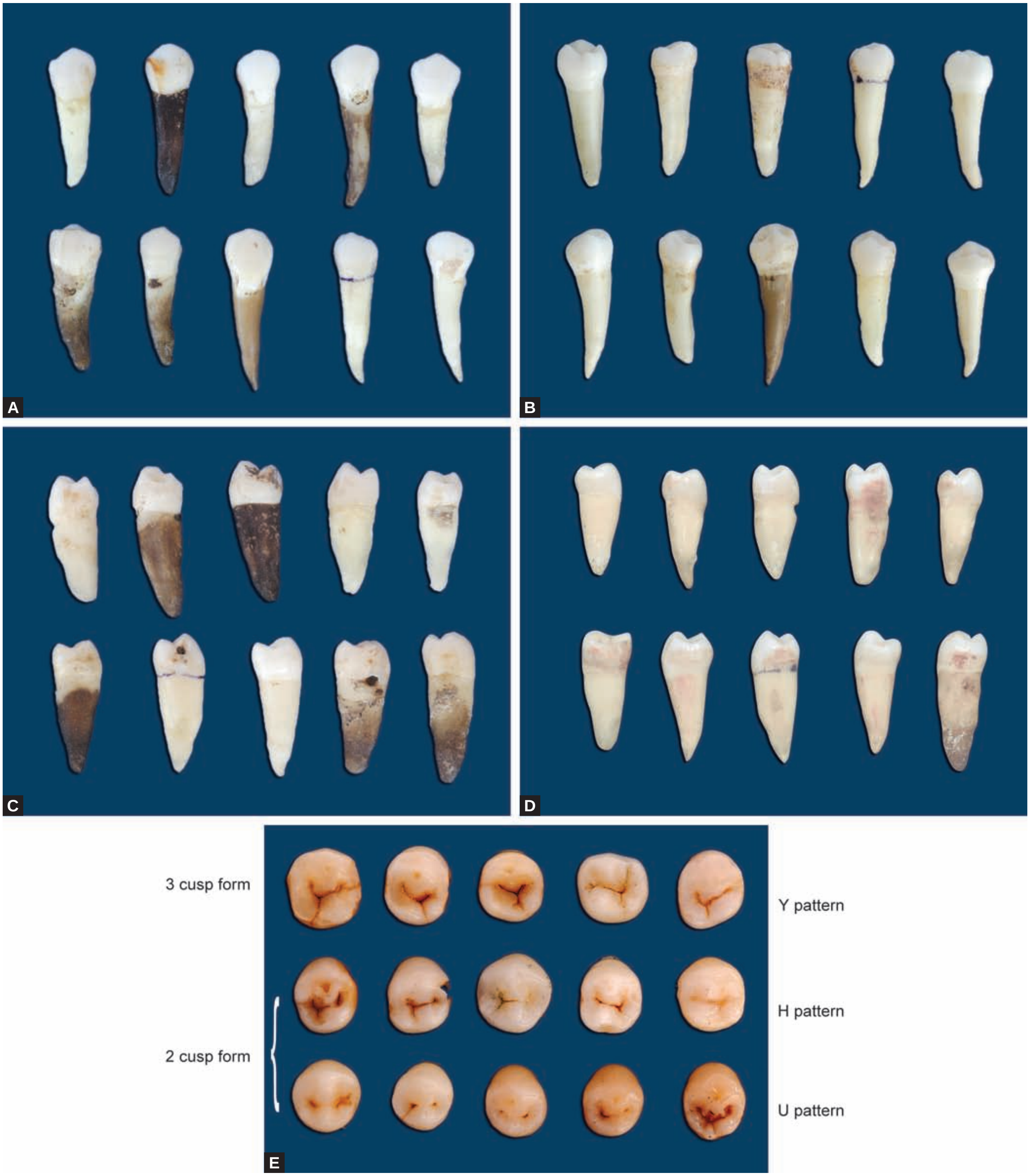
- The crown appears short and bulky from buccal aspect.
- The buccal surface is smooth and convex.
- The buccal ridge extending from cervical line to the buccal cusp tip is very prominent.

Lingual Aspect (Fig. 11.17)

Geometric shape: *Trapezoidal* like the buccal aspect.

Crown Outlines

Mesial, distal and cervical outlines are similar to that of buccal aspect.



Figures 11.15A to E Mandibular 2nd premolar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

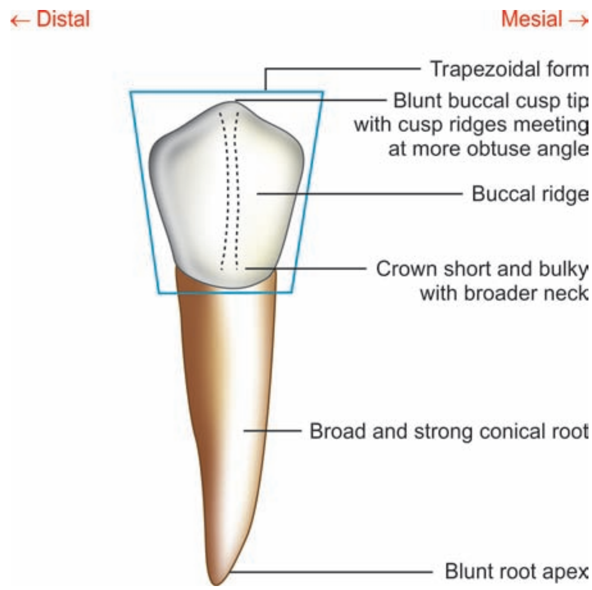


Figure 11.16 Mandibular 2nd premolar—buccal aspect

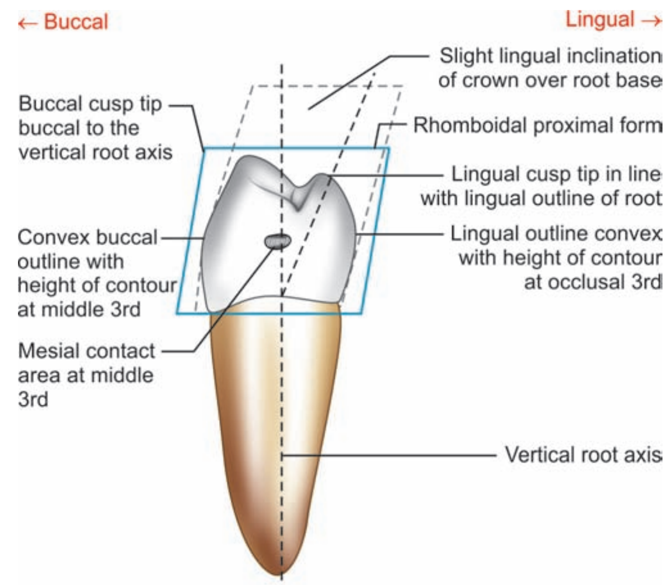


Figure 11.18 Mandibular 2nd premolar—mesial aspect

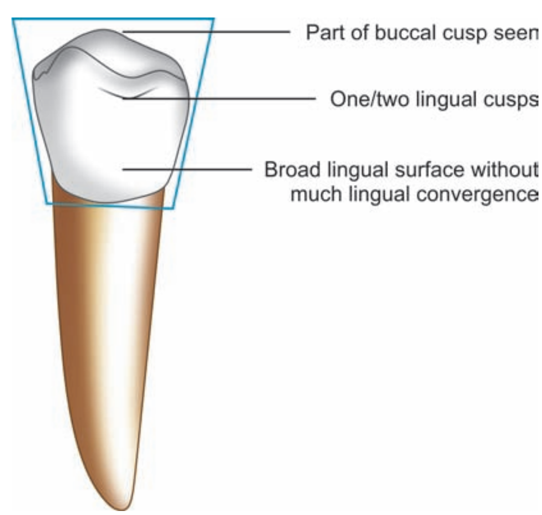


Figure 11.17 Mandibular 2nd premolar—lingual aspect

Occlusal Outline

- Occlusal outline is formed by the lingual cusp tip and cusp ridges of lingual cusp/cusps (depending on cusp type)
- A part of buccal cusp is seen since the lingual cusp are not as long as the buccal cusp.

Lingual Surface within the Outlines

- The crown appears bulky from lingual aspect too
- The crown does not taper much lingually and thus, very little of proximal surfaces can be seen
- In the three cusps type, there are two lingual cusps: *mesiolingual* and *distolingual*
- The lingual cusp/cusps are well developed and are of nearly same length as that of buccal cusp
- A part of occlusal surface may be seen from lingual aspect
- The lingual surface is smooth and spheroidal.

Mesial Aspect (Fig. 11.18)

Geometric shape: It is *rhomboidal* similar to proximal aspect of all mandibular posteriors.

Crown Outlines

Buccal Outline

Buccal outline is convex and the height of contour is at the middle third of crown.

Lingual Outline

- It is less convex and its height of contour is at the occlusal third of the crown
- The lingual outline is out of confines of the root base.

Occlusal Outline

- Occlusal outline is concave
- The mesial marginal ridge is at right angles to the long axis of the tooth.

Cervical Outline

The cervical outline curves occlusally.

Mesial Surface within the Outlines

- The crown is lingually inclined on its root base but not to the extent of mandibular 1st premolar
- The buccal cusp tip is blunt and is buccal to the vertical root axis

- The lingual cusp tip is in line with lingual outline of the root
- The mesial surface is smoothly convex and devoid of any developmental groove
- *Mesial contact area*: It is at the middle third of the crown and centered buccolingually.

Distal Aspect (Fig. 11.19)

Geometric shape: It is *rhomboidal* similar to the mesial aspect.

Crown Outlines

Buccal, lingual and cervical outlines are similar to that of the mesial aspect.

Occlusal Outline
The distal marginal ridge is also at right angles to the long axis but is at a lower level than the mesial marginal ridge.

Distal Surface within the Outlines

- Distal surface is also smoothly convex.
- More of occlusal surface can be seen than from mesial aspect, as distal marginal ridge is at a lower level.
- Distal contact area is at the same level as the mesial contact area but is broader.

Occlusal Aspect (Fig. 11.20)

Occlusal morphology varies in mandibular 2nd premolar.

There are two common forms:
1. Three cusps type with a 'Y' groove pattern.
2. Two cusps type with a 'U' or 'H' groove pattern.

Three Cusps Type (More Common)

Geometric shape: *Square-shaped* with nearly equal mesiodistal crown width buccally and lingually.

Cusp and Cusps Ridges
There are three cusps:
1. Buccal cusp is the largest one, followed by mesiolingual cusp and distolingual cusp in that order.
2. The lingual lobes are well developed.
3. Each cusp has mesial and distal cusp ridges of its own, and a triangular ridge sloping from cusp tip towards the center of the occlusal surface.

Grooves and Pits

Grooves
- There are three developmental grooves converging at a central pit and thus, forming a *'Y' shaped pattern.* Few supplementary grooves radiate from developmental grooves in the triangular fossa.
  1. *Mesial developmental groove*: It is long and runs from the central pit mesiobuccally and ends in the mesial triangular fossa.
  2. *Distal developmental groove*: It is a shorter groove running from the central pit to the distal triangular fossa.
  3. *Lingual developmental groove:*
     - It runs in a lingual direction between two lingual cusps and ends on the lingual surface of the crown. It is usually centered over the root
     - The mesiolingual cusp is wider than distolingual cusp; the lingual groove is placed slightly distal to the center of the crown
     - In three cusp type, there is no central developmental groove.

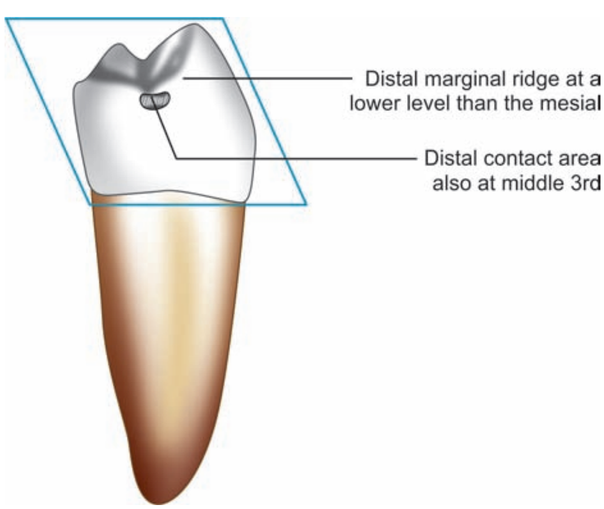


Figure 11.19 Mandibular 2nd premolar—distal aspect

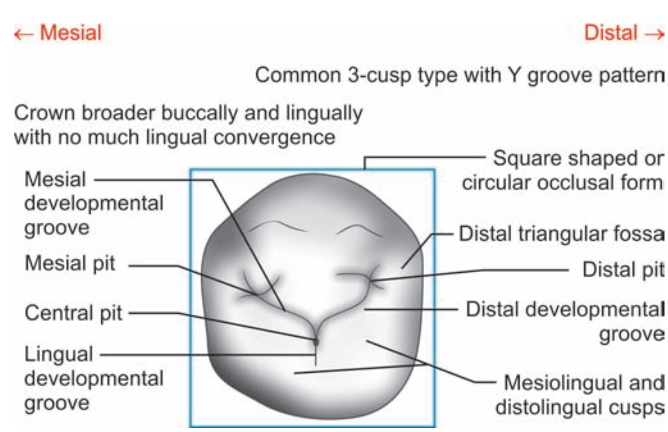


Figure 11.20 Mandibular 2nd premolar—occlusal aspect

Pits

There are three pits:

1. *Central pit* is located in the center of occlusal surface buccolingually and slightly distal to the center mesiodistally.
2. *Mesial pit* is in the mesial triangular fossa.
3. *Distal pit* is in the distal triangular fossa.

Marginal Ridges and Fossae Marginal Ridges

- Both the marginal ridges are strongly developed
- Sometimes supplementary groove can cross them.

Fossae

- There are two small triangular fossae—mesial and distal
- Triangular fossae harbor mesial/distal developmental groove mesial/distal pit and some supplemental grooves.

Two Cusps Type

Geometric shape: Circular in outline.

Cusps and Ridges

- The two cusps are *buccal* and *lingual*
- Buccal cusp is larger and lingual cusp is also well developed though it is slightly smaller
- The crown tapers slightly towards lingual aspect
- The cusps have mesial and distal cusp ridges and occlusally converging triangular ridges.

Grooves and Pits

Grooves

- The *central developmental groove* extends mesiodistally across the occlusal surface and ends in mesial and distal fossae
- It may be straight/crescent shaped and separates the triangular ridges of buccal and lingual cusps.

There are two groove patterns:

1. *'U' pattern*: Where central groove is crescent shaped.
2. *'H' pattern*: Where central groove is straight connecting mesial and distal fossa.

Pits

- There may be mesial and distal pits located in the mesial and distal fossae
- In two cusps type, there is no central pit.

Marginal Ridges and Fossae

- Mesial and distal marginal ridges are strongly developed
- The fossae near marginal ridges are irregular rather than triangular and are called as *mesial and distal occlusal fossae.*

ROOT

- *Number*: Single root almost never bifurcated
- *Size*: The root is broader, stronger and longer than that of the mandibular 1st premolar
- *Form*: The root is conical tapering from cervix to apex
- It is wider mesiodistally and does not taper much towards lingual aspect
- Buccal surfaces are convex and proximal surfaces are flat
- *Apex*: It is more blunt
- *Curvature*: The root may be straight or its apical end may have a distal curvature.

VARIATIONS (FIG. 11.21)

- Very long/very short root
- A developmental groove may be seen on buccal surface of the root.

DEVELOPMENTAL ANOMALIES

- Dens evaginatus (Leong's premolar) (**Fig. 11.22**)
- Supernumerary premolars.

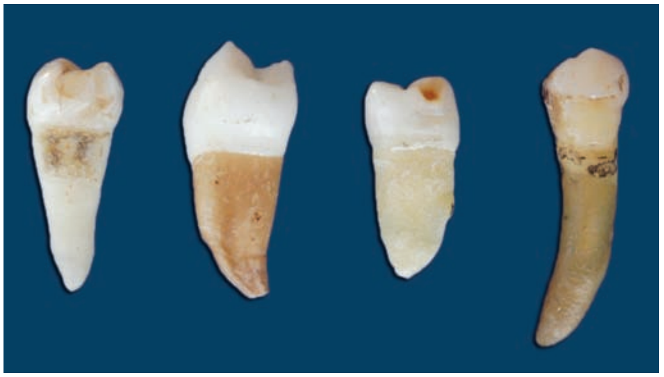


Figure 11.21 Mandibular 2nd premolar—variations

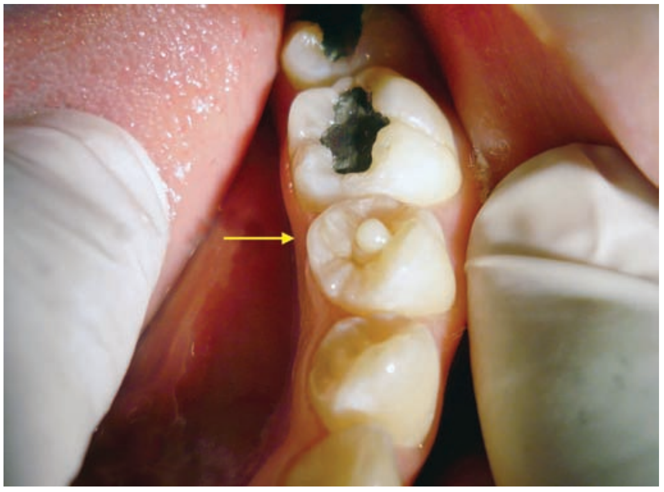
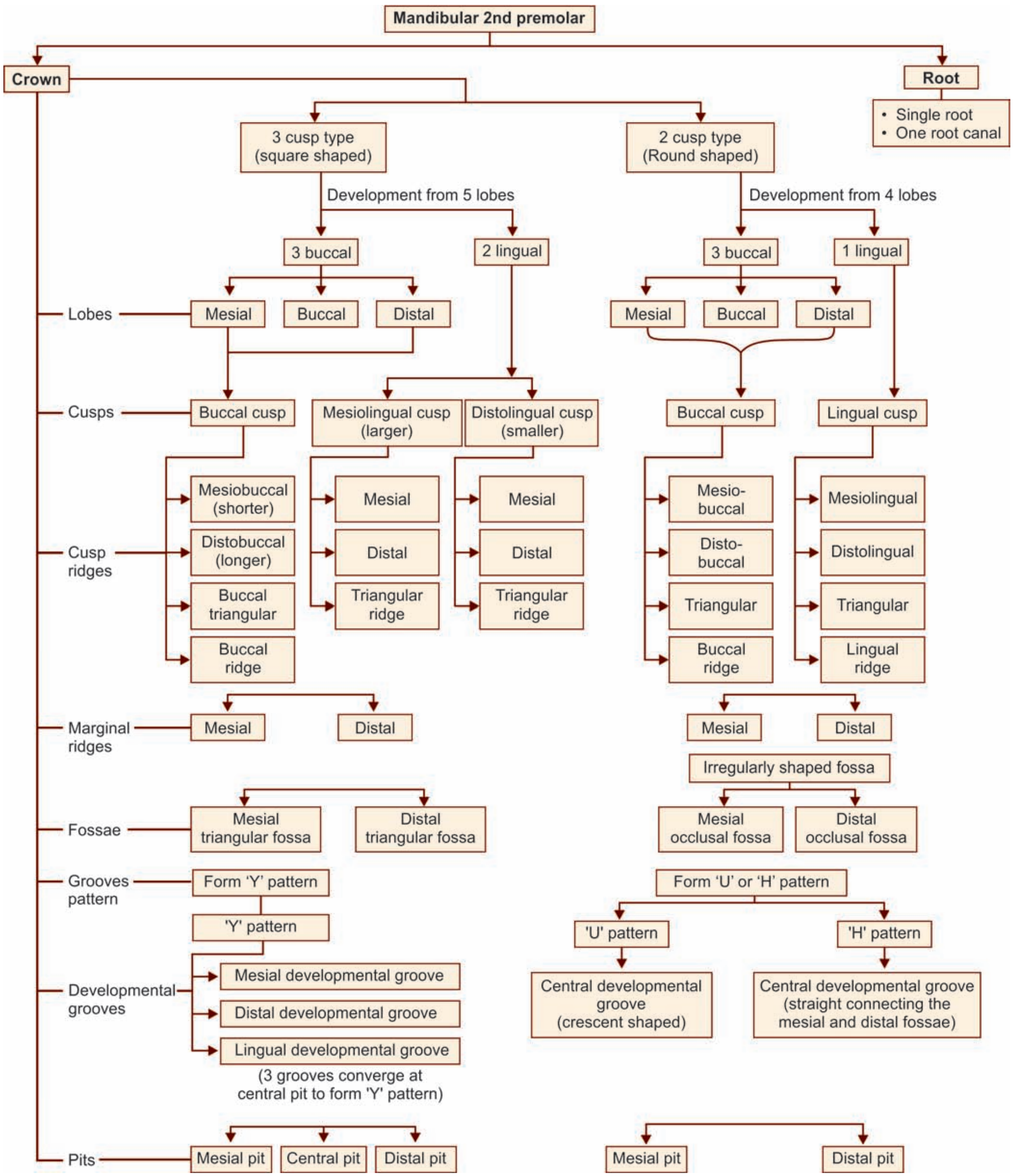
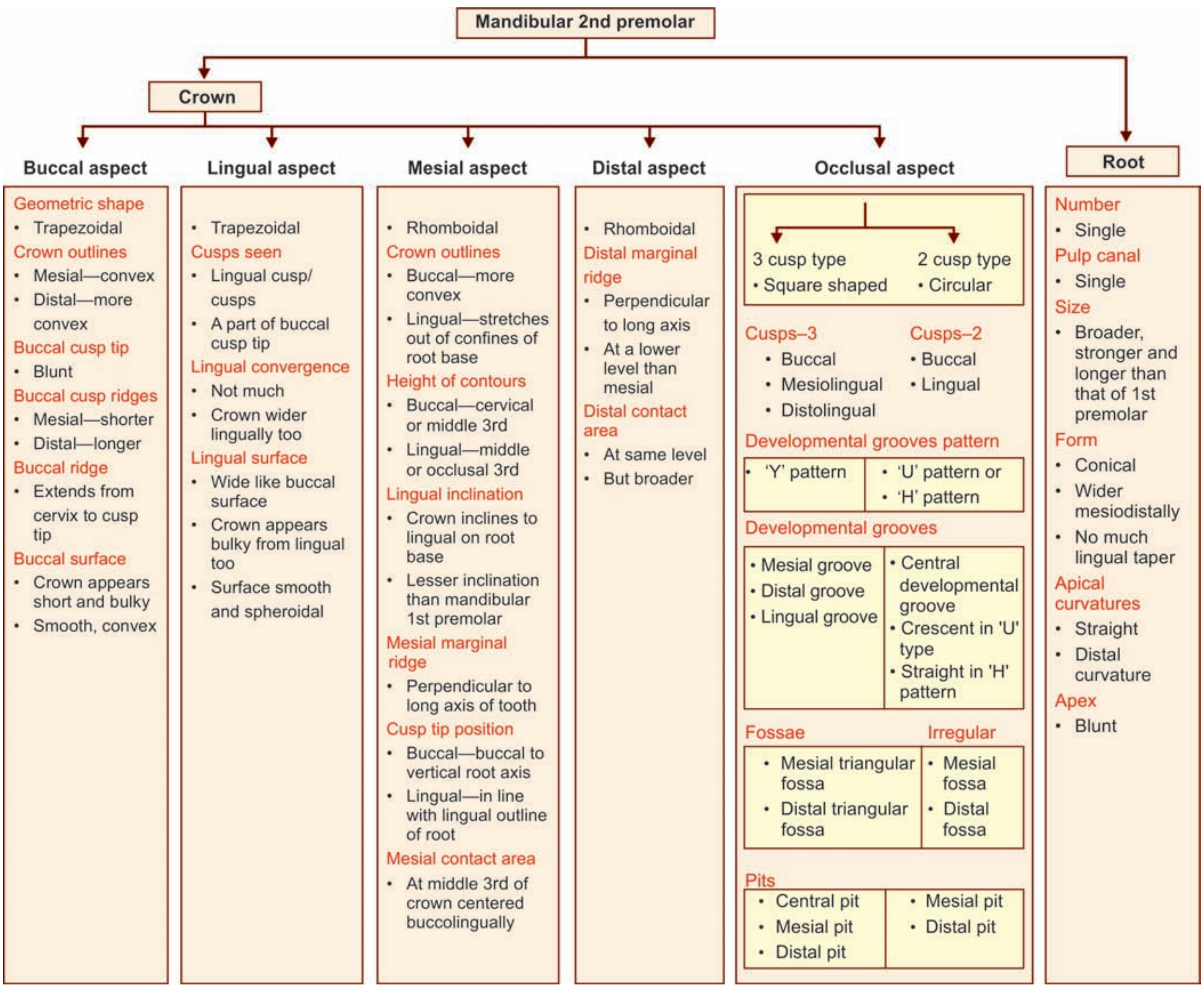


Figure 11.22 Dens evaginatus (Leong's premolar)

Flow chart 11.3 Mandibular 2nd premolar—major anatomic landmarks



Flow chart 11.4: Mandibular 2nd premolar—summary



CLINICAL CONSIDERATIONS

Whether it is of 3 cusp type or 2 cusp type has to be noted while restoring this tooth.

The mandibular 2nd premolar anatomy is summarized in **Flow charts 11.3 and 11.4**. **Box 11.2** gives the identification features of this tooth.

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.
2. Awawdeh LA, Al-Qudah AA. Root form and canal morphology of mandibular premolars in a Jordanian population. Int Endod J. 2008;41(3):240-8.

Box 11.2 Mandibular permanent 2nd premolar—identification features

Identification features of mandibular 2nd premolar

- Lingual lobes are well developed into one or two lingual cusps
- It is the only premolar with three cusps
- The lingual cusps are almost at the same height as that of buccal cusps
- Lingual inclination of crown on root base
- The three cusps type has 'Y' shaped groove pattern on occlusal surface
- On two cusp type 'U' or 'H' shaped groove pattern seen
- Crown and root have very slight lingual convergence
- Mesiolingual developmental groove not present
- Single root with less tendency for bifurcation.

Side identification

- Apical third of the root may show a distal curvature.
- In 3 cusp type, mesiolingual cusp is larger than the distolingual cusp.

3. Cleghorn BM, Christie WH, Dong CC. The root and root canal morphology of the human mandibular 2nd premolar: a literature review. J Endod. 2007;33(9):1031-7.

MULTIPLE CHOICE QUESTIONS

1. Mandibular permanent premolars differs from each other in their:
   a. Development
   b. Form
   c. Both a and b
   d. Neither a nor b
2. Mandibular permanent 1st premolar develops from:
   a. 4 lobes
   b. 5 lobes
   c. 3 lobes
   d. 2 lobes
3. Mandibular permanent 2nd premolar develops from:
   a. 4 lobes
   b. 5 lobes
   c. 3 lobes
   d. 2 lobes
4. Compared to mandibular 2nd premolar the mandibular 1st premolar is:
   a. Smaller
   b. Larger
   c. Same size
   d. None
5. Compared to mandibular 1st premolar the mandibular 2nd premolar is:
   a. Smaller
   b. Larger
   c. Same size
   d. None
6. Mandibular permanent 1st premolar has:
   a. Two cusps
   b. Three cusps
   c. Four cusps
   d. One cusp
7. Functional cusp of mandibular permanent 1st premolar is:
   a. Buccal cusp
   b. Lingual cusps
   c. Both a and b
   d. Neither a nor b
8. Non-functional cusp of mandibular 1st premolar is:
   a. Buccal cusp
   b. Lingual cusp
   c. Both a and b
   d. Neither a nor b
9. The largest cusp of mandibular permanent 1st premolar is:
   a. Lingual cusp
   b. Buccal cusp
   c. Accessory cusp
   d. None
10. The feature of mandibular permanent 1st premolar is that are true:
    a. Mesial and distal contact areas at same level
    b. Buccolingual measurement is similar to that of mandibular canine
    c. Occlusal surface slopes drastically lingually in a cervical direction
    d. All of the above

Answers

1. c	2. a	3. b	4. a	5. b	6. a	7. a	8. b	9. b	10. d

CHAPTER 12

The Permanent Maxillary Molars

There are six molars on each arch and three in each quadrant. They occupy the most posterior segment of the dental arch (**Fig. 12.1**). The molars are the largest and strongest teeth owing to their greater crown bulk and excellent anchorage of their multiple roots. The maxillary molars generally have three roots; two buccal and one palatal, whereas the mandibular molars have two roots; mesial and distal. The 3rd molars and some 2nd molars may have fused roots.

The molar teeth do not succeed any deciduous teeth but erupt distal to the deciduous 2nd molars. Thus, the permanent molars are not succedaneous teeth as they do not have any predecessors. The permanent 1st molars erupt about six years of age, thus are sometimes called *six years molars*. The 3rd molars are present only in the permanent dentition and are commonly referred to as *wisdom teeth*. 3rd molars are the last teeth to erupt into oral cavity at around 18 to 21 years of age.

Figure 12.1 Permanent maxillary molars

COMMON CHARACTERISTICS (CLASS TRAITS) OF MOLARS

- The molars develop from four to five lobes: One lobe for each cusp
- They are generally the largest teeth in both the arches
- Their crowns are shorter cervico-oclusally although they are wider in all other aspects. Usually the distal halves of the crowns are shorter
- The molar have four or five cusps and two or three roots
- The bifurcated/trifurcated roots are strong, well formed and are usually well spaced to have the best anchorage
- The crowns usually taper from mesial to distal aspect so that the buccolingual width of the mesial half is greater than that of the distal half
- The mesial and distal contact areas are broader and at the same level
- Usually, their distal marginal ridge is at a lower level than the mesial marginal ridge
- The cervical line on proximal and other surface is rather straight without much curvature
- The crest of curvature of the crowns on buccal surface is at the cervical third, whereas that of the lingual curvature in the middle third of the crown
- The lingual cusps (especially, the mesiolingual cusp) are longer than the buccal cusps
- Their occlusal tables are wide and best sited for communition of food.

FUNCTIONS OF MOLARS

- Molars have widest occlusal tables and are the main teeth used for trituration and communition of food.
- They give support to the cheeks.

PERMANENT MAXILLARY 1ST MOLAR

Permanent maxillary 1st molar is the largest tooth in the maxillary arch. It develops from five lobes, has a large crown and three well-formed roots. The tooth has four well-developed cusps and a small supplemental cusp. The four cusps are mesiobuccal, distobuccal, mesiolingual and the dentolingual. The small, non-functional cusp found lingual to the mesiolingual cusp, is called the '*cusp/tubercle of Carabelli*' or simply as the fifth cusp (**Fig. 12.2**). The presence of a well-developed fifth cusp or any trace of its development (*Carabelli's trait*) is the characteristic feature of maxillary 1st molars. The Carabelli's trait has varied expression; it can be in the form of a well developed fifth cusp or in the form of a groove, depression or pit on the mesial portion of the lingual surface (**Fig. 12.3**).

The trifurcated root provides an excellent anchorage in the alveolar bone and its tripod design is best suited to resist the oblique occlusal forces. The three roots are mesiobuccal, distobuccal and lingual. The lingual root is the longest among the three roots.

The maxillary 1st molars begin to calcify at birth and erupt around 6 years of age. The chronology and measurements are given in **Table 12.1**.

DETAILED DESCRIPTION OF MAXILLARY 1ST MOLAR FROM ALL ASPECTS

Figures 12.4 to 12.6 show maxillary 1st molar from various aspects.

CROWN

The crown of maxillary permanent 1st molar has five aspects:
1. Buccal
2. Lingual
3. Mesial
4. Distal
5. Occlusal.

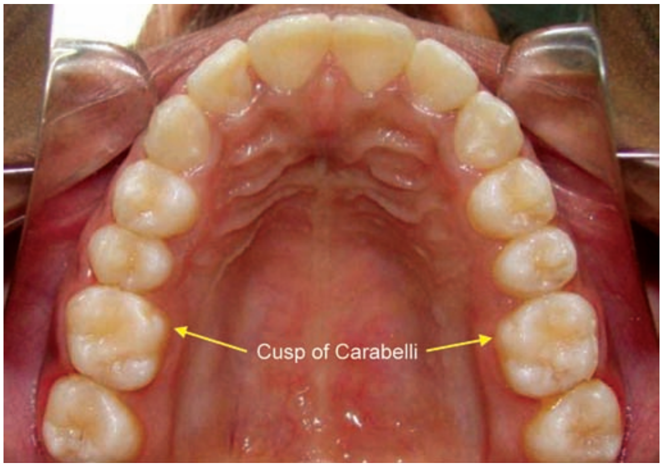


Figure 12.2 Cusp of Carabelli of permanent maxillary 1st molar

Buccal Aspect (Fig. 12.7)

Geometric shape: The buccal aspect has a *trapezoidal* shape with the shorter uneven side towards the cervical portion.

Table 12.1 Maxillary 1st molar—chronology and measurements

Chronology	
First evidence of calcification Enamel completed Eruption Roots completed	At birth 3–4 years 6 years 9–10 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	7.5
Length of root	Buccal–12.0, lingual–13.0
Mesiodistal diameter of crown	10.0
Mesiodistal diameter of crown at cervix	8.0
Buccolingual diameter of crown	11.0
Buccolingual diameter of crown at cervix	10.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

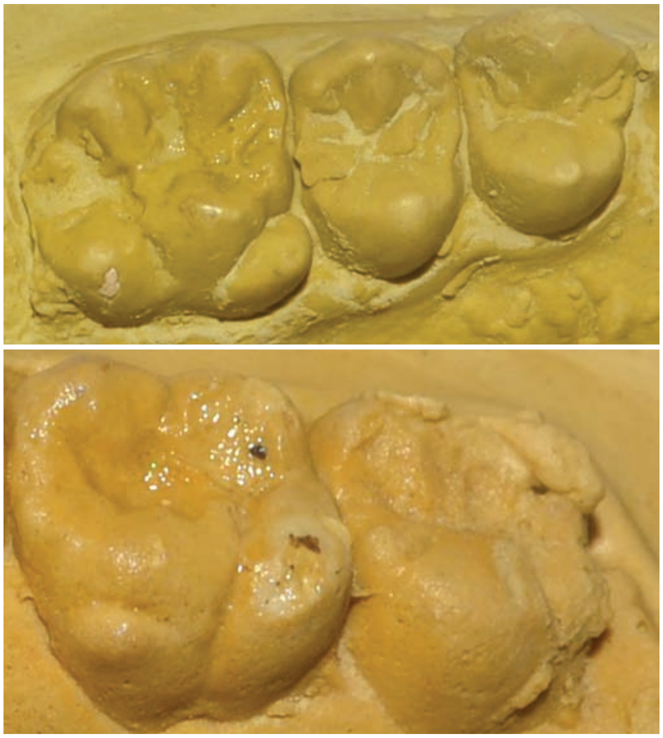


Figure 12.3 Varied expressions of Carabelli's trait

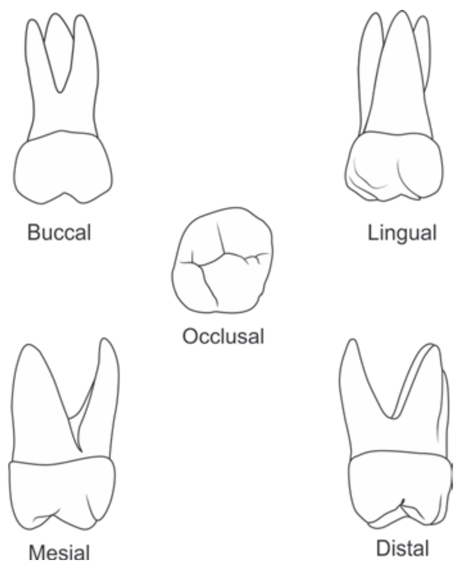


Figure 12.4 Maxillary 1st molar—line drawings

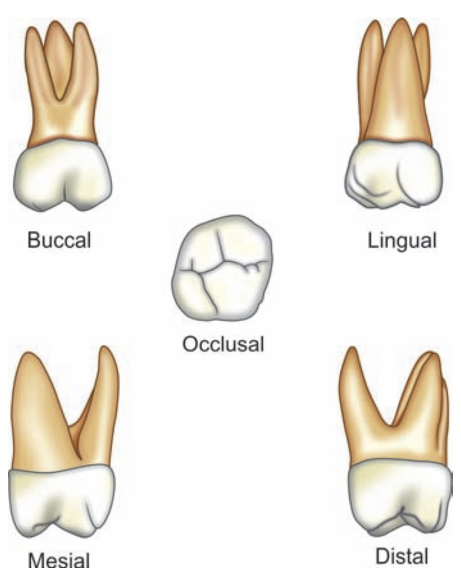


Figure 12.5 Maxillary 1st molar—graphic illustrations

Crown Outlines

The buccal aspect of the crown is bounded by four outlines:

1. Mesial outline
2. Distal outline
3. Occlusal outline
4. Cervical outline.

Mesial Outline

- The mesial outline is straight for most its course and becomes slightly convex as it joins the occlusal outline.
- The maximum convexity of mesial outline (*mesial contact area*) is at the occlusal third of the crown.

Distal Outline

- The distal outline is a more convex arc from cervix up to the point where it joins the occlusal outline.
- Its maximum convexity (*distal contact area*) is at the middle third of the crown.

Occlusal Outline

- The occlusal outline is formed by the mesiobuccal and distobuccal cusp tips and their cusp slopes
- The cusp slopes of mesiobuccal cusp make an obtuse angle, whereas the cusp slopes of distobuccal cusp meet at right angle
- The occlusal outline is interrupted in midway by the buccal developmental groove.

Cervical Outline

The cervical line on buccal surface of the crown is irregular and curves slightly in an apical direction.

Buccal Surface within the Outlines

- All the cusps (most of buccal cusps and part of lingual cusps) are visible from buccal aspect
- Some portion of distal surface can also be seen from this aspect as the crown tapers distally form mesial surface.
- The mesiobuccal cusp is widest but the distobuccal cusp is more pointed.
- Both the buccal cusps are nearly of same length though the mesiobuccal cusp may be longer.
- The *buccal developmental groove* separating the buccal cusp runs for half the length of buccal surface and ends in the buccal pit.
- The buccal surface is more convex in the cervical third, slightly concave/flattened in the middle third and is convex again in the occlusal third of the crown.

Lingual Aspect (Fig. 12.8)

Geometric shape: Trapezoidal like buccal aspect.

Crown Outlines

Mesial Outline

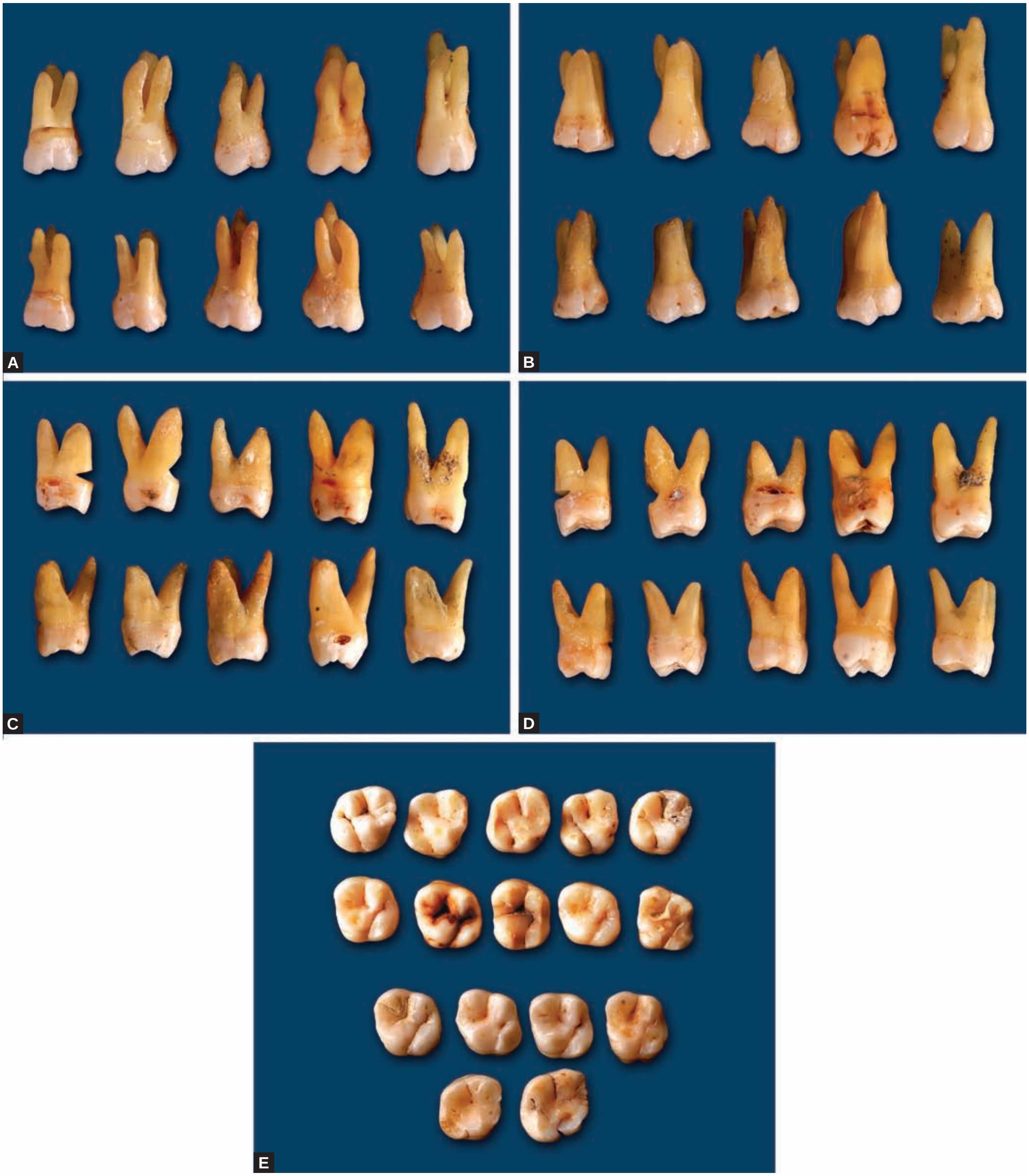
The mesial outline assumes a straight course dropping down from cervical area in a mesio-occlusal direction joins the mesial slope of mesiolingual cusp at right angles.

Distal Outline

The distal outline forms a semicircular arc by merging smoothly with the distolingual cusp.

Occlusal Outline

- The slopes of mesiolingual cusp are longer and meet at an obtuse angle.
- The *lingual developmental groove* interrupts the occlusal outline.



Figures 12.6A to E Maxillary 1st molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

Cervical Outline

The cervical outline on lingual surface is nearly straight.

Lingual Surface within the Outlines

- Only lingual cusps can be seen from the lingual aspect as the shorter buccal cusps are obscured.
- The mesiolingual cusp is much larger than the distolingual cusp which is smooth and spheroidal.
- The *lingual development groove* separating the two lingual cusps is confluent with the distolingual cusp, and extends mesiocervically to end at the center of lingual surface.
- The characteristic feature of lingual surface of maxillary 1st molar is the presence of some expression of *Carabelli's trait*. The fifth cusp may be well developed into a large cusp or may show traces of its development in the form of grooves, depressions or pits.
- When well developed, the fifth cusp ridge is cervically placed than the cusp ridge of mesiolingual cusp. It is usually separated by the mesiolingual cusp by a groove.
- A developmental depression begins at the center of lingual surface just cervical to the lingual developmental groove and extends beyond the cervical line onto the lingual surface of the lingual root to fade out at the middle third of the root.

Mesial Aspect (Fig. 12.9)

Geometric shape: It is *trapezoidal* like proximal aspect of all maxillary posteriors with shorter uneven side towards the occlusal portion.

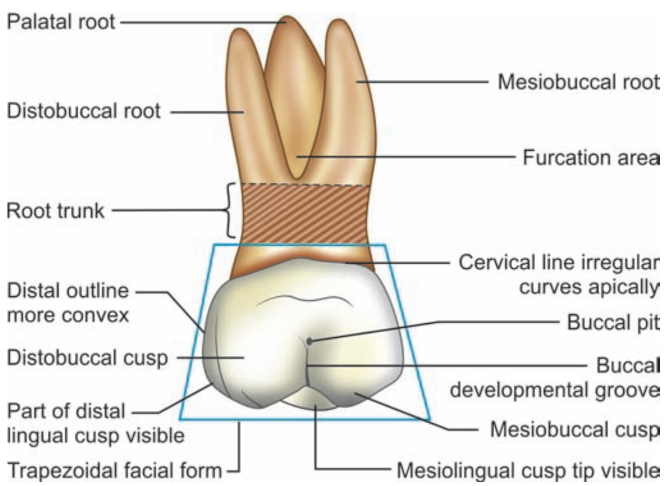


Figure 12.7 Maxillary 1st molar—buccal aspect

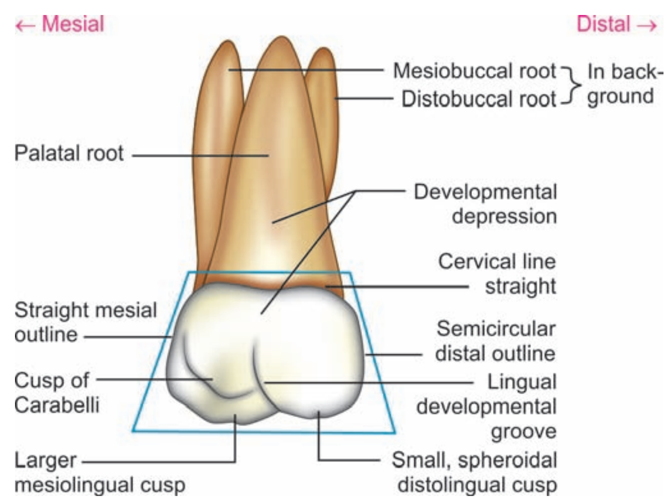


Figure 12.8 Maxillary 1st molar—lingual aspect

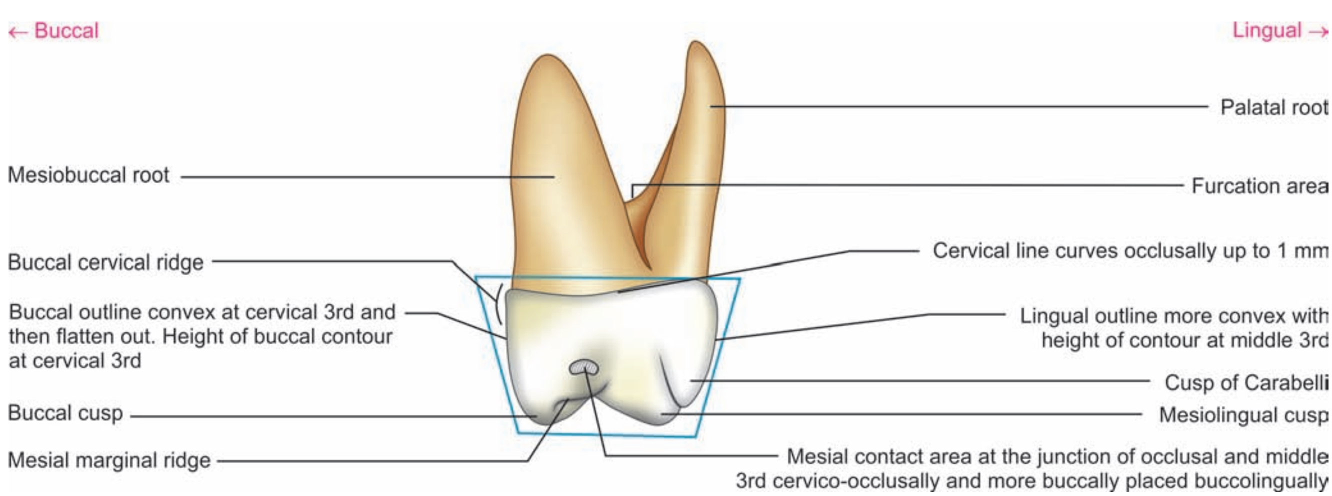


Figure 12.9 Maxillary 1st molar—mesial aspect

Crown Outlines

Buccal Outline

- The buccal outline is convex in cervical third and flattens out as it runs occlusally
- Height of contour of the buccal outline is within the cervical third.

Lingual Outline

- The lingual outline is a more convex arc from cervical line to the tip of mesiolingual cusp
- Height of lingual contour is at the middle third of the crown
- The lingual outline curves inwards when a well developed fifth cusp is present.

Occlusal Outline

It is formed by the mesial marginal ridge along with the triangular ridges of mesiobuccal and mesiolingual cusps towards the center of the occlusal surface.

Cervical Outline

Cervical outline on mesial surface curves occlusally up to 1 mm.

Mesial Surface within the Outlines

- The mesiobuccal, mesiolingual and fifth cusps are seen from mesial aspect.
- The cusp tips of mesiolingual and mesiobuccal cusp are within the confines of the root trunk.
- The mesiolingual cusp tip is on line with the long axis of the lingual root. The mesiobuccal cusp tip is on line with the buccal outline of the mesiobuccal root.
- There is a concavity cervical to the contact area which may extend onto the cervical portion of root trunk.
- The *mesial contact area* is at the junction of occlusal and middle third of the crown and is more buccally placed buccolingually.

Distal Aspect (Fig. 12.10)

Geometric shape: It is *trapezoidal* similar to mesial aspect.

The distal aspect has four outlines as mesial aspect.

Crown Outlines

Buccal Outline

The buccal outline is similar to that of the mesial aspect, except that some portion of buccal surface can also be seen as the buccal surface of the crown slants distally.

Lingual Outline

The lingual outline is smoothly convex from cervix to the distolingual cusp tip.

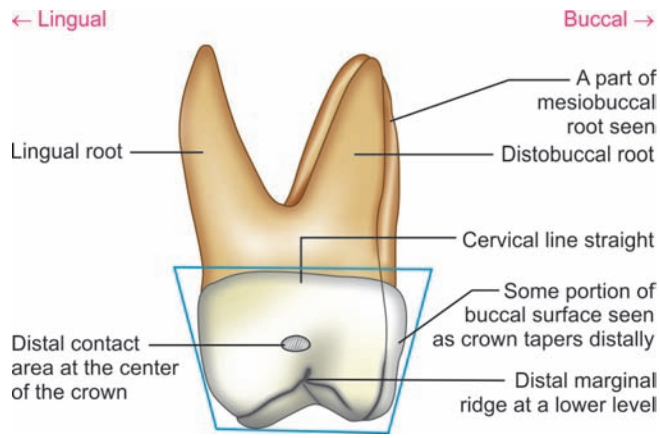


Figure 12.10 Maxillary 1st molar—distal aspect

Occlusal Outline

The distal marginal ridge is shorter and at a lower level than the mesial marginal ridge. Thus, some part of occlusal surface with triangular ridges of distal cusps may be seen.

Cervical Outline

The cervical line on distal surface is nearly a straight line without much curvature.

Distal Surface within the Outlines

- Only distobuccal and distolingual cusps are seen from distal aspect
- The distal surface is narrower than the mesial surface as the crown tapers towards distal aspect
- The distal surface is smoothly convex except for a concave area near the cervical line
- The *distal contact area* is at the center of the crown both cervico-occlusally and buccolingually.

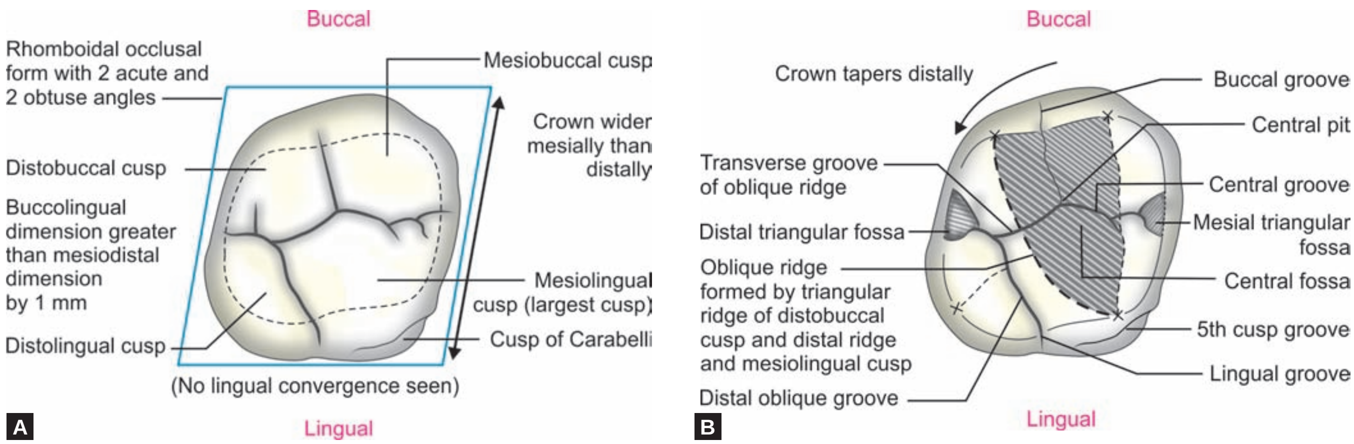
Occlusal Aspect (Figs 12.11A and B)

Geometric shape: The occlusal aspect the maxillary 1st molar is *rhomboidal* with two acute angles and two obtuse angles. Its sides are not equal.

- The two acute angles are—mesiobuccal and distolingual
- Two obtuse angles are—distobuccal and mesiolingual.

Relative Dimensions

- The buccolingual dimension of the crown is greater than the mesiodistal dimension by about 1 mm
- The crown tapers distally, thus it can be noted that, the buccolingual measurement of the crown mesially is greater than the same measurement distally



Figures 12.11A and B Maxillary 1st molar—occlusal aspect

- The mesiodistal dimension of the crown lingually is greater than its mesiodistal dimension buccally. In other words, the crown does not show lingual convergence which is generally seen in most permanent teeth.

Maxillary Molar Primary Cusp Triangle (Fig. 12.12)

- From the developmental point of view, the maxillary molars have only three primary cusps namely, the *mesiobuccal, the distobuccal and the mesiolingual*
- The distolingual cusp becomes progressively smaller on 2nd and 3rd maxillary molars
- The cusp of Carabelli present only in the 1st molar is considered as a secondary cusp
- A triangular outline can be visualized by tracking the cusp ridges of three primary cusps, the mesial marginal ridge and oblique ridge
- These three primary cusps can be seated on the root trunk divided into three roots
- This triangular arrangement of the three primary cusps is characteristic of all maxillary molars and is called as the *maxillary molar primary cusp triangle*. The design of the maxillary molar primary cusp triangle becomes progressively more evident from 1st molar to the 3rd molar.

Boundaries of the Occlusal Surface

The occlusal surface in the center of occlusal aspect in bounded by:

- Mesial and distal cusp ridges of four major cusps
- Mesial and distal marginal ridges.

Occlusal Surface within Boundaries

The occlusal surface exhibits:

- Cusps and cusp ridges
- Grooves and pits
- Fossae and marginal ridges.

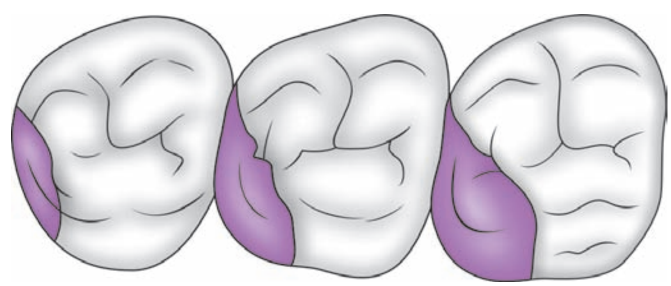


Figure 12.12 Maxillary molar primary cusp triangle

Cusps and Cusp Ridges

- The maxillary 1st molar has four major cusps and a supplemental fifth cusp (cusp of Carabelli), which may or may not be well developed.
- The cusps in the decreasing order of size are:
  - Mesiolingual (largest cusp)
  - Mesiobuccal
  - Distobuccal
  - Distolingual
  - Fifth cusp.
- Each cusp has mesial and distal cusp ridges and a triangular ridge of its own slopping towards the center of the occlusal surface
- There are inclined planes on either side of each triangular ridge
- There is an additional ridge crossing the occlusal surface obliquely, called the *oblique ridge*
- *The oblique ridge is formed by the union of the triangular ridge of the distobuccal cusp and the distal ridge of the mesiolingual cusp*. It is at the same level as the marginal ridges and is sometimes crossed by a developmental groove.

Grooves and Pits

Grooves

The maxillary 1st molar exhibits several developmental and supplemental grooves on its occlusal surface. The developmental grooves are situated at the bottom of deep long sulci traversing across the occlusal surface in different directions.

The developmental grooves are:
- The buccal developmental groove
- The central developmental groove
- The transverse groove of oblique ridge
- Distal oblique groove
- Fifth cusp groove
- Multiple supplemental grooves.

Buccal developmental groove: It runs buccally from the central pit located in the central fossa and continuous onto the buccal surface of the crown separating the two buccal cusps.

Central developmental groove: It runs in a mesial direction and ends at the apex of mesial triangular fossa where it is joined by supplemental grooves. This groove separates the triangular ridges of mesiobuccal and mesiolingual cusps.

Transverse groove of oblique ridge: It runs in a distolingual direction from the central pit and crosses the oblique ridge to reach the distal fossa.

Distal oblique groove
- It is irregular and runs in an oblique direction; parallel to the oblique ridge. This groove separates the distolingual cusp from the rest of the occlusal surface which forms the primary triangle of maxillary molars
- The distal oblique groove joins the lingual developmental groove which runs the lingual surface separating the two lingual cusps.

Fifth cusp groove: It separates the fifth cusp from the mesiolingual cusp, when the fifth cusp is not well developed, these is some trace of fifth cusp development in the form of a developmental groove which is also called as fifth cusp groove.

Multiple supplemental grooves: There are several supplementary grooves especially at the apices of mesial and distal triangular fossae. Some of these supplemental grooves may cross the marginal ridges.

Pits

Three pits can be noted on the occlusal surface of maxillary 1st molar.

Central Pit
- It is a pin point depression in the central fossa. Three major developmental grooves originate from the central pit and run in three different directions. The three grooves are at obtuse angles to each other. They are:
  - The buccal developmental groove radiating in a buccal direction.
  - The central developmental groove running mesially
  - Transverse groove of oblique ridge running distally.

Mesial Pit

It is at the apex of mesial triangular fossa developmental groove terminates at this pit.

Distal Pit

It is at the apex of the distal triangular fossa and the distal oblique grooves ends at this pit.

Fossae and Marginal Ridges

- There are two major and two minor fossae.
- The two major fossae are *central fossa* and the *distal fossa*.
- The two minor fossae are *mesial* and *distal triangular fossae*.

Major Fossae
- The central fossa is a large triangular depression in the center of the occlusal surface mesial to the oblique ridge.
  - The central fossa is bounded by the distal slope of the mesiobuccal cusp, mesial slope of the distobuccal cusp, the crests of the oblique ridge and the crests of triangular ridge of mesiobuccal and mesiolingual cusps.
  - It has the central pit at its center and three major developmental grooves run across it.
- The distal fossa is small linear developmental depression distal to the oblique ridge. It has distal oblique developmental groove at its deepest position.

Minor Fossae
- Mesial triangular fossa is a triangular depression having mesial marginal ridge for its base and mesial pit for its apex. Supplemental grooves radiate from the mesial pit forming the side of the triangle.
- The distal triangular fossa has the distal marginal ridge at its base and distal pit at its apex. Supplemental grooves radiate from the distal pit forming the sides of triangle.

Marginal Ridges

The mesial and distal marginal ridges are well developed. The distal marginal ridge is shorter and is at a lower level than the mesial marginal ridge.

ROOT

Number

The maxillary molar has three well formed roots they are mesiobuccal, distobuccal and lingual/palatal.

Size

In general, the roots are about twice the length of the crown. The palatal root is longest and largest and the two buccal roots are of nearly same length. The mesiobuccal root is larger than the distobuccal root.

Form

- The roots are strongly developed and designed to withstand the occlusal forces. The root trunk is about 1/3 the root length is well within the confines of the crown
- The root soon divides into three branches with the level of furcation nearest to the cervical line on the mesial surface and far from the cervical line on the distal surface
- The palatal root is wider mesiodistally but narrower buccolingually. It extends lingually and stretches out of the confines of the crown before bending back in a buccal direction at its apical third
- The mesiobuccal root is broader buccolingually than mesiodistally. The distobuccal root is the smallest root
- The two buccal roots diverge from the root trunk for half their length and face each other again at their apical halves
- The distobuccal root is more distally tilted whereas the mesiobuccal root has relatively straight long axis.

Visibility from Different Aspects

- All the three roots are visible from buccal and lingual aspects. Only two roots, i.e. the palatal and mesiobuccal are visible from the mesial aspect, since the smaller distobuccal root is not seen.
- From distal view, the palatal and distal roots are in focus with that of mesiobuccal root seen in background.

Developmental Grooves and Depressions on Root

- There is a deep developmental groove beginning at the bifurcation of the buccal roots and runs towards the cervical line.
- There is a developmental depression at the bifurcation point of mesiobuccal and lingual root which extends lingually towards the cervical line.

Apices

All the three roots have bluntly rounded apices.

Curvature

In general, the buccal roots tend to tilt distally. The palatal root has a vertical axis and its apical third is curved buccally.

VARIATIONS

Morphology of maxillary 1st molar does not very much except for the widely varied expression of the Carabelli's trait.

DEVELOPMENTAL ANOMALIES (FIGS 12.13A AND B)

- Supernumerary roots (tooth may have extra roots)
- Dilaceration of root (sharp bend in the root)
- Concrescence (fusion of two adjacent teeth by cementum).

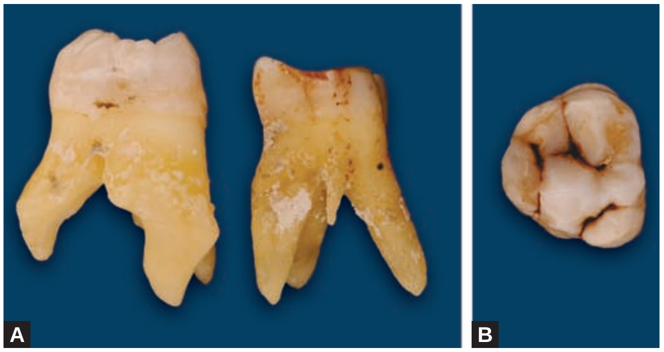
CLINICAL CONSIDERATIONS

- The anteroposterior position of maxillary and mandibular 1st molars establish the important Angle's key of occlusion (**Figs 12.14A to C**).
- As the three roots provide excellent anchorage, left and right maxillary 1st molars are used for anchorage in orthodontic treatment (**Fig. 12.15**).
- The oblique ridge has to be restored during conservative and prosthetic procedures on the maxillary 1st molar
- Carabelli's trait is used in anthropology for distinguishing the different population groups. Cusp of Carabelli is much more frequently seen in white population and less frequent in Mongoloid and Negroid race groups.

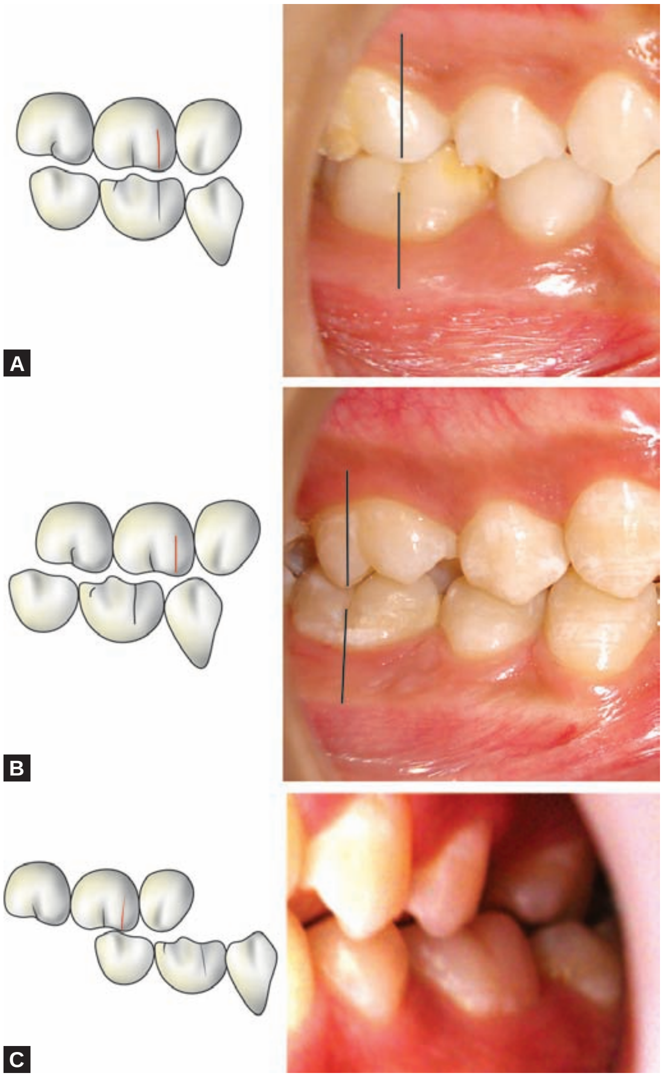
The maxillary 1st molar anatomy is summarized in **Flow charts 12.1 and 12.2**. **Box 12.1** gives the identification features of this tooth.

PERMANENT MAXILLARY 2ND MOLAR

The permanent maxillary 2nd molar resembles the permanent maxillary 1st molar closely and supplements the latter in function. The crown of maxillary permanent 2nd molar is slightly shorter than that of maxillary permanent 1st molar, although the roots are as long as the roots of maxillary permanent 1st molar. The roots are not as divergent as seen in maxillary permanent 1st molar. The distobuccal cusp is somewhat less well developed than that in maxillary 1st molar. The distolingual cusp is smaller leaving the maxillary molar primary cusp triangle more prominent.



Figures 12.13A and B Maxillary 1st molar—developmental anomalies



Figures 12.14A to C Angle's key of occlusion: (A) Class 1; (B) Class 2; (C) Class 3

There are two forms of maxillary 2nd molar depending on their occlusal anatomy (**Figs 12.16A and B**):

1. *Four cusp type* with *rhomboidal occlusal design*. This type is more common and resembles maxillary 1st molar in occlusal form.
2. *Three cusp type* with *pear/heart-shaped occlusal aspect* resembling maxillary 3rd molar.

The maxillary and mandibular 2nd molars begin to calcify by 2½ years and erupt around 12 years of age. The maxillary and mandibular 2nd molars are thus sometimes referred to as the *12-year molars*. The chronology and measurements of maxillary 2nd molar are given in **Table 12.2**.

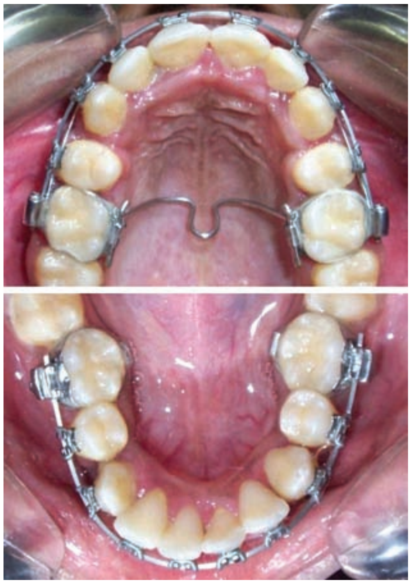


Figure 12.15 Permanent maxillary 1st molars are often used as intraoral anchorage units during orthodontic treatment. The irregular teeth are pulled back into normal alignment using the 1st molars as steady pillars of anchorage

DETAILED DESCRIPTION OF MAXILLARY 2ND MOLAR FROM ALL ASPECTS

Figures 12.17 to 12.19 show maxillary 2nd molar from various aspects.

CROWN

Buccal Aspect (Fig. 12.20)

Geometric shape: It is *trapezoidal* with shorter uneven side towards the cervical portion.

Crown Outlines

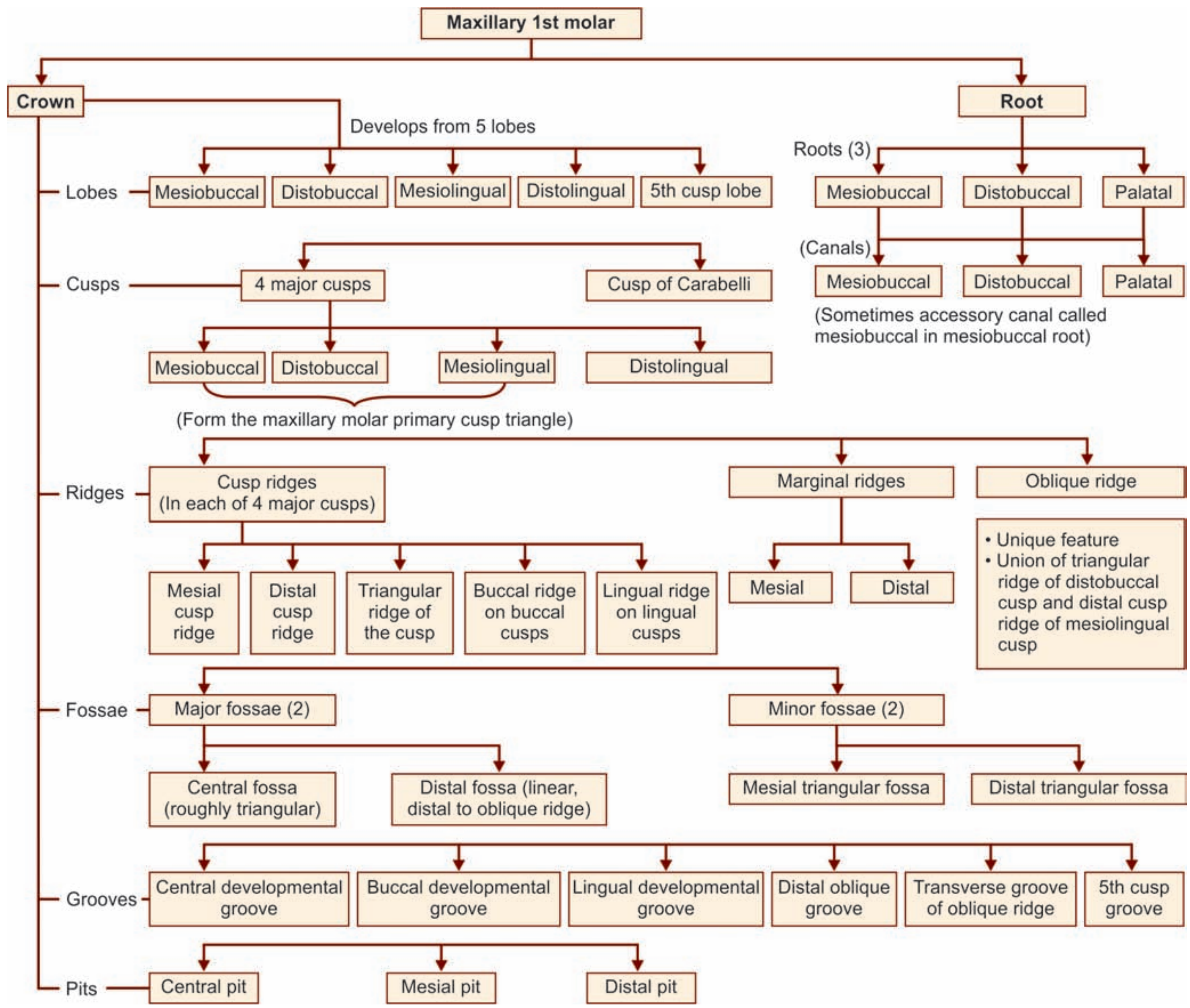
Mesial Outline

- The mesial outline is nearly a straight line extending mesio-occlusally up to the mesial contact area where it becomes convex
- Its maximum convexity (*mesial contact area*) is at the junction of occlusal and middle third of crown.

Distal Outline

- The distal outline is convex from cervix to the point where it joins the occlusal outline
- Its maximum convexity (*distal contact area*) is at the middle third of the crown.

Flow chart 12.1 Maxillary 1st molar—major anatomic landmarks



Box 12.1 Maxillary 1st molar—identification features

Identification features of maxillary 1st molar
- The tooth has a large crown and three roots
- The crown is wider buccolingually than mesiodistally
- Its occlusal aspect is rhomboidal
- The cusp of Carabelli is a unique feature of maxillary molar, present lingual to the mesiolingual cusp
- Another characteristic feature of maxillary molar is the oblique ridge running obliquely from the mesiolingual cusp to the disto-lingual cusp.

Side identification
- When viewed occlusally, the crown is wider mesially than distally
- By locating the cusp of Carabelli that is located lingual to the mesiolingual cusp
- The buccal roots tend to have a distal inclination.

Occlusal Outline

- The occlusal outline is formed by the cusp tips and ridges of the buccal cusps separated by the buccal groove
- The outline appears to tilt cervically in a distal direction.

Cervical Outline

The cervical line on buccal surface is nearly straight mesiodistally.

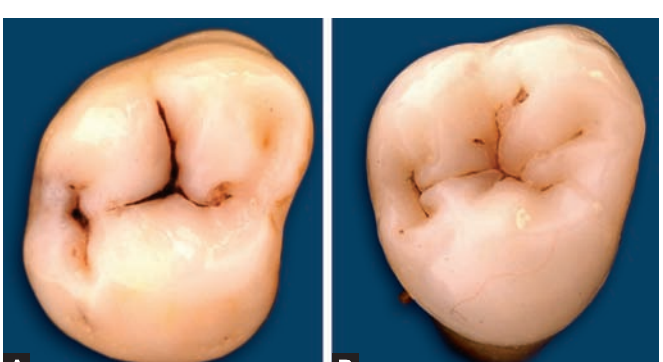
Buccal Surface within the Outlines

- Buccal surface is similar to that of maxillary permanent 1st molar. But the crown is shorter and narrower mesiodistally

Flow chart 12.2 Maxillary 1st molar—summary

Maxillary 1st molar

- **Crown**
  - **Buccal aspect**
    - Geometric shape
      - Trapezoidal with shorter uneven side towards cervix
    - Crown outlines
      - Mesial—slightly convex
      - Distal—more convex
    - Cusps seen
      - Both the buccal cusps
      - Part of lingual cusps (all cusps seen)
    - Buccal cusps
      - Mesiobuccal—wider
      - Distobuccal—more pointed
      - Both cusps are, of same length
    - Cervical line
      - Irregular
      - May dip apically towards furcation
    - Developmental grooves
      - Buccal developmental groove
    - Buccal surface
      - Broad
      - Convex in cervical 3rd and flattened in middle 3rd
  - **Lingual aspect**
    - Trapezoidal like buccal aspect
    - Lingual convergence
      - No lingual convergence
      - Crown wider lingually than buccally
    - Cusps seen
      - Only lingual cusps seen
    - Lingual cusps
      - Mesiolingual cusp—larger
      - Distolingual cusp—small spheroidal
    - Accessory cusp/cusp of Carabelli
      - Lingual to the mesiolingual cusp
    - Developmental grooves
      - Lingual developmental groove
      - Fifth cusp groove
  - **Mesial aspect**
    - Trapezoidal with shorter uneven side towards occlusal
    - Crown outlines
      - Buccal—convex–(cervical ridge) cervically and then straight
      - Lingual—more convex
    - Cusps seen
      - Mesiobuccal
      - Mesiolingual
      - Cusp of Carabelli
    - Height of contours
      - Buccal—cervical 3rd on cervical ridge
      - Lingual—at middle 3rd
    - Mesial surface
      - Concavity present cervical to contact area
    - Mesial contact area
      - At junction of middle and occlusal 3rd
      - Buccally placed buccolingually
  - **Distal aspect**
    - Trapezoidal like mesial aspect
    - Cusp seen
      - Only distobuccal and distolingual cusps seen
    - Distal marginal ridge
      - Shorter
      - At lower level than mesial marginal ridge
    - Cervical line
      - Straight line without curvature
    - Distal contact area
      - At center of crown both cervico-occlusally and buccolingually
  - **Occlusal aspect**
    - Rhomboidal with 2 acute and 2 obtuse angles
    - 2 acute angles—mesiobuccal and distolingual
    - 2 obtuse angles—distobuccal and mesiolingual angles
    - Relative dimensions
      - Buccolingual dimension greater than mesiodistal dimension by 1 mm
    - Crown taper
      - Towards distal
      - Crown wider buccolingually at mesial than distal characteristic feature of maxillary 1st molar
    - Oblique ridge
      - Characteristics feature
    - Developmental grooves
      - Buccal groove
      - Lingual groove
      - Central groove
      - Transverse groove of oblique ridge
      - Distal oblique groove
      - Fifth cusp groove
    - Fossae
      - 2 major
        - Central fossa
        - Distal fossa
      - 2 minor
        - Mesial and distal triangular fossae
    - Pits
      - Central
      - Mesial
      - Distal
- **Root**
  - Number
    - 3 roots
    - Mesiobuccal
    - Distobuccal
    - Palatal
  - Pulp canals
    - 3 or 4 canals
  - Size
    - Twice the length or crown
    - All 3 roots of same length
    - Palatal larger
  - Root curvature
    - Buccal roots tilt distally
    - Palatal root—straight
  - Apices
    - Blunt



Figures 12.16A and B The maxillary 2nd molar are of two forms: (A) 4 cusp/rhomboidal type; (B) 3 cusp type/heart-shaped type

- The distobuccal cusp is much smaller and shorter than the mesiobuccal cusp. Thus, a part of distolingual cusp can be seen from the buccal aspect
- The *buccal developmental groove* separates the two buccal cusps.

Lingual Aspect (Fig. 12.21)

Geometric shape: *Trapezoidal* similar to buccal aspect.

Crown Outlines

- Mesial outline
- Distal outline
- Cervical outline

} are similar to buccal aspect

Table 12.2 Maxillary 2nd molar—chronology and measurements

Chronology	
First evidence of calcification Enamel completed Eruption Roots completed	2½ years 7–8 years 12–13 years 14–16 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	7.0
Length of root	buccal—11.0 lingual—12.0
Mesiodistal diameter of crown	9.0
Mesiodistal diameter of crown at cervix	7.0
Buccolingual diameter of crown	11.0
Buccolingual diameter of crown at cervix	10.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

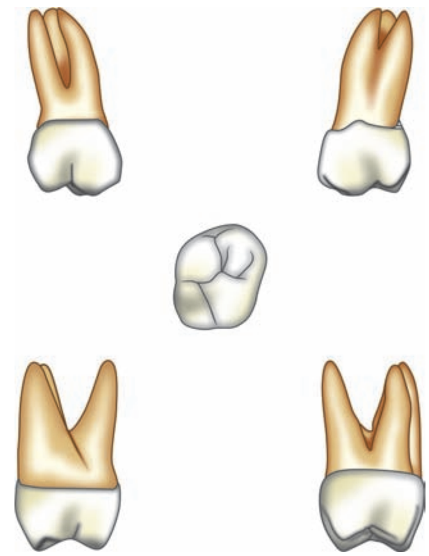


Figure 12.18 Maxillary 2nd molar—graphic illustrations

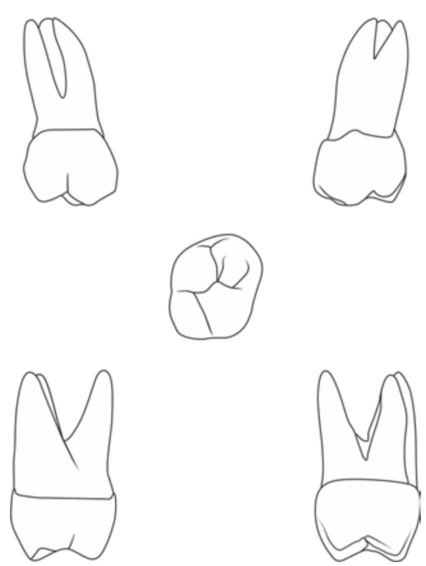


Figure 12.17 Maxillary 2nd molar—line drawings

Occlusal Outline
- The occlusal outline is formed by the cusp tips and cusp ridges of sharper mesiolingual cusp and roundened distolingual cusp.
- The outline is interrupted by the lingual developmental groove.

Lingual Surface within the Outlines
- The distolingual cusp is much smaller and shorter than the mesiolingual cusp
- The lingual surface is smoothly convex except for the *lingual developmental groove* separating the two lingual cusps
- There is no fifth cusp seen.

Mesial Aspect (Fig. 12.22)

Geometric shape: The crown is trapezoidal with shorter uneven side towards the occlusal portion.

Crown Outlines

Buccal Outline
- The buccal outline is more convex in its cervical third and is less convex from there up to the mesiobuccal cusp tip
- *Height of buccal contour* is in the cervical third of the crown. Buccal contour of all the molars exhibit maximum convexity at the cervical third—due to buccal cervical ridge.

Lingual Outline
- The lingual outline is convex from cervix to the mesiolingual cusp tip
- Height of lingual contour—at the middle third.

Occlusal Outline
The mesial marginal ridge forms a smooth concave arc merging with the mesial cusp ridges of mesiobuccal and mesiolingual cusps.

Figures 12.19A to E Maxillary 2nd molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

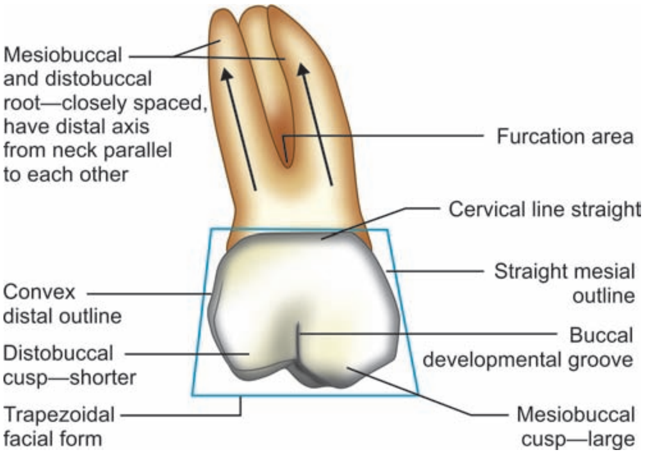


Figure 12.20 Maxillary 2nd molar—buccal aspect

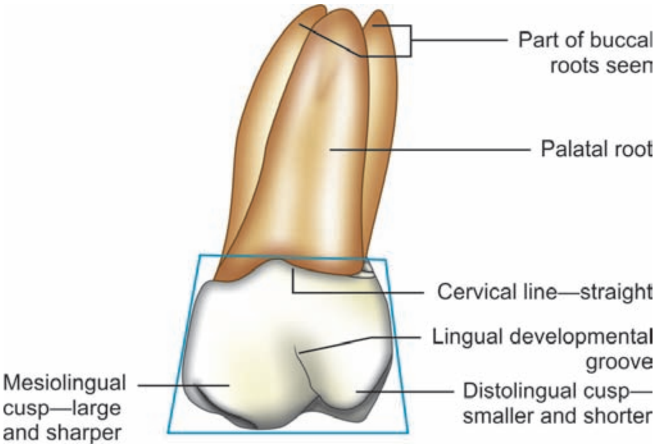


Figure 12.21 Maxillary 2nd molar—lingual aspect

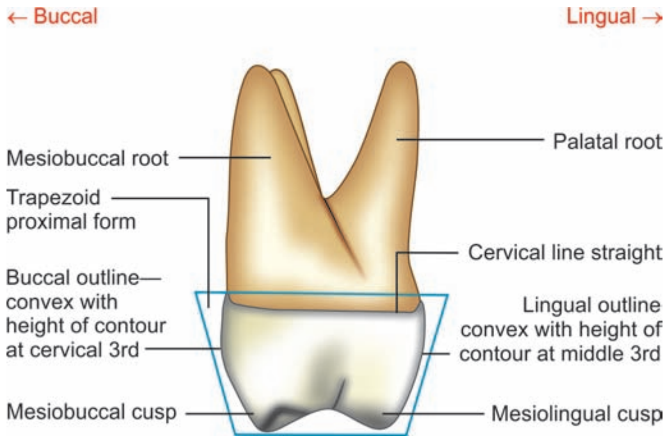


Figure 12.22 Maxillary 2nd molar—mesial aspect

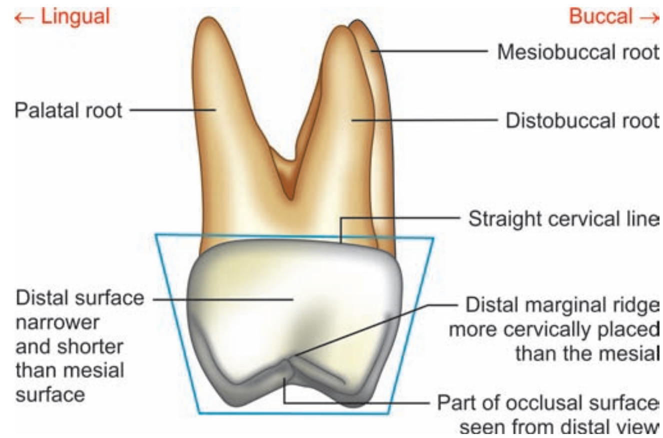


Figure 12.23 Maxillary 2nd molar—distal aspect

Cervical Outline

The cervical line is almost a straight line.

Mesial Surface within the Outlines

- The mesial surface is smoothly convex and the crown appears shorter than that of maxillary permanent 1st molar
- The mesiobucccal and mesiolingual cusps are almost of same length, although the mesiolingual cusp is larger.

Distal Aspect (Fig. 12.23)

Geometric shape: *Trapezoidal* like that of mesial aspects.

Crown Outlines

- Buccal outline
- Lingual outline
- Cervical outline

} are similar to mesial aspect

Occlusal Outline

- The distal marginal ridge is at a lower level than mesial marginal ridge
- It is rather irregular and slopes cervically towards the smaller distobuccal cusp.

Distal Surface within the Outlines

- The distal surface is narrower and shorter than the mesial surface
- As the distal marginal ridge is more cervically placed, some portion of occlusal surface can be seen
- Some part of buccal surface and mesiobuccal cusp can also been seen from distal aspect.

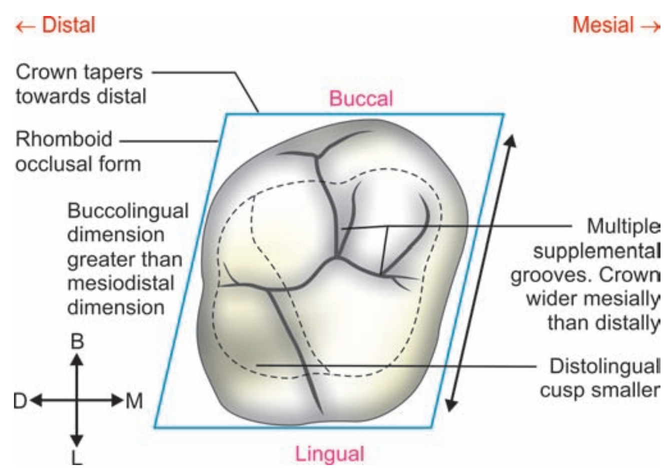


Figure 12.24 Maxillary 2nd molar—occlusal aspect

Occlusal Aspect (Fig. 12.24)

Geometric shape: In the four-cusp type:

- The occlusal aspect appears *more rhomboidal*.
- The mesiobuccal and distolingual line angle are more acute
- The distobuccal and mesiolingual line angles are more obtuse.

In the three-cusp type:

- The occlusal form is *heart shaped*, highlighting the primary cusp triangle of the maxillary molars.
- The distolingual cusp is very small.

Relative Dimensions

- The buccolingual dimension is more than the mesiodistal dimension, especially so in the four cusp type with rhomboid form.
- The distobuccal cusp is small and less well developed.

Rhomboidal Form

- The tooth resembles maxillary permanent 1st molar.
- Mesiolingual cusp is the largest followed by the mesiobuccal cusp. The distobuccal cusp is less well-developed and its small size accentuates the rhomboid outline of occlusal aspect.
- The distolingual cusp is small and appears to be separated from the rest of the occlusal portion.
- The oblique ridge is less prominent.
- The crown tapers towards the distal surface. Thus, the buccolingual dimension of the crown is greater mesially than distally.
- Multiple supplemental grooves can be seen along with the developmental grooves.

Heart-shaped Form

- This type of maxillary 2nd molar resembles maxillary 3rd molar
- The mesiolingual cusp is as well developed as seen in the 1st maxillary molar
- But the distolingual cusp is very minute or absent making the crown appear heart shaped.

ROOT

Number

There are three roots originating from a common root base.

Size

The roots are as long as those of maxillary 1st molar roots.

Form

- The buccal roots are more distally inclined than that of maxillary 1st molar, often reaching out of the distal extremity of the crown
- The lingual root does not diverge much lingually and it is within the confines of the crown when seen from proximal aspects
- The mesiobuccal and distobuccal roots are in close approximation and they have a parallel course.

Apices

The apices of the root are sharper than that of maxillary 1st molar.

Curvature of Roots

In general, all the three roots are inclined distally.

VARIATIONS (FIGS 12.25A AND B)

- Fused root
- Long/short root
- Supernumerary roots
- Crown with accentuated rhomboid outline and multiple small tubercles.

DEVELOPMENTAL ANOMALIES

- Dilacerations of roots
- Concrescence.

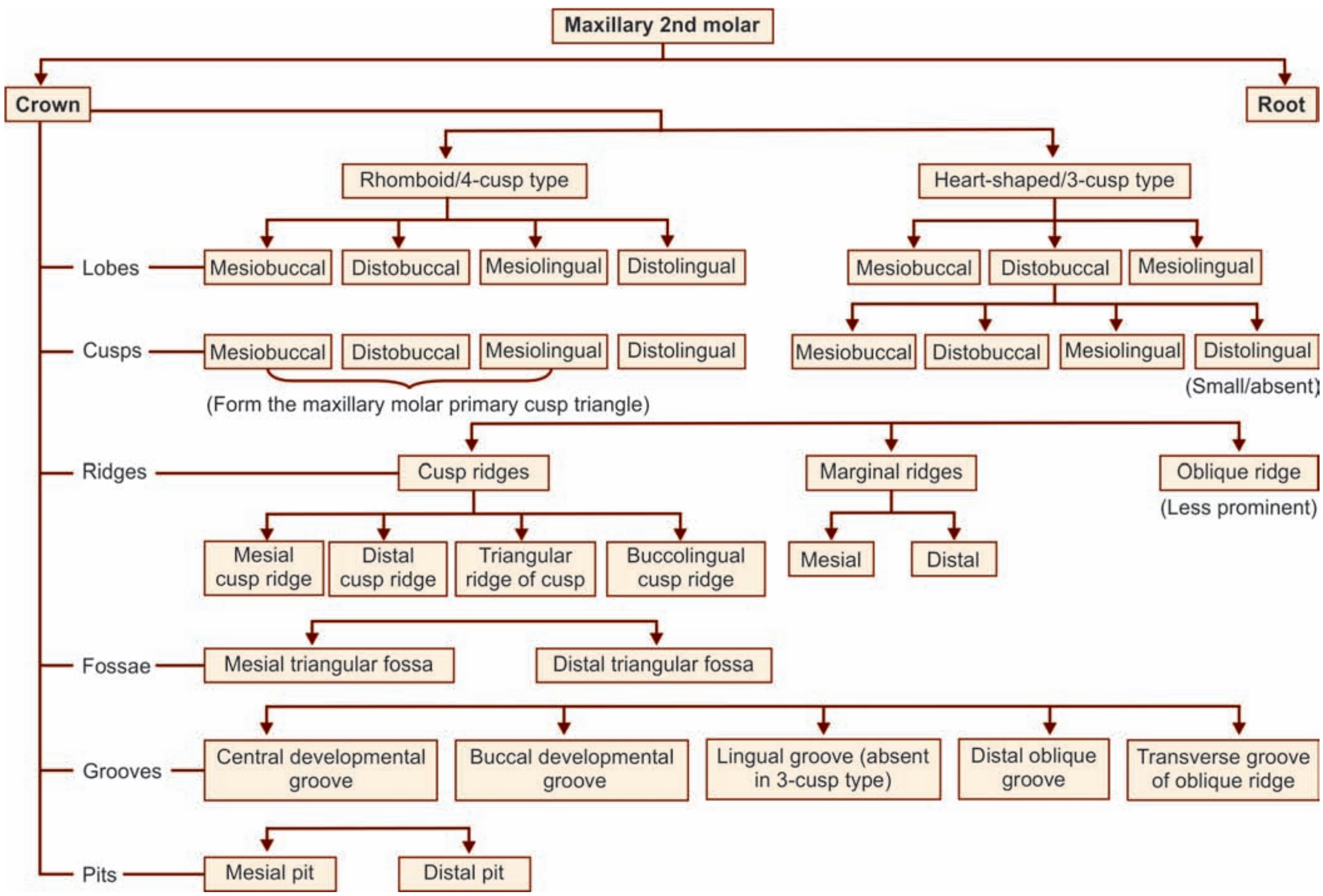
Flow chart 12.3 gives major anatomic landmarks of maxillary 2nd molar and **Flow chart 12.4** summarizes the tooth anatomy. **Box 12.2** gives the identification features of the tooth.

PERMANENT MAXILLARY 3RD MOLAR

The permanent maxillary 3rd molars, in both the dental arches are highly variable in their size and form than any other teeth. They are the most common teeth to be congenitally missing. In maxillary 3rd molar crown is smaller and shows resemblance to heart shaped type of second maxillary permanent molar when viewed occlusally (**Fig. 12.26**). The distolingual cusp is very small and poorly developed, or may even be completely absent. The tooth assists the 2nd molar in function. The roots are shorter and have a strong tendency to fuse. Sometimes, the maxillary 3rd molars appear as developmental anomalies with little or no resemblance to adjacent teeth. The maxillary 3rd molar is directly compared with the maxillary 2nd molar in its description.

Figures 12.25A and B Maxillary 2nd molar—variation: (A) Supernumerary root; (B) Accentuated rhomboid form with multiple small tubercles on the occlusal surface

Flow chart 12.3 Maxillary 2nd molar—major anatomic landmarks



Box 12.2 Maxillary 2nd molar—identification features

Identification features of maxillary 2nd molar

- Crown is shorter with comparatively long roots. The root is trifurcated
- There is no evidence of the 5th cusp development
- Mesiolingual cusp is the largest
- Distolingual cusp is small or absent
- The oblique ridge is less prominent
- The roots do not spread out much, tend to fuse and have a distal inclination.

Side identification

- The crown is wider mesially than distally
- The distolingual cusp is small or absent
- The roots are not wide apart and are inclined distally.

The maxillary and mandibular 3rd molars are the last teeth to erupt into oral cavity at around 17 to 21 years of age. Since they erupt late in life, they are also commonly referred to as the *wisdom teeth*. The chronology and measurements of the maxillary 3rd molar are given in **Table 12.3**.

DETAILED DESCRIPTION OF MAXILLARY 3RD MOLAR FROM ALL ASPECTS

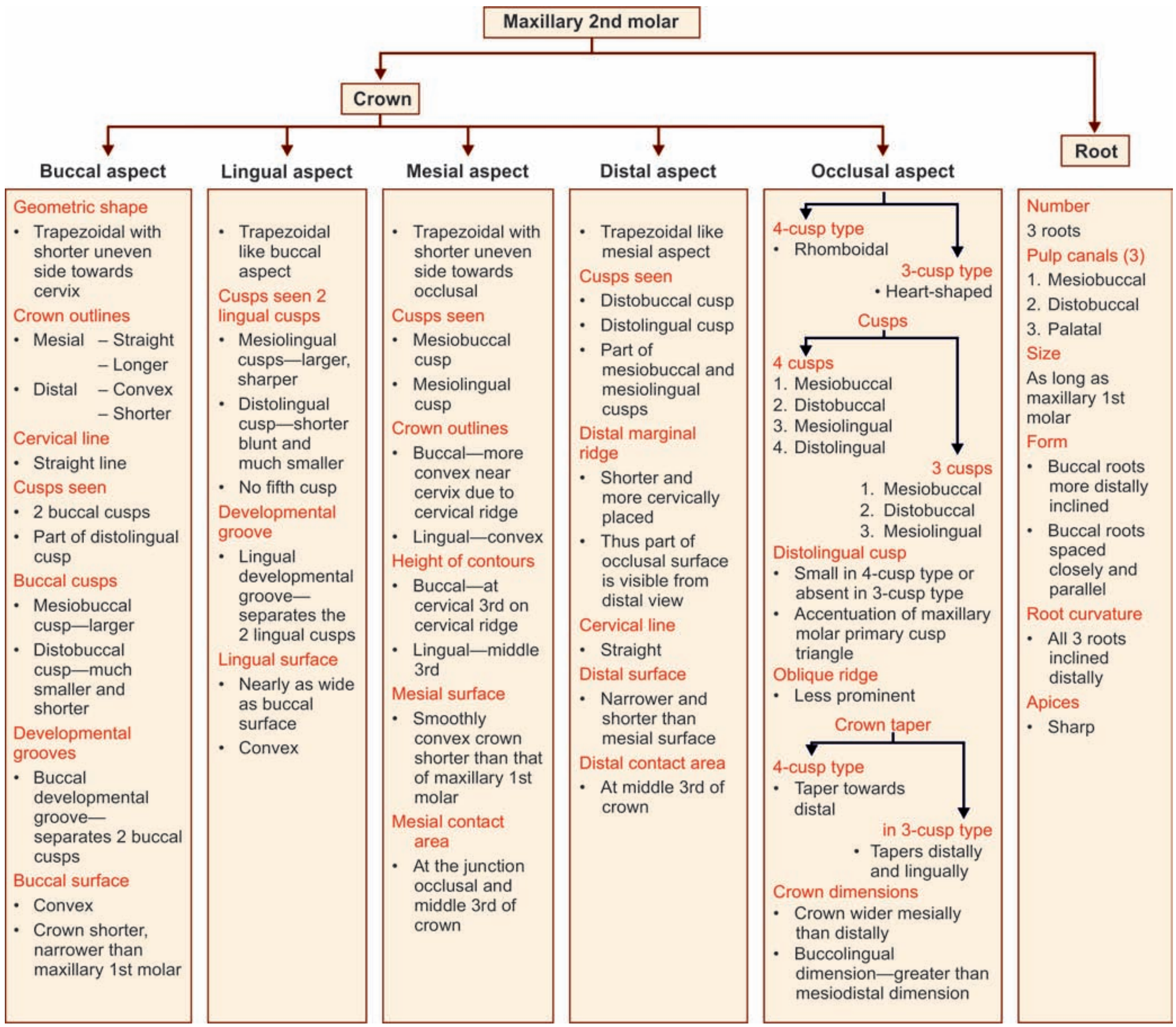
Figures 12.27 to 12.29 show maxillary 3rd molar from various aspects.

CROWN

Buccal Aspect (Fig. 12.30)

- The mesiobuccal and distobuccal cusps are seen from buccal aspect. When compared to maxillary 2nd molar, the crown is shorter in length and narrower in its mesiodistal width. The distobuccal cusp is much smaller than the mesiobuccal cusp.
- The cervical line is irregular without much curvature.
- Buccal developmental groove is seen separating the two buccal cusps.

Flow chart 12.4 Maxillary 2nd molar—summary



Lingual Aspect (Fig. 12.31)

- The mesiolingual cusp occupies most of the lingual aspect of the crown and thus, there is no lingual developmental groove
- Sometimes a small distolingual cusp may be present.
- The lingual surface is spheroidal.

Mesial and Distal Aspects (Figs 12.32 and 12.33)

- The distal surface is shorter and narrower than the mesial surface
- The cervical line on proximal surfaces is rather straight.

Occlusal Aspect (Fig. 12.34)

From the occlusal view, the tooth generally resembles the heart shaped type of maxillary permanent 2nd molar.

Geometric shape: The occlusal aspect has a heart-shaped outline formed by the three major cusps, namely mesiobuccal, distobuccal and mesiolingual.

Relative Dimensions

- The buccolingual dimension is greater than mesiodistal dimension
- The crown is larger buccally than lingually.

Figure 12.26 Maxillary 3rd molar resembles heart 2nd molar occlusally

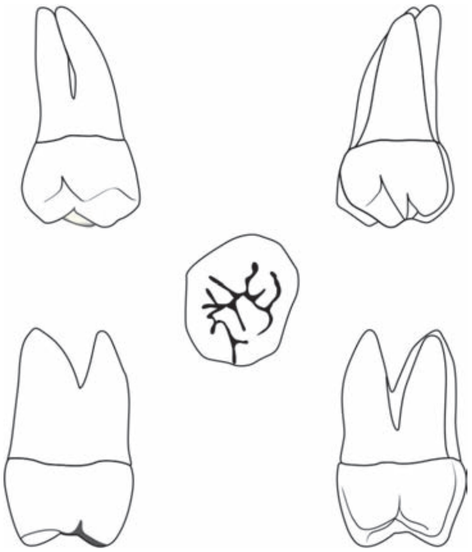


Figure 12.27 Maxillary 3rd molar—line drawings

Table 12.3 Maxillary 3rd molar—chronology and measurements

Chronology	
First evidence of calcification Enamel completed Eruption Roots completed	7–9 years 12–16 years 17–21 years 18–25 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	6.5
Length of root	11.0
Mesiodistal diameter of crown	8.5
Mesiodistal diameter of crown at cervix	6.5
Buccolingual diameter of crown	10.0
Buccolingual diameter of crown at cervix	9.5
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

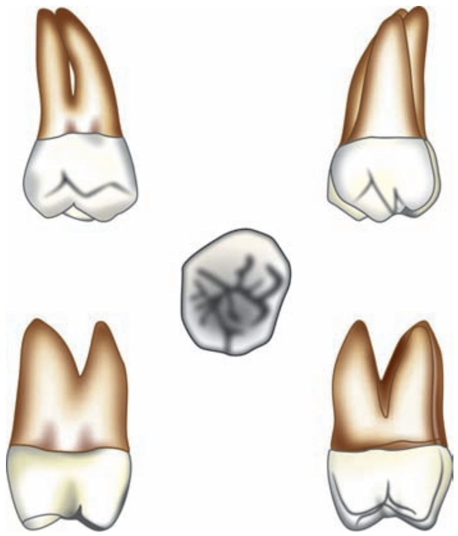


Figure 12.28 Maxillary 3rd molar—graphic illustrations

Occlusal Features

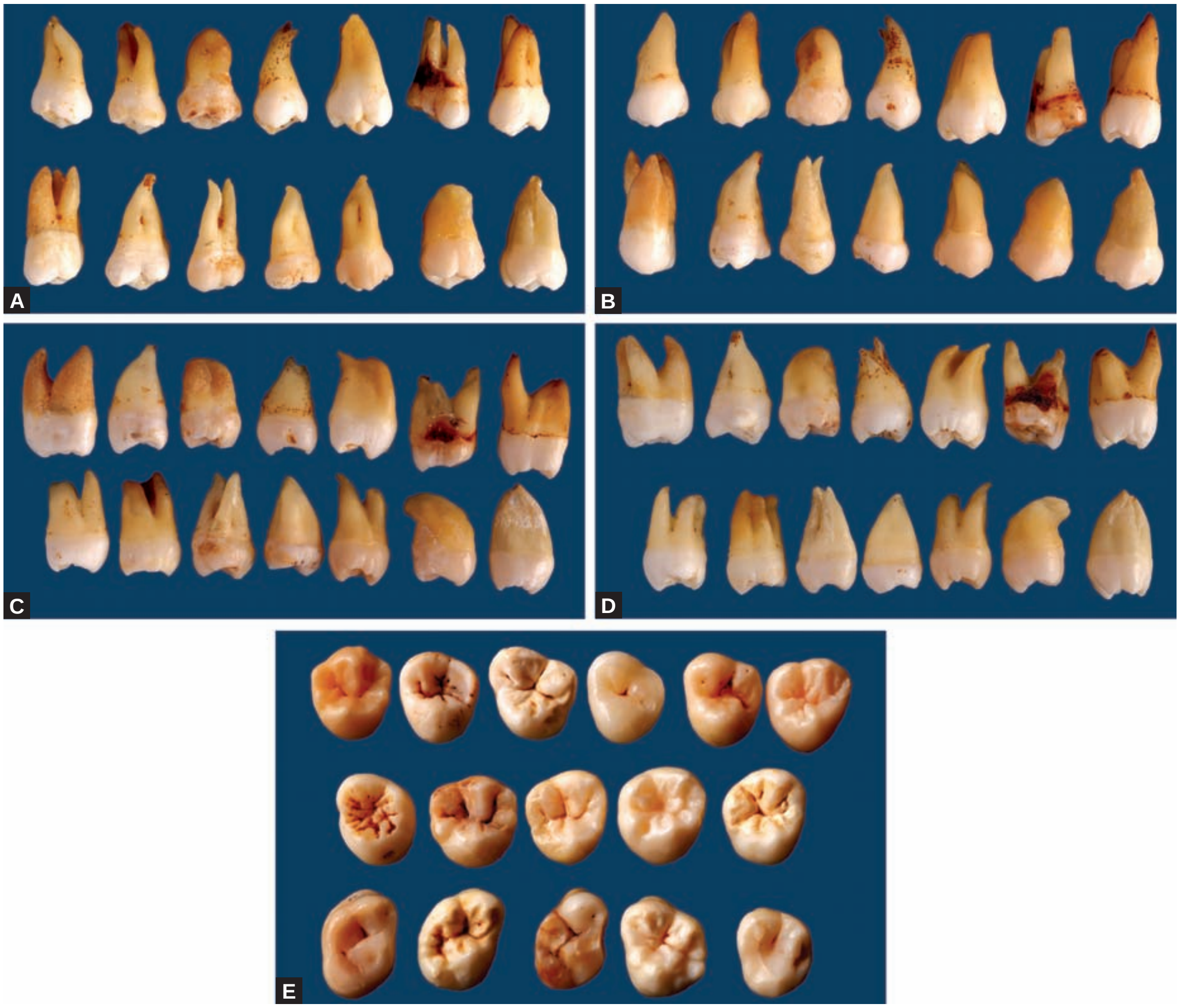
- The occlusal form can be irregular with small tubercles and multiple supplemental grooves.
- Sometimes the tooth has four cusps and close resemblance to maxillary 2nd molar.

ROOT

- Though maxillary 3rd molars have three roots, they function like a single unit as they are often fused together
- The fused roots may show division in apical end
- The roots collectively bend in a distal direction.

VARIATIONS (FIG. 12.35)

- Crown and root of the tooth can be well formed resembling maxillary 2nd molar
- Very long or very short roots
- The crown form varies greatly and often sometimes appear like anomalies.



Figures 12.29A to E Maxillary 3rd molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

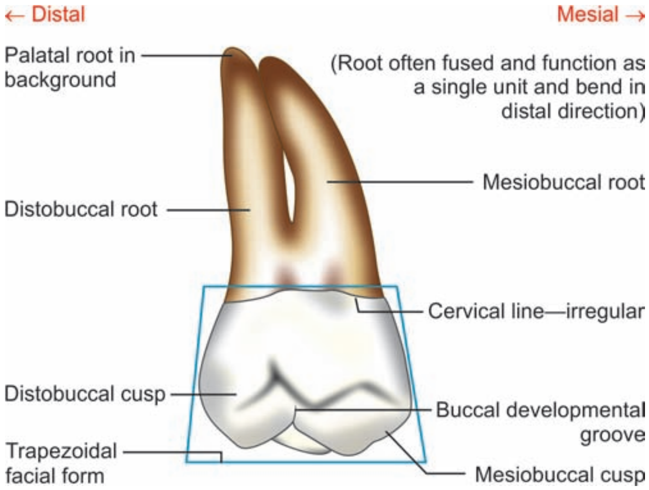


Figure 12.30 Maxillary 3rd molar—buccal aspect

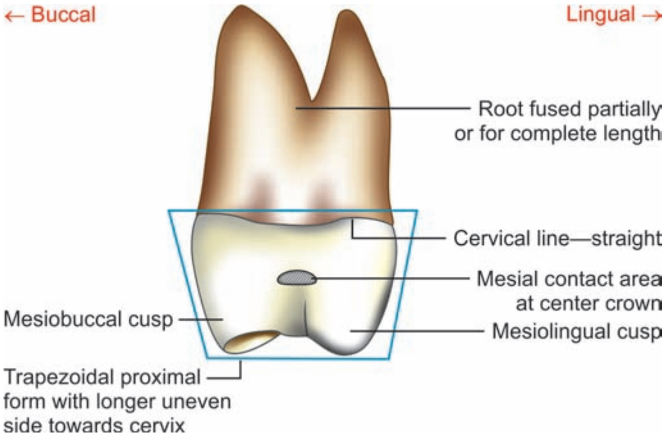


Figure 12.31 Maxillary 3rd molar—lingual aspect

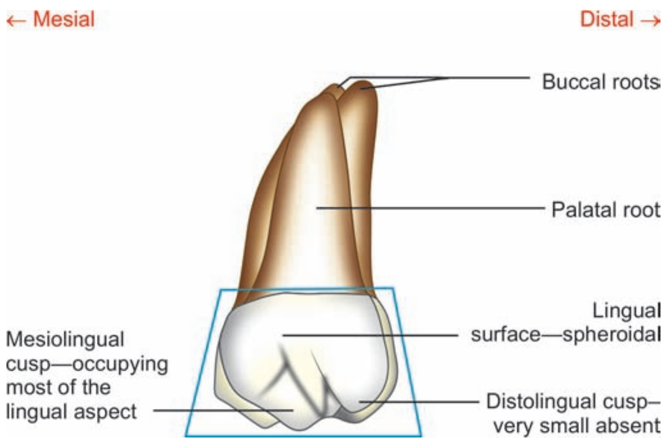


Figure 12.32 Maxillary 3rd molar—mesial aspect

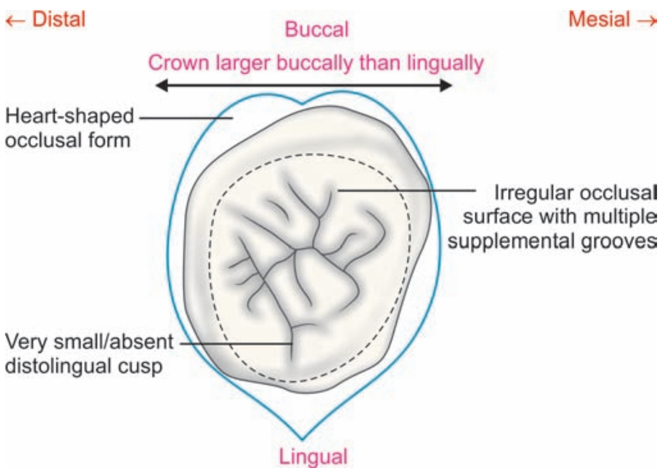


Figure 12.34 Maxillary 3rd molar—occlusal aspect

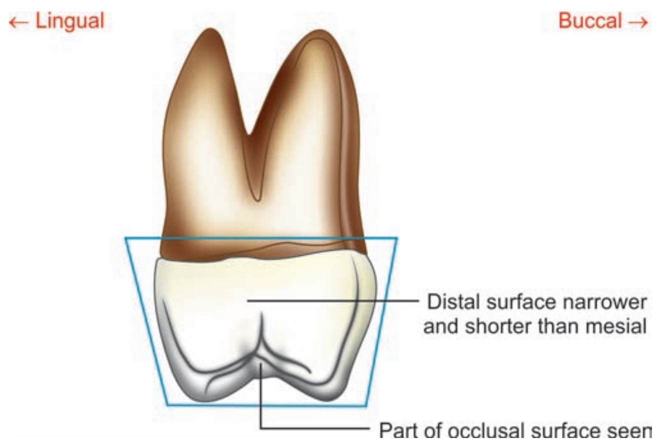
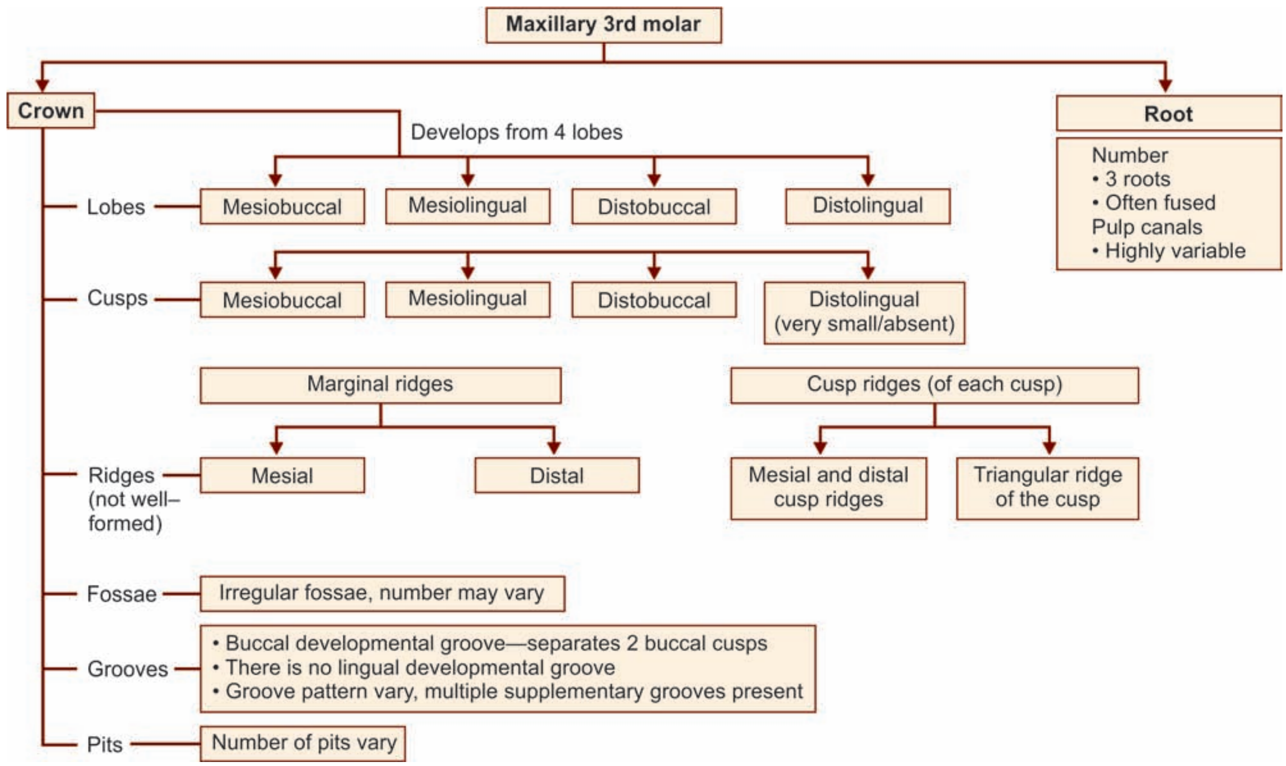


Figure 12.33 Maxillary 3rd molar—distal aspect

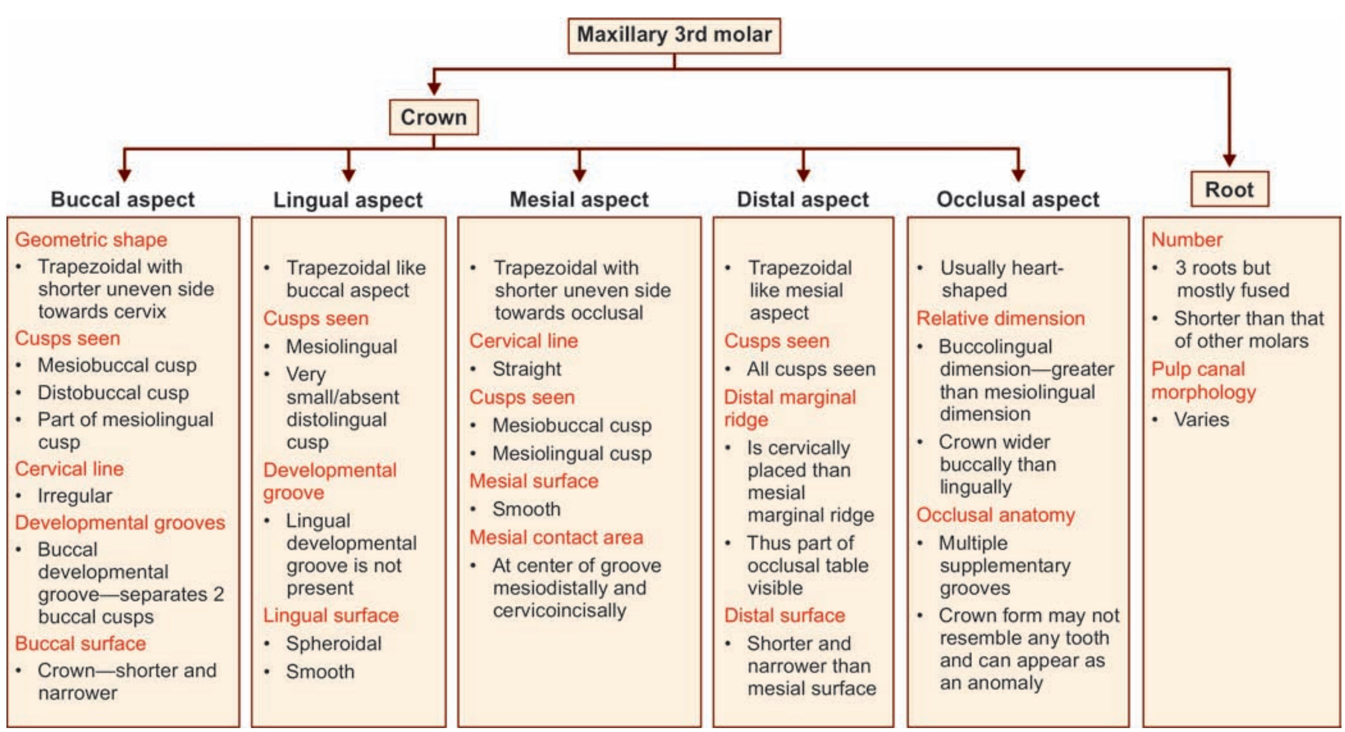
Figure 12.35 Maxillary 3rd molars—variations

Figure 12.36 The 3rd molar are the most commonly impacted teeth

Flow chart 12.5 Maxillary 3rd molar—major anatomic landmarks



Flow chart 12.6 Maxillary 3rd molar—summary



Box 12.3 Maxillary 3rd molar—identification features

Identification features of maxillary 3rd molar
- Smaller tooth with fused roots
- The crown has heart shaped occlusal outline with a well-developed mesiolingual cusp forming most of the lingual portion
- Very small or no distolingual cusp
- Multiple supplemental grooves and several small tubercles giving an irregular occlusal form to the tooth.

CLINICAL CONSIDERATIONS

- 3rd molars are the most common teeth to be congenitally missing impacted teeth
- They may be impacted in the jaw (**FIg. 12.36**)
- They often erupt buccally rather than in line with the dental arch due to shorter space.

Flow chart 12.5 shows the major anatomic landmarks of maxillary 3rd molar.

Flow chart 12.6 summarizes the morphology of maxillary 3rd molar.

Box 12.3 shows the identification features of maxillary 3rd molar.

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.
2. Khraisat A, Alsoleihat F, Subramani K, Taha ST, Al-Rabab'ah MA, Al-Bitar ZB. Hypocone reduction and Carabelli's traits in contemporary Jordanians and the association between Carabelli's trait and the dimensions of the maxillary first permanent molar. Coll Antropol. 2011;35(1):73-8.
3. Townsend GC, Brown T. The Carabelli's trait in Australian aboriginal dentition. Arch Oral Biol 1981;26:809-14.

MULTIPLE CHOICE QUESTIONS

1. Non-functional cusp of maxillary permanent 1st molar is:
   a. Mesiobuccal cusp
   b. Distobuccal cusp
   c. Mesiolingual cusp
   d. Cusp of Carabelli
2. How many cusps are seen in maxillary permanent 1st molar?
   a. Four
   b. Five
   c. Two
   d. Three
3. Tripod design of maxillary permanent 1st molar is best suited to resist:
   a. Oblique occlusal forces
   b. Horizontal force
   c. Vertical force
   d. Transverse force
4. The geometrical shape of buccal aspect of maxillary permanent 1st molar is:
   a. Trapezoidal
   b. Triangular
   c. Octagonal
   d. Hexagonal
5. Mesial contact area of maxillary permanent 1st molar is located at:
   a. Occlusal third of the crown
   b. Incisal third of the crown
   c. Cervical third of the crown
   d. None of the above
6. The cervical line on buccal surface of the crown of the maxillary permanent 1st molar is:
   a. Regular
   b. In occlusal direction
   c. In apical direction and irregular
   d. None of the above
7. Which cusp of maxillary permanent 1st molar is widest?
   a. Mesiobuccal cusp
   b. Distobuccal cusp
   c. Mesiolingual cusp
   d. Distolingual cusp
8. Which cusp is sharper in maxillary permanent 1st molar?
   a. Mesiobuccal cusp
   b. Distobuccal cusp
   c. Mesiolingual cusp
   d. Distolingual cusp
9. Groove separating mesiobuccal cusp from distobuccal cusp of maxillary permanent 1st molar is:
   a. Mesiobuccal developmental groove
   b. Distobuccal developmental groove
   c. Buccal developmental groove
   d. Transverse developmental groove
10. Groove separating mesiolingual cusp from distolingual cusp of maxillary permanent 1st molar is:
   a. Mesiobuccal developmental groove
   b. Distobuccal developmental groove
   c. Lingual developmental groove
   d. Transverse developmental groove

Answers

1. d	2. c	3. a	4. a	5. a	6. c	7. a	8. b	9. d	10. c

CHAPTER 13

The Permanent Mandibular Molars

The mandibular molars along with their maxillary counterparts are the most efficient grinding teeth in the dental arches. The three mandibular molars resemble each other in morphology and their size decreases from 1st to 3rd molars. The mandibular molars have larger crowns and two well-developed roots which are suitably spaced to impart maximum anchorage in the alveolar bone. In mandibular molars, the mesiodistal dimension of the crown is larger than the buccolingual dimension by about 1 mm. It can be remembered that the maxillary molars are wider buccolingually than they are mesiodistally.

PERMANENT MANDIBULAR 1ST MOLAR

Mandibular and maxillary 1st molars are among the first permanent teeth to erupt into oral cavity along with the mandibular central incisors at around 6 years of age (**Fig. 13.1**). The mandibular 1st molar is the largest tooth in the mandibular arch. It has five cusps: Two buccal, two lingual and a distal cusp; and two roots—mesial and distal. The chronology and measurements of the mandibular 1st molar are given in **Table 13.1**.

Figure 13.1 Mandibular and maxillary 1st molars are the first permanent teeth to erupt into oral cavity with mandibular central incisors at 6 years of age (6 years molars)

Table 13.1 Mandibular 1st molar—chronology and measurements

Chronology	
First evidence of calcification	At birth
Enamel completed	2½–3 years
Eruption	6–7 years
Roots completed	9–10 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	7.5
Length of root	14.0
Mesiodistal diameter of crown	11.0
Mesiodistal diameter of crown at cervix	9.0
Buccolingual diameter of crown	10.5
Buccolingual diameter of crown at cervix	9.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

DETAILED DESCRIPTION OF MANDIBULAR 1ST MOLAR FROM ALL ASPECTS

Figures 13.2 to 13.4 show mandibular 1st molar from various aspects.

CROWN

The crown has five aspects:
1. Buccal
2. Lingual
3. Mesial
4. Distal
5. Occlusal.

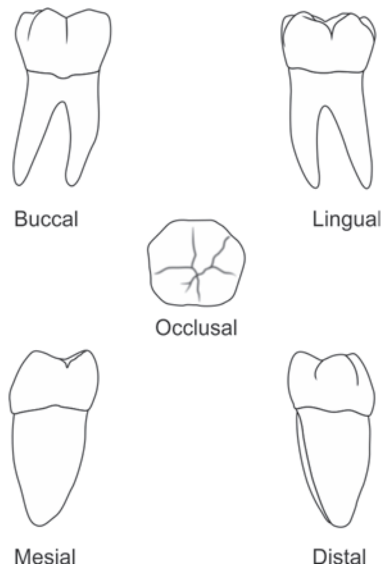


Figure 13.2 Mandibular 1st molar—line drawing

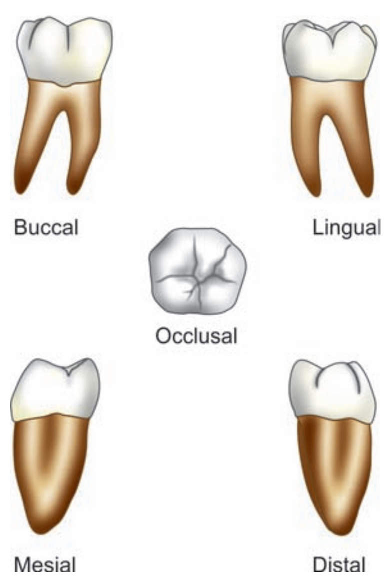


Figure 13.3 Mandibular 1st molar—graphic illustrations

Buccal Aspect (Fig. 13.5)

Geometric shape: The buccal aspect is *trapezoidal* with its shorter uneven side towards the cervical portion.

Crown Outlines

The buccal aspect has four outlines:
1. Mesial
2. Distal
3. Occlusal
4. Cervical.

Mesial Outline
- The mesial outline is convex except near the cervical line where it is concave.
- Its maximum convexity (*mesial contact area*) is at the junction of occlusal and middle thirds.

Distal Outline
The distal outline begins as a straight line near cervix and soon becomes convex forming the *distal contact area* at the middle third of crown.

Occlusal Outline
- The occlusal outline is formed by the cusp ridges of the two buccal cusps and a small distal cusp
- The outline is interrupted by two developmental grooves separating the three cusps
- The tips of two lingual cusps are also seen in the background.

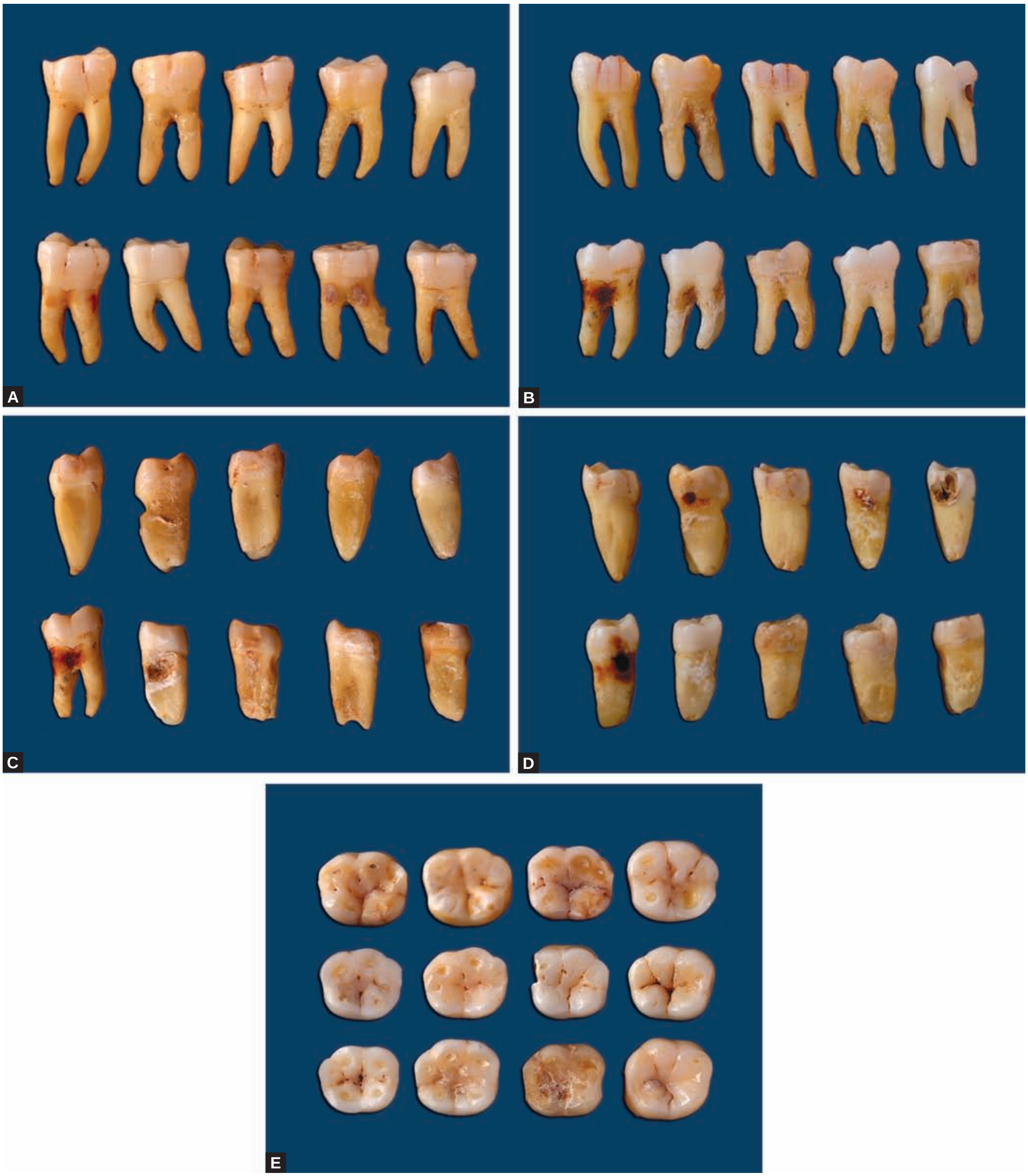
Cervical Outline
The cervical line on buccal surface is curved apically and often shows a sharp dip pointing towards the bifurcation area.

Buccal Surface within the Outlines

- All the five cusps are visible from buccal aspect
- The lingual cusps are seen in the background as they are at higher level than the buccal cusps
- Most of the buccal surface is formed by the two buccal cusps and the distal cusp (mesial portion)
- The mesiobuccal cusp is wider than the distobuccal cusp, which is relatively sharper of the two
- The mesial and distal cusp ridges of the two buccal cusps are relatively flat and meet at more obtuse angles
- The two buccal cusps are separated by the *mesiobuccal developmental groove* which runs for half the distance of buccal surface to end in the buccal pit
- It is placed slightly mesial to the root bifurcation
- The distobuccal and distal cusps are separated by the *distobuccal developmental groove* which approaches the distobuccal line angle of the crown. Occasionally, this groove may be absent
- The buccal surface is convex in the occlusal third except for the interruption of buccal grooves and it is more convex in the cervical third forming the buccal cervical ridge
- There is a linear concavity in the middle third of the crown extending in a mesiodistal direction, just above the cervical ridge of buccal surface.

Lingual Aspect (Fig. 13.6)

Geometric shape: It is *trapezoidal* like the buccal aspect.



Figures 13.4A to E Mandibular 1st molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

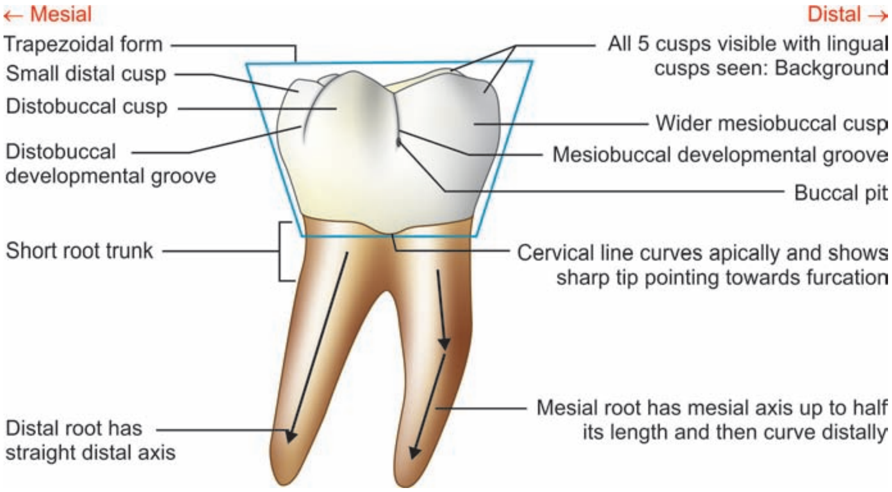


Figure 13.5 Mandibular 1st molar—buccal aspect

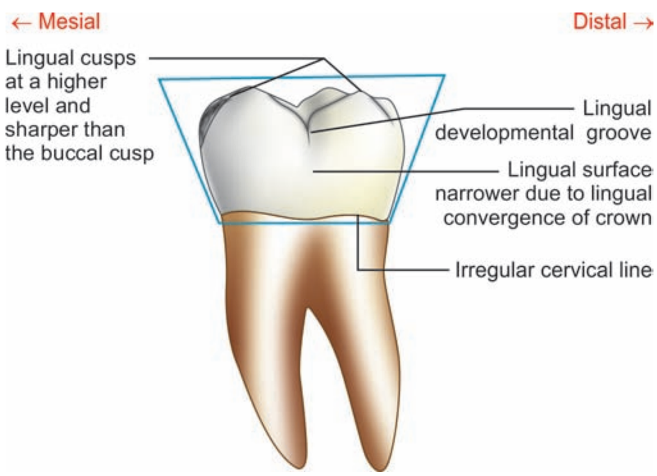


Figure 13.6 Mandibular 1st molar—lingual aspect

Crown Outlines

The lingual aspect has four outlines:
- Mesial outline
- Distal outline } are similar to buccal aspect

Occlusal Outline
The occlusal outline is formed by sharp cusp tips of the lingual cusps and their cusp ridges. The outline is interrupted by the lingual developmental groove in its midway.

Cervical Outline
The cervical line on lingual surface is irregular and may bend apically towards the root bifurcation.

Lingual Surface within the Outlines

- From lingual aspect only lingual cusps and small part of distal cusp are seen
- The crown tapers lingually making the lingual surface narrower than the buccal surface and a part of distal cusp are also visible. Thus, a part of mesial and distal surfaces of the crown can be seen from lingual aspect
- The two lingual cusps are almost of same width and are sharper and longer than the buccal cusps
- The mesiolingual cusp tip is at a higher level than the distolingual cusp
- The distal cusp tip is at a much lower level
- The *lingual developmental groove* separating the two lingual cusps runs for a shorter distance on the lingual surface and is in line with the bifurcation of the root
- The lingual surface is smoothly convex in the occlusal portion, and becomes flat in the cervical third
- There is a shallow concavity in the center of the lingual surface at middle third.

Mesial Aspect (Fig. 13.7)

Geometric shape: The proximal aspect is *rhomboidal* like that of all the mandibular posteriors.

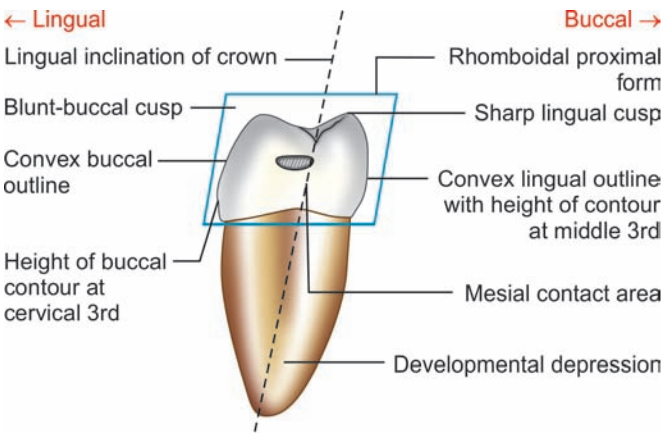


Figure 13.7 Mandibular 1st molar—mesial aspect

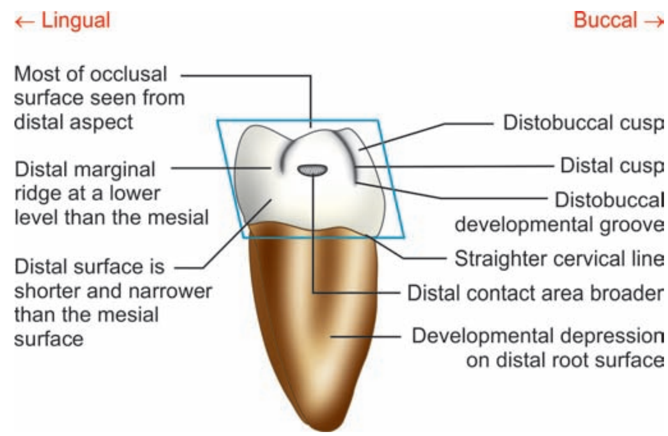


Figure 13.8 Mandibular 1st molar—distal aspect

Crown Outlines

Buccal Outline
- The buccal outline is more convex in the cervical third at the buccal cervical ridge and from there, it is slightly convex up to the flattened mesiobuccal cusp tip
- The *height of buccal contour* is in the cervical third of the crown.

Lingual Outline
- The lingual outline is evenly convex from cervix to the mesiolingual cusp tip
- The *height of lingual contour* is at the middle third.

Occlusal Outline
- The occlusal outline shows a sharp mesiolingual cusp tip at a higher level than the flattened mesiobuccal cusp tip
- The mesial marginal ridge merges smoothly with the mesial ridge of mesiolingual and mesiobuccal cusps and forms a concave outline.

Cervical Outline

The cervical line on mesial surface may be straight or slightly curved occlusally and is at a higher level lingually than buccally.

Mesial Surface within the Outlines

- Only two cusps namely, mesiodistal and mesiolingual cusps can be seen from this aspect.
- The crown shows a lingual inclination on its root base when seen from proximal view. However, the buccal and lingual cusp tips are within the confines of the root base.
- The mesial surface is smoothly convex except for the shallow concavity just below the contact area, which joins the central depression on mesial surface of the mesial root.
- The *mesial contact area* is at the junction of occlusal and middle third of the crown cervico-occlusally and in the center of the crown buccolingually below the mesial marginal ridge.

Distal Aspect (Fig. 13.8)

Geometric shape: It is *rhomboid* similar to the mesial aspect.

Crown Outlines

- Buccal outline
- Lingual outline

} are similar to buccal aspect

Occlusal Outline
- The distal marginal ridge is shorter and is at a lower level than the mesial marginal ridge
- It is placed lingual to the center of the crown buccolingually
- The distal marginal ridge merges smoothly with the distal ridges of the distolingual and the distal cusps.

Cervical Outline

The cervical line on the distal surface is rather straight without occlusal curvature.

Distal Surface within the Outlines

- The distal surface is shorter and narrower than the mesial surface. Most of the buccal surface and some portion of lingual surface can be seen from this aspect as the crown tapers distally
- The distolingual and the distal cusps are in the direct line of view. Most of the distobuccal cusp is also seen along with the distobuccal developmental groove
- Most of the occlusal surface along with the mesial marginal ridge is visible from this aspect as the crown is placed with a distal inclination on the root base and distal marginal ridge is at a lower level
- The distal surface is smoothly convex
- The *distal contact area* is on the distal contour of the distal cusp and is placed more buccally and at a higher level than the mesial contact area. The distal contact area is broader than the mesial as the tooth contacts with the 2nd molar tooth distally.

Occlusal Aspect (Figs 13.9A and B)

Geometric shape: The occlusal aspect of 1st molar is roughly *hexagonal with unequal sides*. When the distal cusp is very small, the occlusal aspect looks quadrilateral which is the basic form of all mandibular molars.

Boundaries of Occlusal Surface

The occlusal surface is bounded by the cusp ridges of all the five cusps and the marginal ridges.

Relative Dimensions

- The mesiodistal measurement of the crown is greater than the buccolingual measurement.
- The crown is bulkier mesially than distally as the crown tapers in a distal direction towards the small distal cusp.

Lingual Convergence

- Furthermore, the mesial and distal surfaces converge lingually making the lingual surface of the crown narrower than the buccal surface
- More of buccal surface can be seen from occlusal aspect and very little of lingual surface.

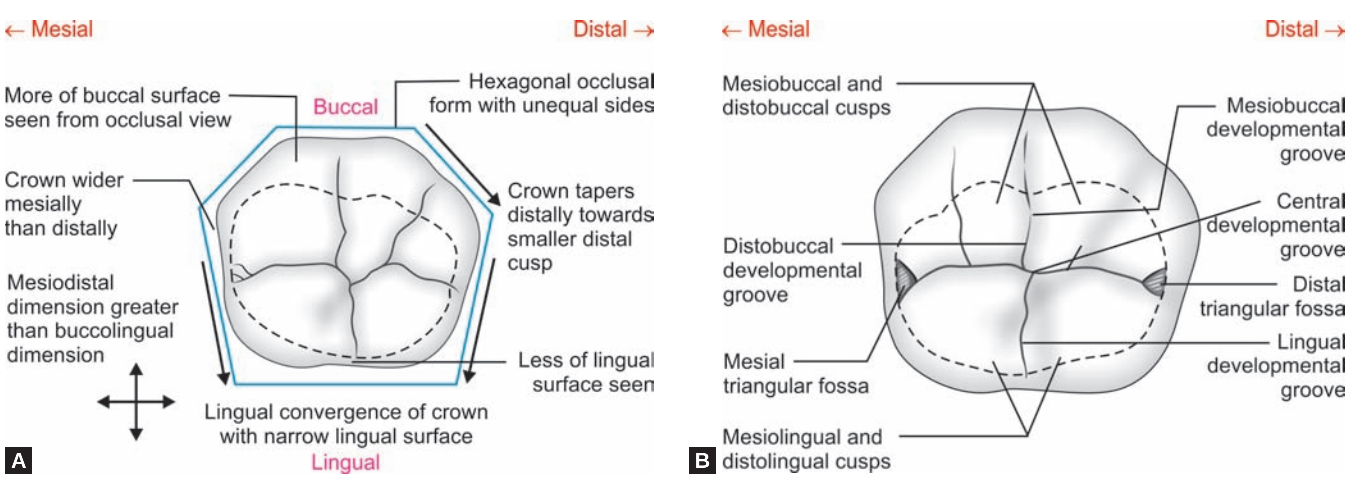
Occlusal Surface within the Boundaries

The occlusal aspect shows the following features:
- Cusps and cusp ridges
- Grooves and pits
- Fossae and marginal ridges.

Cusps and Cusp Ridges
- From the developmental point of view, the mandibular molars have four major cusps; distal cusp is a minor cusp, although it is often functional. Whereas, the maxillary molars have three major cusps
- Among the five cusps of mandibular 1st molars, the mesiobuccal cusp is the largest followed by the mesiolingual and distolingual cusps which are nearly equal in size. The distobuccal is the next cusp to follow and the distal cusp is the smallest one. The size of the distal cusp can vary.
- The cusp ridges of the buccal cusps and distal cusp are usually flattened by occlusal wear. The lingual cusps are sharp with well-defined cusp ridges.
- Each cusp has a triangular ridge along with two inclined planes on either side of the triangular ridge. As expected, the triangular ridges of the lingual cusps are well defined.

Fossae and Marginal Ridges

Fossae
- There is one major fossa namely *central fossa* and two minor fossae *mesial and distal triangular fossae*.
- The *central fossa* is a circular large depression in the center of the occlusal surface.
- It is bounded buccally by the distal slope of mesiobuccal cusp, the mesial and distal slopes of the distobuccal cusp and the mesial slope of distal cusp. Lingually, it is limited by the distal slope of mesiolingual and the mesial slope of distolingual cusp.
- The *mesial triangular fossa* has the mesial marginal ridge as base, the mesial pit as apex and the mesial slopes of mesiobuccal and mesiolingual cusps as the sides of the triangle
- The *distal triangular fossa* is smaller than the mesial triangular fossa. It has the distal marginal ridge as the base, distal pit as the apex and the distal slopes of the distolingual and the distal cusps as the sides of the triangle.



Figures 13.9A and B Mandibular 1st molar—occlusal aspect

Marginal Ridges

The distal marginal ridge is shorter and at a lower level than the well-developed mesial marginal ridge.

Grooves and Pits

- There are four developmental grooves and some supplemental grooves are seen on the occlusal surface
- There are three pits. The *central pit* is at the center of the central fossa. The *mesial and distal pits* are in the mesial and distal triangular fossae respectively
- The *central developmental groove* originates at the central pit and runs in the opposite directions. Its mesial course from the central pit is relatively smooth and terminates in the mesial triangular fossa. Again from the central pit, the central groove takes a rather irregular course in a distal direction and ends in the distal triangular fossa
- The *mesiobuccal developmental groove* joins the central developmental groove just mesial to the central pit and runs buccally separating the mesiobuccal and distobuccal cusps and ends on the buccal surface in the buccal pit
- The *distobuccal developmental groove* joins the central groove, distal to the central pit and runs distobuccally between the distobuccal and distal cusps to end on the buccal surface
- The *lingual developmental groove* takes a lingual course from the central pit and extends onto the lingual surface separating the two lingual cusps
- Several supplemental grooves can be seen originating from the developmental grooves.

ROOT

Number: There are well developed two roots—mesial and distal.

Size

The roots are nearly twice as long as the crown. Both the roots are of same length.

Form

- The mandibular 1st molar has a short root trunk and the bifurcation is more near to the cervical line (3–4 mm). There are developmental depressions on the buccal and lingual surfaces of the root trunk extending from the bifurcation point up to the cervical lines
- The mesial root has a straight vertical axis up to half its length, and its apical half is curved distally
- The distal root slants distally from the root base without much curvature.

Developmental Depressions

- There are developmental depressions on mesial and distal surfaces of both the roots extending for the entire length of roots.
- The developmental depressions help to provide increased anchorage to the roots in the alveolar bone.

Apices

The mesial root has a blunt apex and distal root has a relatively sharp apex.

Cross-section of Roots

Cross-sections of both roots show that roots are thinner in the center due to developmental depressions and border buccally and lingually.

VARIATIONS (FIGS 13.10A AND B)

- The mesial root may be bifurcated at the apical third
- There can be an extra cusp on the occlusal surface.

DEVELOPMENTAL ANOMALIES

- Dilacerations
- Concrescence
- Taurodontism.

CLINICAL CONSIDERATIONS

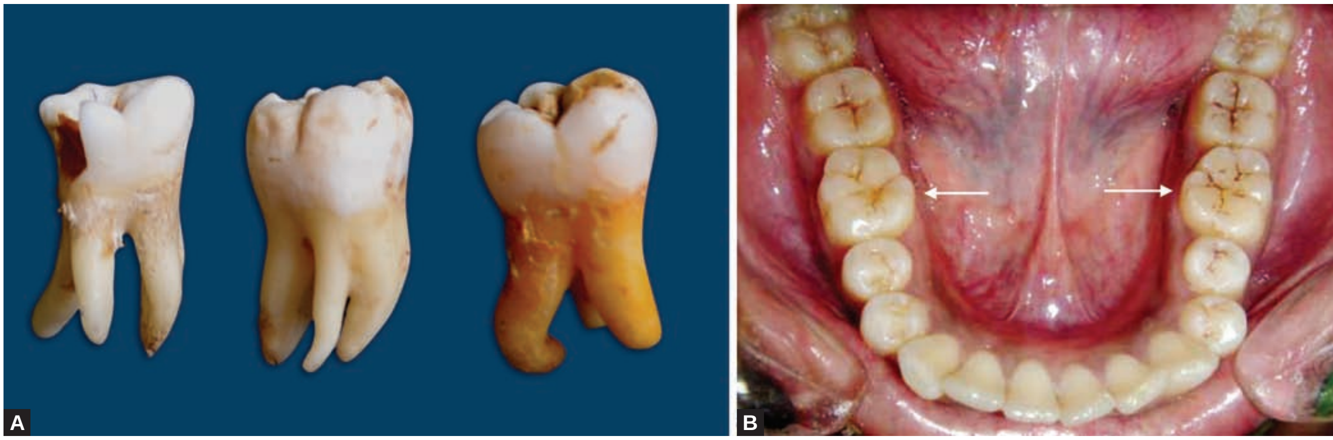
- The mandibular 1st molars are most commonly affected by dental caries as they erupt early in life and have multiple grooves
- The mandibular 1st molars occlude with the maxillary 1st molar and they together form an important key of occlusion
- The maxillary and mandibular 1st molars erupt (about 6–7 years) when all the primary teeth are still intact and functioning. Thus they provide broader occlusal table assisting the primary molars in mastication of more complex food for growing children.

Flow charts 13.1 and 13.2 summarize the anatomy of mandibular 1st molar. **Box 13.1** gives the tooth's identification features.

PERMANENT MANDIBULAR 2ND MOLAR

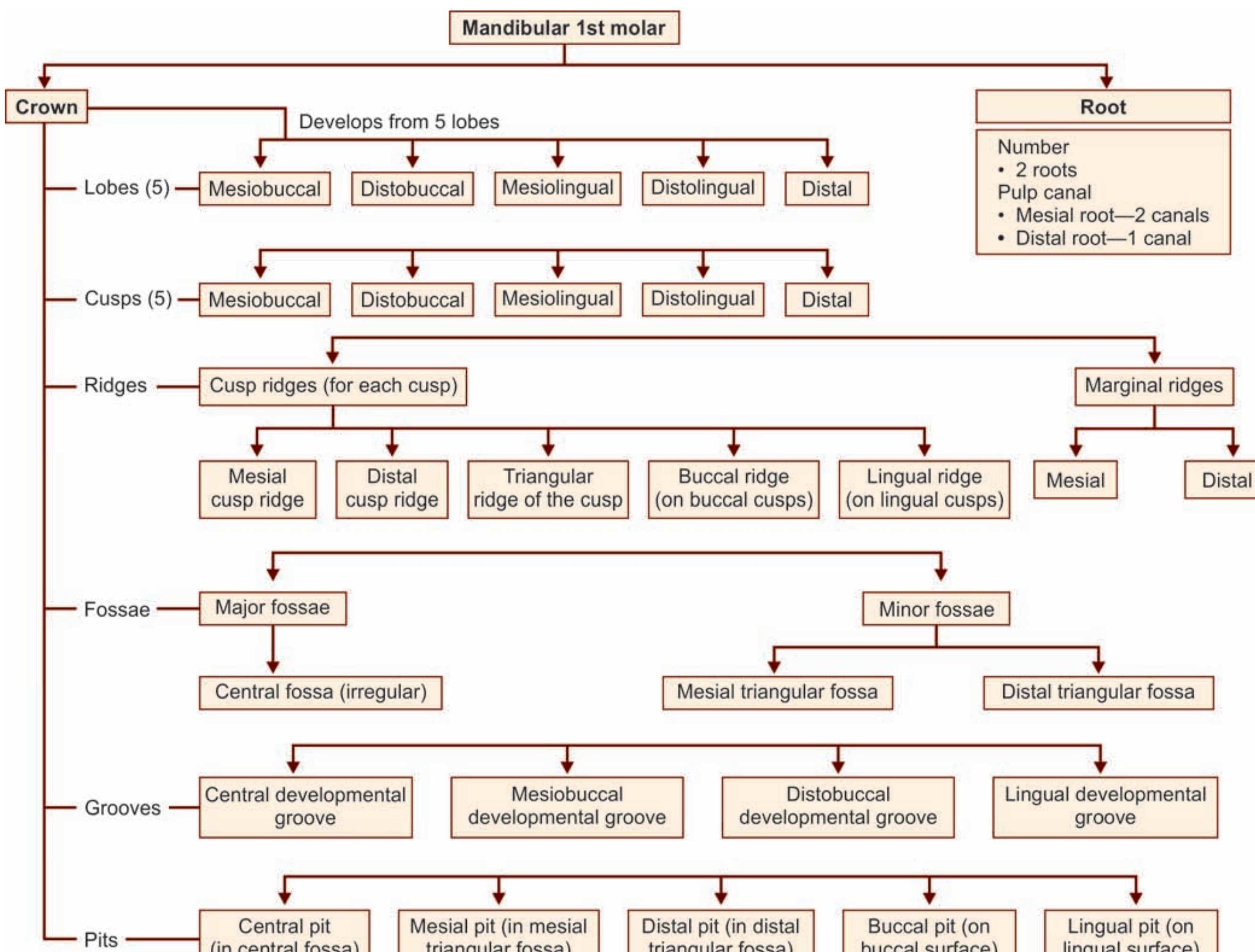
The permanent mandibular 2nd molar is smaller than the mandibular 1st molar from all aspects. It has four well-developed cusps but there is no distal cusp. The tooth has two roots, mesial and distal which may be as long as that of mandibular 1st molar though they are not so broad buccolingually. Both the roots have a marked distal inclination and are closely spaced.

The chronology and measurements of the mandibular 1st molar are given in **Table 13.2**.



Figures 13.10A and B Mandibular 1st molar—variations: (A) Bifurcated mesial root; (B) Supernumerary cusp/six-cusped molar (cusp intermedium)

Flow chart 13.1 Mandibular 1st molar—major anatomic landmarks



Flow chart 13.2 Mandibular 1st molar—summary

Mandibular 1st molar

Crown

Buccal aspect

Geometric shape
- Trapezoidal

Crown outlines
- Mesial—convex, concave near cervix
- Distal—slightly convex

Cusps seen
- All cusps seen
- 2 buccal cusps, a distal cusp in foreground
- Tips of lingual cusps seen as they are at higher level
- Mesiobuccal cusp wider than distobuccal
- Buccal cusps are blunt

Cervical line
- Curved apically
- Sharp tip pointing towards bifurcation

Developmental grooves
- Mesiobuccal developmental groove
- Distobuccal developmental groove

Buccal surface
- Convex in cervical ridge
- Linear concavity at middle 3rd

Pits
- Buccal pit

Lingual aspect

- Trapezoidal

Lingual convergence
- Crown tapers lingually

Cusps seen
- Only 2 lingual cusps and portion of distal cusp
- Lingual cusps are sharper
- Both lingual cusps of same width

Cervical line
- Irregular and dips apically towards bifurcation

Developmental grooves
- Lingual developmental groove between lingual cusps

Lingual surface
- Convex, flat cervically

Pits
- Lingual pit

Mesial aspect

- Rhomboidal

Crown outlines
- Buccal—convex at cervical 3rd on buccal cervical ridge
- Lingual—evenly convex

Height of contours
- Buccal—at cervical 3rd
- Lingual—at middle 3rd

Cusps seen
- Mesiobuccal flattened Mesiolingual—sharp tip

Lingual inclination of crown
- Crown inclined lingually on root base
- Cusp tips within confines of root

Mesial surface
- Smoothly convex
- Shallow concavity below contact area that joins developmental depression on mesial root

Mesial contact area
- At junction of occlusal and middle 3rd cervico-occlusally

Pits
- Buccal pit

Distal aspect

- Rhomboidal

Cusps seen
- Distolingual and distal cusps in direct view
- Most of distobuccal cusp also seen

Distal marginal ridge
- Shorter and at a lower level than mesial marginal ridge. Placed lingually due to presence of distal cusp

Distal surface
- Narrower and shorter
- Part of occlusal surface seen
- Part of buccal surface seen

Distal contact area
- On distal contour of distal cusp and at center of crown buccolingually

Occlusal aspect

- Hexagonal

Relative dimension
- Mesiodistal dimension greater than buccolingual dimension
- Crown bulkier mesially than distally towards distal cusp

Crown taper
- Tapers lingually
- Tapers distally

Lingual inclination
- More of buccal surface seen and very little lingual surface seen from occlusal view

Cusps: 5 cusps
- Mesiobuccal, mesiolingual and distal (smallest)
- Mesiolingual and distolingual

Fossae
- Major—central fossa
- Minor—mesial and distal triangular fossae

Grooves
- Central developmental groove
- Mesiobuccal, distobuccal, lingual grooves

Pits
- Central, mesial and distal

Root

Number
- 2 roots

Pulp canals
- 3 canals

Size
- As long as crown
- Both roots of same length

Form
- Short root trunk
- Bifurcation near to cervical line

Developmental depressions
- On buccal and lingual surfaces of root trunk
- On mesial and distal surfaces of both roots for entire length

Root curvature
- Mesial root—apical half-curved distally
- Distal root has distal axis from furcation

Apices
- Mesial—blunt
- Distal—sharp

Box 13.1 Mandibular 1st molar—identification features

Identification features of mandibular 1st molar
- The mandibular 1st molars have five cusps and two well formed roots
- The distal cusp is the smallest cusp and helps to identify the tooth and its side.

Side identification
- Smallest cusp, i.e. the distal cusp helps in identifing the side
- Roots often show distal curvature.

DETAILED DESCRIPTION OF MANDIBULAR 2ND MOLAR FROM ALL ASPECTS

Figures 13.11 to 13.13 show mandibular 2nd molar from various aspects.

CROWN

Buccal Aspect (Fig. 13.14)

Geometric shape: Buccal aspect of mandibular 2nd molar is *trapezoidal*.

Crown Outlines

Mesial and Distal Outlines

The mesial and distal outlines are usually convex with their maximum convexity at the center of middle third of the crown.

Occlusal Outline

- The occlusal outline is formed by the flattened cusp ridges of two buccal cusps

Table 13.2 Mandibular 2nd molar—chronology and measurements

Chronology	
First evidence of calcification Enamel completed Eruption Roots completed	2 ½–3 years 7–8 years 11–13 years 14–15 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	7.0
Length of root	13.0
Mesiodistal diameter of crown	10.5
Mesiodistal diameter of crown at cervix	8.0
Buccolingual diameter of crown	10.0
Buccolingual diameter of crown at cervix	9.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

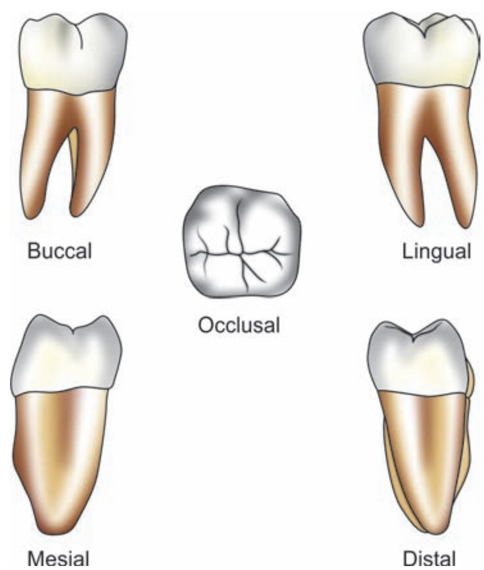


Figure 13.12 Mandibular 2nd molar—graphic illustrations

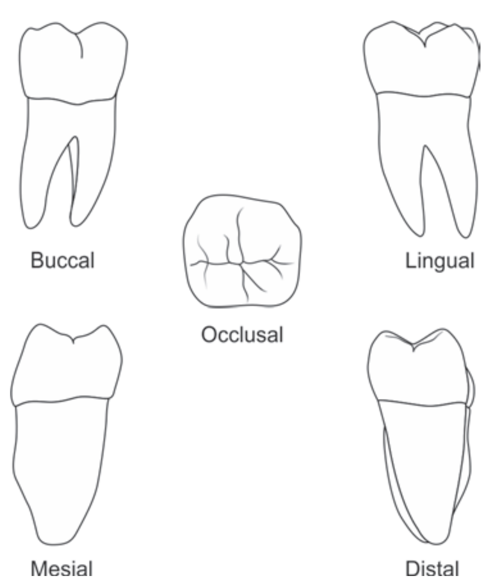


Figure 13.11 Mandibular 2nd molar—line drawing

- Occlusal outline is divided by the buccal developmental groove
- The lingual cusps may be seen from buccal view.

Cervical Outline

The cervical outline on buccal surface of the tooth may be a straight line or may tip apically near the bifurcation.

Buccal Surface within the Outlines

- The crown appears shorter and narrower than that of mandibular 1st molar
- The mesiobuccal and distobuccal cusps are equal in their width and are separated by a short buccal developmental groove which ends within the occlusal third of the crown.
- The buccal aspect has only one developmental groove as there is no distal cusp.
- The buccal cervical ridge may not be as pronounced as in the mandibular 1st molar.

Lingual Aspect (Fig. 13.15)

Geometric shape: Trapezoidal like that of the buccal aspect.

Crown Outlines

- Mesial outline
- Distal outline
- Cervical outline

} are similar to that of buccal aspect

Occlusal Outline

- It is formed by the cusp ridges of two lingual cusps and is separated by the lingual developmental groove
- The buccal cusps are not seen as the lingual cusp tips are at a higher level.

Lingual Surface within the Outlines

- The lingual surface is nearly as wide as the buccal surface since the tooth does not converge much towards the lingual aspect
- The mesiolingual and distolingual cusps are of equal width and are sharper than the buccal cusps
- The *lingual developmental groove* separating the two lingual cusps runs for a short distance onto the lingual surface.

Figures 13.13A to E Mandibular 2nd molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

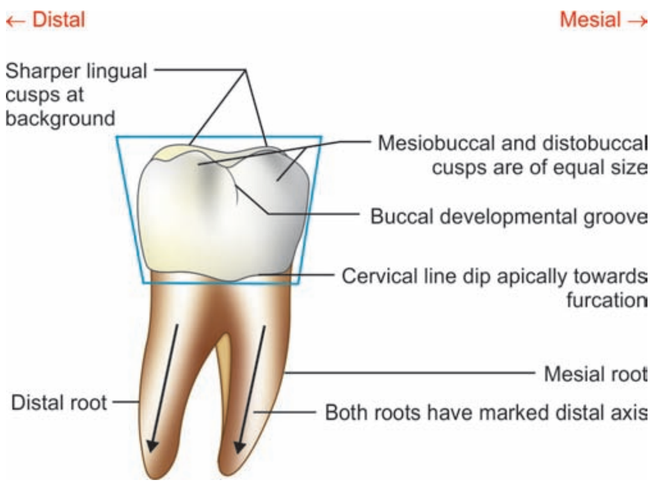


Figure 13.14 Mandibular 2nd molar—buccal aspect

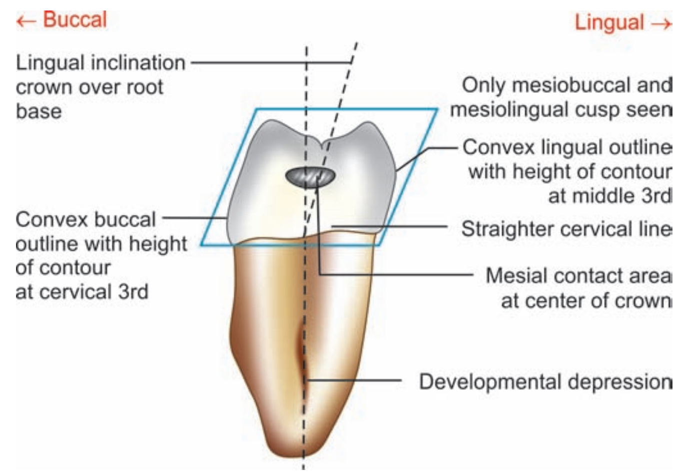


Figure 13.16 Mandibular 2nd molar—mesial aspect

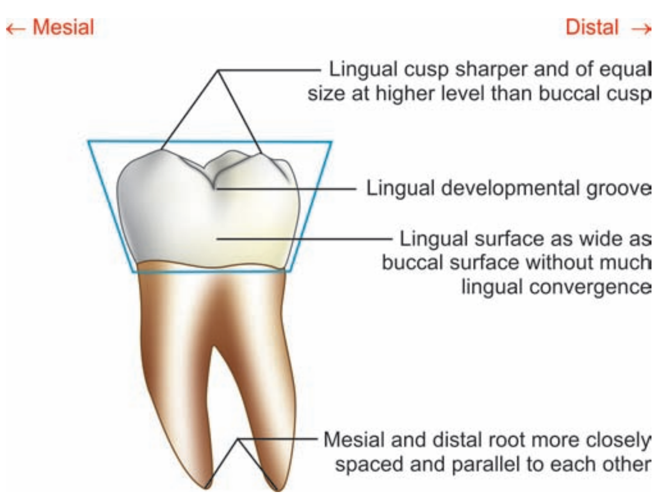


Figure 13.15 Mandibular 2nd molar—lingual aspect

Mesial Aspect (Fig. 13.16)

Geometric shape: It is *rhomboidal* similar to the proximal aspects of all mandibular posterior.

Crown Outlines

Buccal Outline

- The buccal outline is convex in the cervical third and becomes flat for the rest of its course
- The *height of buccal contour* is in the cervical third of the crown.

Lingual Outline

- It is convex from cervix up to the mesiolingual cusp tip.
- The *height of lingual contour* is in the middle third of the crown.

Occlusal Outline

The occlusal outline is formed by the mesial marginal ridge along with the mesial ridges of mesiobuccal and mesiolingual cusps.

Cervical Outline

The cervical line on the mesial surface is rather straight and regular.

Mesial Surface within the Outlines

- The mesial aspect is similar that of mandibular 1st molar
- Only mesiobuccal and mesiolingual cusps are seen from the mesial aspect
- The crown shows a lingual inclination on the root base
- The mesial surface is convex for most of its part and may be flattened near the cervical line, below the contact area
- *Mesial contact area*: It is at the center of the mesial surface both cervico-occlusally and buccolingually.

Distal Aspect (Fig. 13.17)

Geometric shape: It is *rhomboidal* like the mesial aspect.

Crown Outlines

- Buccal outline
- Lingual outline
- Cervical outline

} are similar to that of mesial aspect

Occlusal Outline

- The distal marginal ridge is at a lower level than the mesial marginal ridge
- Some of occlusal surface can be seen from distal aspect.

Distal Surface within the Outlines

- The distobuccal and distolingual cusps are seen and there is no distal cusp
- Some part of occlusal surface can be seen from this aspect as the distal marginal ridge is at a lower level
- The *distal contact area*: It is at the center of the distal surface both cervico-occlusally and buccolingually. Generally, the contact area both mesially and distally are at the same level in case of molars.

Occlusal Aspect (Figs 13.18A and B)

Geometric Shape

- The occlusal aspect of the 2nd molar is *rectangular*, with the opposing sides nearly equal in length.
- All the four angles are nearly equal, and form right angles.

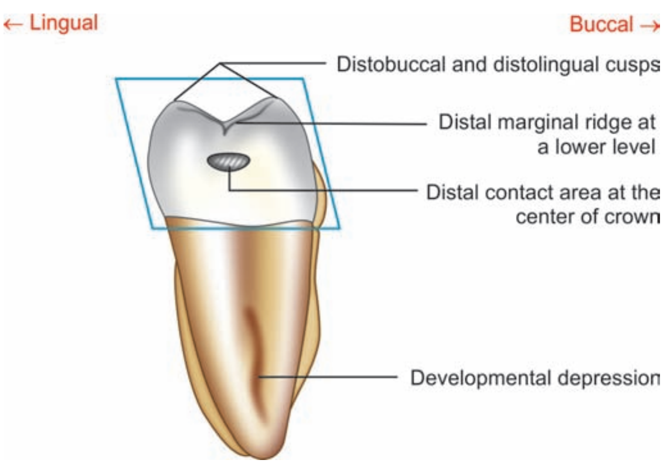


Figure 13.17 Mandibular 2nd molar—distal aspect

Relative Dimensions

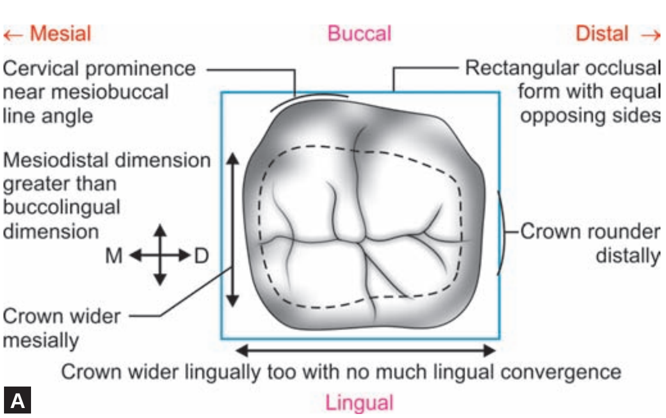
- The mesiodistal dimension is greater than the buccolingual dimension.
- From occlusal view, it can be appreciated that the tooth is as wide lingually as it is buccally. This is because the tooth does not taper much lingually.
- It can also be noted that the distal outline of the crown is more rounded than the mesial outline.
- Viewed occlusally, the crown is squarish and broader mesially and is more rounded distally.
- There is often a prominence seen cervically near the mesiobuccal line angle.

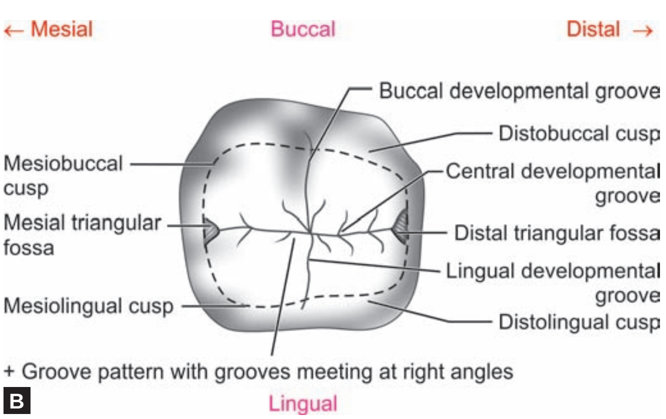
Occlusal Surface within the Boundaries

- Cusps and cusp ridges
- Fossae and marginal ridges
- Grooves and pits.

Cusps and Cusp Ridges
- The mandibular 2nd molar has only four cusps. There is no distal cusp
- The mesiobuccal and distobuccal cusps are almost equal in size, although the cervical portion of the tooth near mesiobuccal cusp may be more bulky
- The mesiolingual and distolingual cusps are equally well developed. In general, the lingual cusp ridges are well defined than the more flattened buccal cusp ridges
- The triangular ridges of all the cusps converge towards the center of the occlusal surface.

Fossae and Marginal Ridges
- There are two fossae; *mesial and distal triangular fossae*
- The mesial and distal triangular fossae are nearly equal in size and may have supplemental grooves
- The *mesial and distal marginal ridges* are well developed and form the base of respective triangular fossa.





Figures 13.18A and B Mandibular 2nd molar—occlusal aspect

Grooves and Pits

- There are three pits; *central, mesial and distal pits*
- The *groove pattern* forms a typical plus mark '+' or a cross in the center of occlusal aspect, dividing the occlusal portion into four nearly equal parts
- The *central developmental groove* runs across the occlusal surface from mesial pit to the distal pit
- The *buccal and lingual grooves* meet the central groove at right angles at the central pit and they run onto the buccal and lingual surfaces of the crown respectively
- There is no distobuccal groove.

ROOT

Number

There are two roots like mandibular 1st molar; the mesial and the distal.

Size

The roots are usually a little shorter than that of mandibular 1st molar, but they can be longer.

Form

- The mesial and distal roots are closely spaced and they are nearly parallel to each other. Both the roots have their axes distally inclined
- The roots may be fused for all or part of their length
- The roots are not as broad buccolingually as those of mandibular 1st molar.

Apices

The apices of both roots are pointed.

Curvature

Apical ends of the roots in some cases show a mesial curvature.

Developmental Depressions

- The mesial and distal roots have developmental depressions on their mesial and distal surfaces.
- The depressions are often seen extending for only apical half of the roots.

VARIATIONS

The mesial and distal roots can vary in their length and development.

DEVELOPMENTAL ANOMALIES

- Dilacerations
- Concrescence
- Taurodontism.

Mandibular 2nd molar anatomy is summarized in **Flow charts 13.3 and 13.4**. **Box 13.2** gives identify cation features of the tooth.

PERMANENT MANDIBULAR 3RD MOLAR

The mandibular 3rd molars exhibit considerable variation in their size, form and position. Their occlusal anatomy in particular is highly variable from having four cusps like mandibular 2nd molar, five cusps like mandibular 1st molar to more than five cusps appearing like small tubercles (**Fig. 13.19**). When their variation in size is considered, the crowns of mandibular 3rd molars tend to be oversized rather than undersized. Whereas, the maxillary 3rd molars tend to be smaller when they are not normal sized.

The two roots present are shorter, often malformed and have a tendency to fuse. The roots are more distally inclined than those of 1st and 2nd mandibular molars. In general, the mandibular 3rd molars resemble mandibular 2nd molars whom they assist in function. The mandibular 3rd molars are the most common teeth to be impacted, either partially or completely. They can be congenitally absent often bilaterally.

The chronology and measurements of the mandibular 1st molar are given in **Table 13.3**.

DETAILED DESCRIPTION OF MANDIBULAR 3RD MOLAR FROM ALL ASPECTS

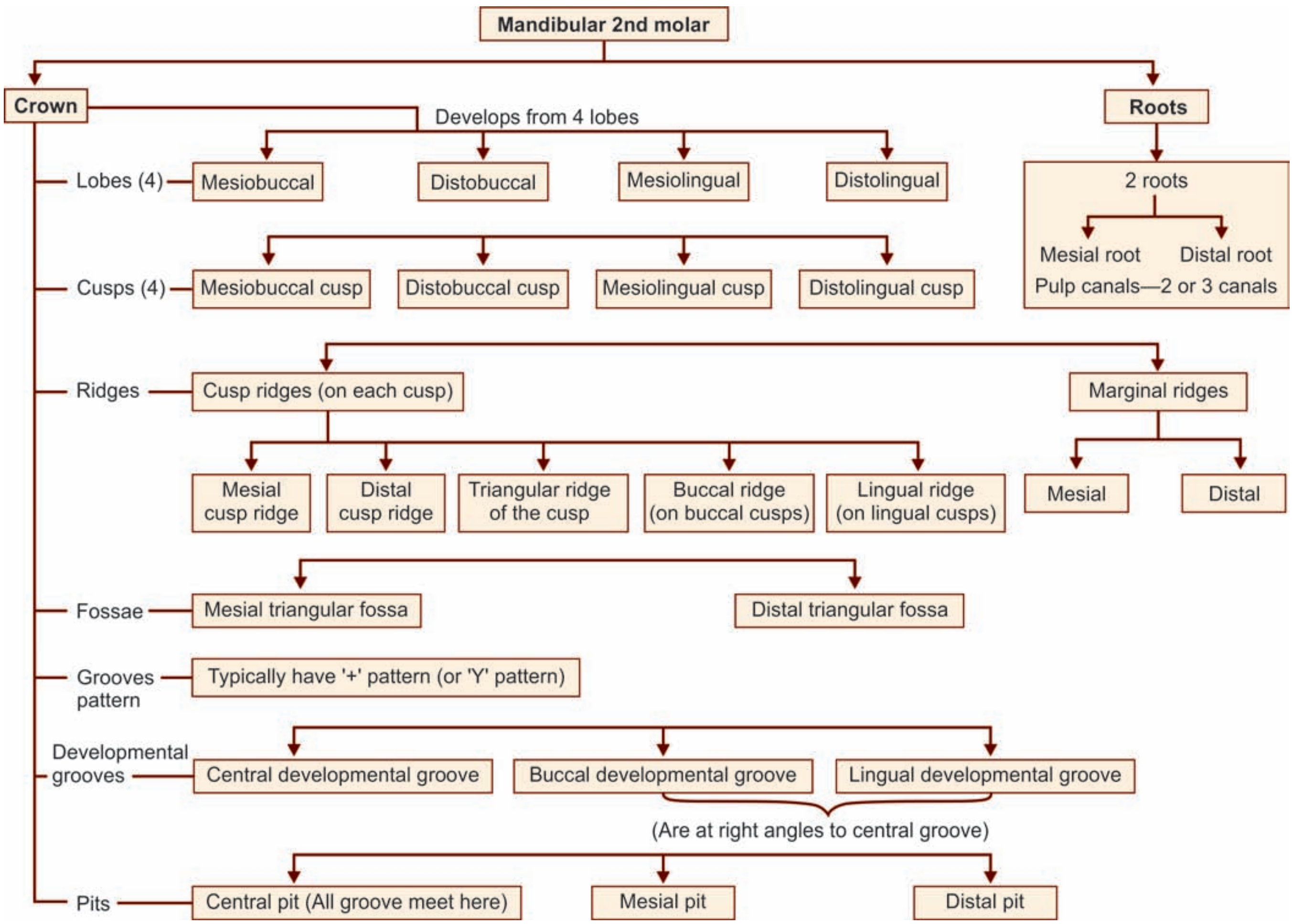
Figures 13.20 to 13.22 show mandibular 3rd molar from various aspects.

CROWN

Buccal Aspect (Fig. 13.23)

- *Geometric shape*: Buccal and lingual aspects of the tooth appear trapezoidal with short uneven side towards the cervical portion.
- The crown is a little smaller or of same size as that of mandibular 2nd molar.
- The two buccal cusps are seen from buccal aspect, and they are separated by the *buccal developmental groove*.
- Mesial and distal outlines are convex with their maximum convexity at a level occlusal to the center of the crown cervico-occlusally.
- The cervical line may be straight or irregular.

Flow chart 13.3 Mandibular 2nd molar—major anatomic landmarks



Box 13.2 Mandibular 2nd molar—identification features

Identification features of mandibular 2nd molar

- The mandibular 2nd molar has four cusps and two roots
- The occlusal aspect has a plus '+' or cross-shaped groove pattern, dividing the occlusal surface into four nearly equal parts
- Both the roots are distally inclined and extend parallelly and are close to each other
- Viewed occlusally, there is cervical prominence seen at mesiobuccal line angle of the crown.

Side identification

- Viewed from occlusal aspect, the crown is wider mesially than distally
- Often, there is a prominence cervically near mesiobuccal line angle when viewed from occlusal aspect
- The roots are inclined distally.

Figure 13.19 Occlusal anatomy of mandibular 3rd molar is highly variable from having 4 to 5 cusps or many small tubercles

Flow chart 13.4 Mandibular 2nd molar—summary

Mandibular 2nd molar

Crown

Buccal aspect

Geometric shape
- Trapezoidal

Crown outlines
- Mesial—convex
- Distal—convex

Cervical line
- Straight or dip apically near bifurcation

Cusps seen
- Mesiobuccal and distobuccal cusps
- Equal in width
- Blunt tips
- Lingual cusps may be seen

Developmental grooves
- Buccal developmental groove separating the buccal cusps

Buccal surface
- Crown narrower and shorter than mandibular 1st molar
- Buccal cervical ridge not prominent

Lingual aspect

- Trapezoidal

Lingual convergence
- Crown do not taper much lingually (not marked)

Cusps seen
- Mesiolingual and distolingual cusps
- Equal in width
- Sharper tips

Developmental grooves
- Lingual developmental groove separating the lingual cusps

Lingual surface
- As wide as buccal surface
- Convex surface

Mesial aspect

- Rhomboidal

Crown outlines

Buccal—convex near cervix, flatter later
- Lingual—convex

Height of contour
- Buccal—at cervical 3rd
- Lingual—middle 3rd

Cusps seen
- Mesiobuccal and mesiolingual cusps

Lingual inclination of crown
- Crown inclined lingually on root base

Mesial surface
- Convex
- Flattened near cervical line

Mesial contact area
- At center of crown both cervico-occlusally and buccolingually

Distal aspect

- Rhomboidal

Cusps seen
- Distolingual and distobuccal cusps

Distal marginal ridge
- At lower level than mesial marginal ridge

Distal surface
- Convex
- Same portion of occlusal surface seen

Distal contact area
- At center of crown both cervico-occlusally and buccolingually

Occlusal aspect

- Rectangular with equal opposite sides

Relative dimensions
- Mesiodistal dimension greater than buccolingual dimension
- Crown equally wider buccally and lingually
- Broader mesially than distally

Mesiobuccal line angle
- Presence of prominence cervically near mesiobuccal line angle

Cusps
- *4 cusps:* 2 buccal, 2 lingual

Fossae
- Mesial and distal triangular

Developmental grooves
- Make '+' or 'Y' pattern
- Central development groove
- Buccal groove
- Lingual groove

Pits
- Central, mesial, distal

Root

Number
- 2 roots

Pulp canals
- 2 or 3 canals

Size
- Both of equal length

Form
- Roots closely spaced and parallel
- Can be fused
- Broad buccolingually

Developmental depressions
- On mesial and distal surfaces of both roots for apical half

Root curvature
- Distal apical curvature

Apices
- Both roots pointed

Table 13.3 Mandibular 3rd molar—chronology and measurements

Chronology	
First evidence of calcification	8–10 years
Enamel completed	12–16 years
Eruption	17–21 years
Roots completed	18–25 years
Measurements **Dimensions suggested for carving technique (in mm)*	
Cervico-occlusal length of crown	7.0
Length of root	11.0
Mesiodistal diameter of crown	10.0
Mesiodistal diameter of crown at cervix	7.5
Buccolingual diameter of crown	9.5
Buccolingual diameter of crown at cervix	9.0
Curvature of cervical line—mesial	1.0
Curvature of cervical line—distal	0.0

Lingual Aspect (Fig. 13.24)

- It is similar to buccal aspect in general
- The two lingual cusps are seen from this aspect and are separated by the *lingual developmental groove*.

Mesial Aspect (Fig. 13.25)

Geometric Shape

- The tooth is *rhomboidal* from proximal aspects similar to other mandibular molars
- The mesiobuccal and mesiolingual cusps are seen from this aspect whose mesial slopes merge with the mesial marginal ridge
- The *height of buccal contour* is at cervical third and that of *lingual contour* is at the middle third of the crown

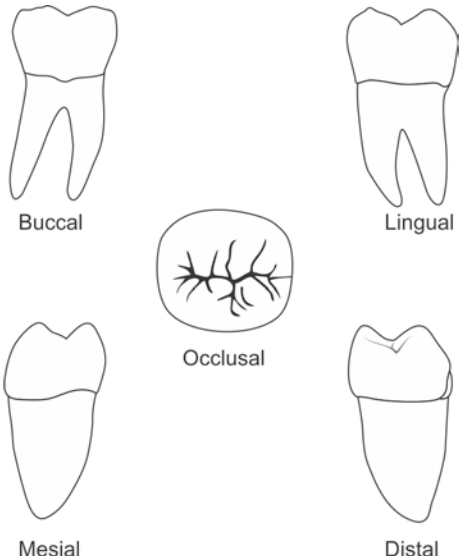


Figure 13.20 Mandibular 3rd molar—line drawing

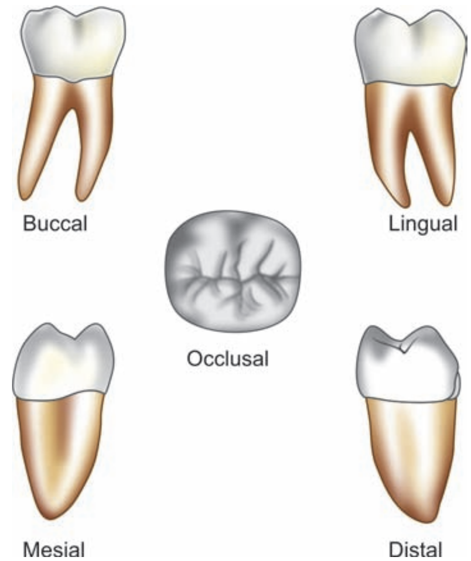
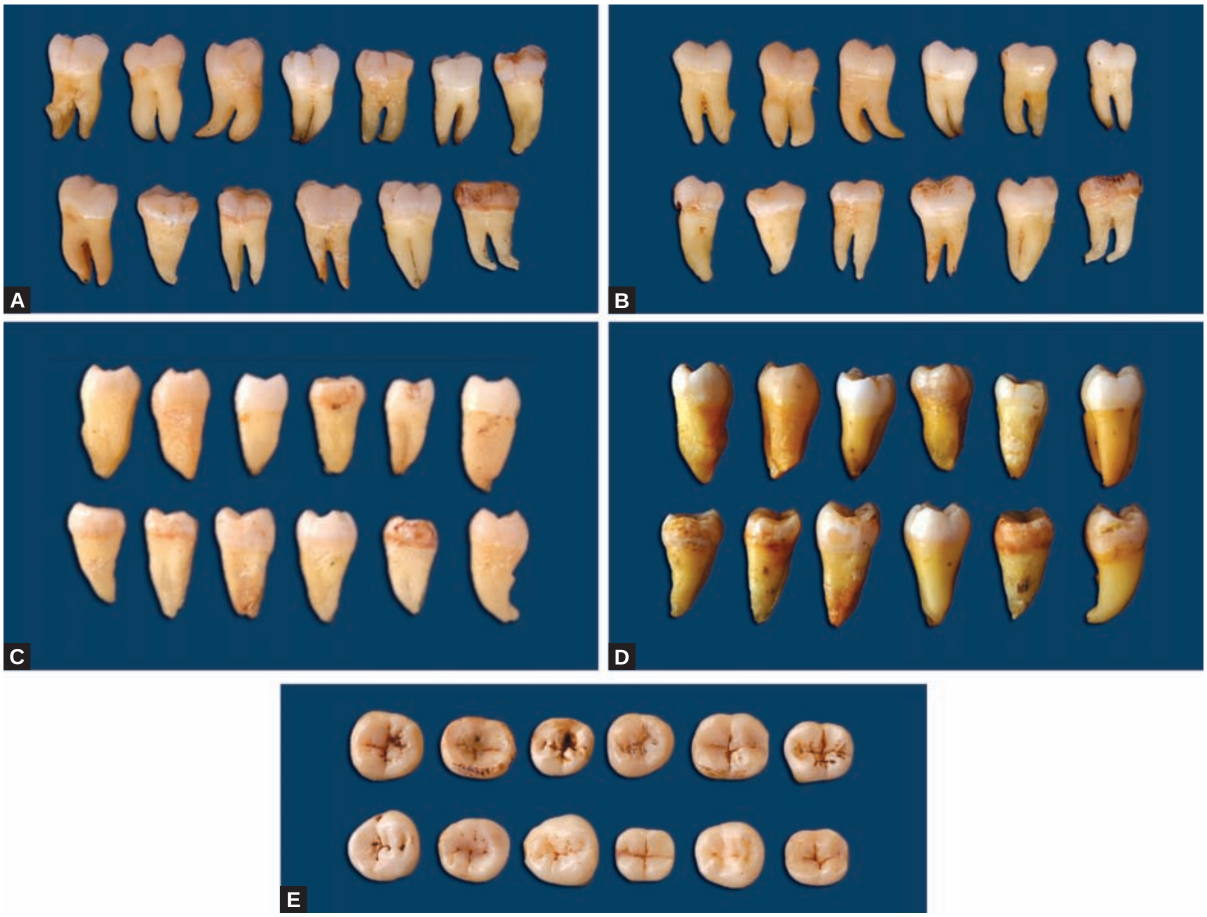


Figure 13.21 Mandibular 3rd molar—graphic illustrations



Figures 13.22A to E Mandibular 3rd molar—typical specimen from all aspects: (A) Buccal aspect; (B) Lingual aspect; (C) Mesial aspect; (D) Distal aspect; (E) Occlusal aspect

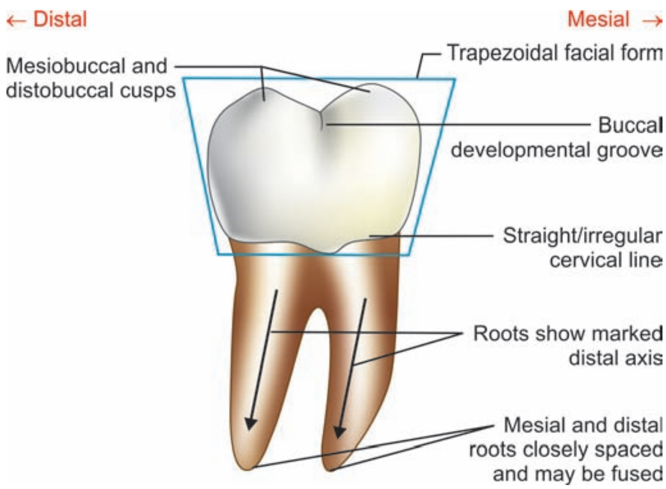


Figure 13.23 Mandibular 3rd molar—features on buccal aspect

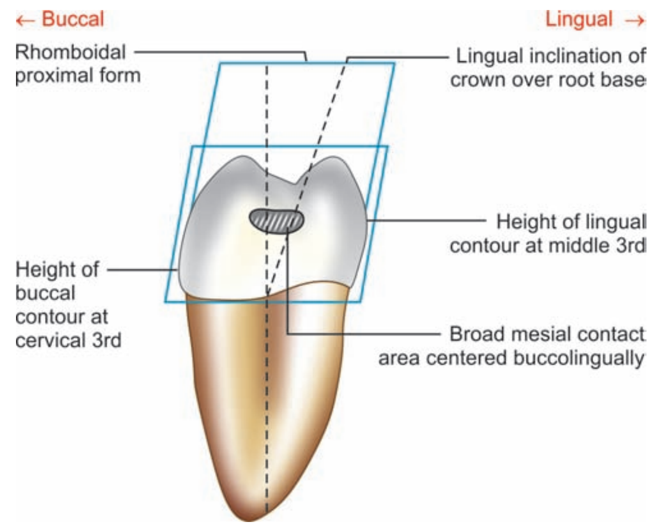


Figure 13.25 Mandibular 3rd molar—features on mesial aspect

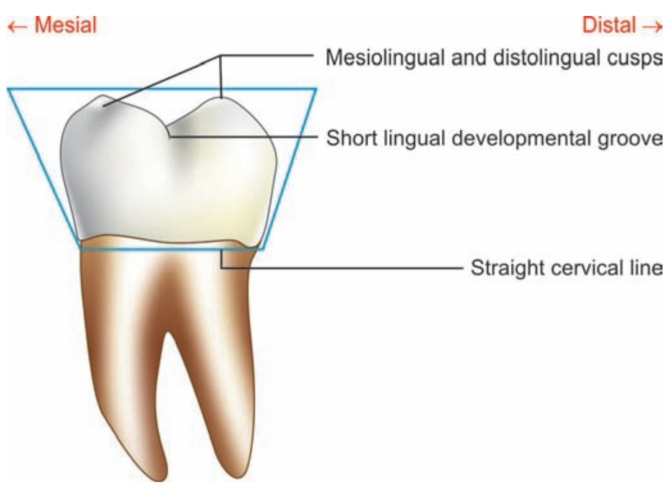


Figure 13.24 Mandibular 3rd molar—features on lingual aspect

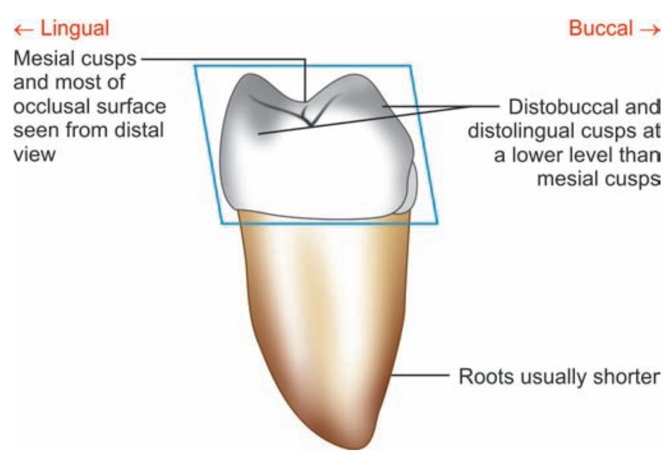


Figure 13.26 Mandibular 3rd molar—features on distal aspect

- The *mesial contact area* is broad, centered buccolingually and a little occlusal to the center of the tooth cervico-occlusally.

Distal Aspect (Fig. 13.26)

Geometric shape: It is rhomboidal similar to mesial aspect.

- The distobuccal and distolingual cusp tips are usually at a lower level than the mesiobuccal and mesiolingual cusp tips
- Distal marginal ridge is at a lower level than the mesial marginal ridge
- Thus the cusps along with most of the portion of occlusal surface can be seen from the distal aspect
- The 3rd molars have only one contact at area—mesial, as they are the last teeth in the dental arches.

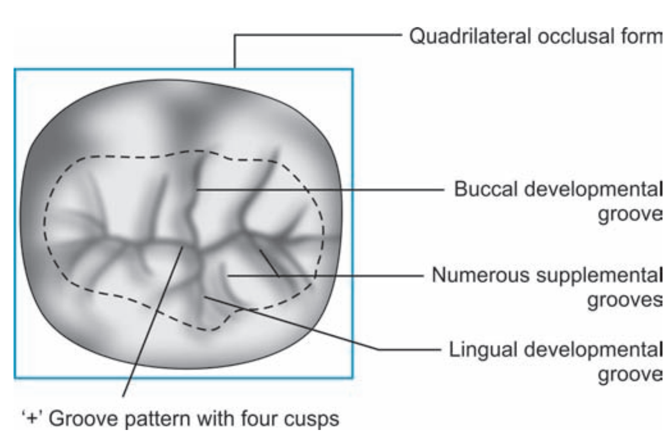


Figure 13.27 Mandibular 3rd molar—features on occlusal aspect

Occlusal Aspect (Fig. 13.27)

Geometric shape: It is quadrilateral similar to that of mandibular 2nd molar.

Relative Dimensions

The mesiodistal dimension is greater than the buccolingual dimension. Crown tends to be smaller distally than mesially.

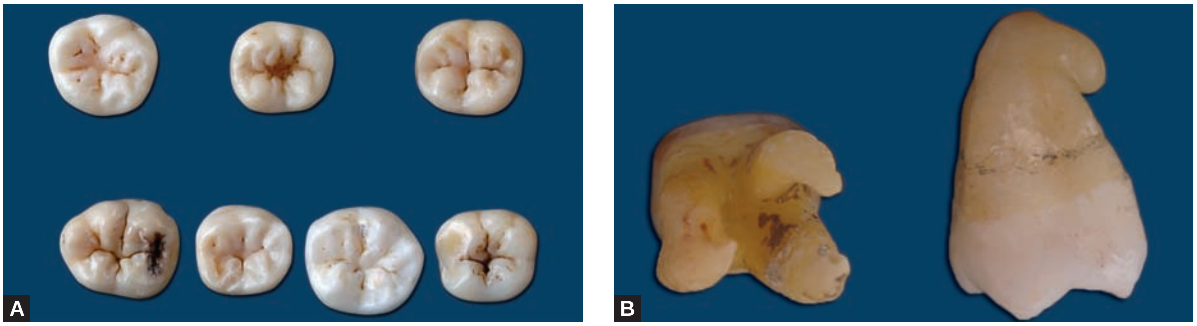
Occlusal Anatomy

- Usually the mandibular 3rd molars have an occlusal design similar to that of mandibular 2nd molar with four cusps and '+' shaped groove pattern. They may also show *'Y' groove pattern*.
- Some 3rd molars may also resemble mandibular 1st molars carrying five cusps. There are yet others which may appear like anomalies with more than five cusps or several small tubercles roughened by multiple grooves.
- When they are well formed and resemble mandibular 2nd molars, the occlusal surface is divided into four parts by central, buccal and lingual developmental grooves.

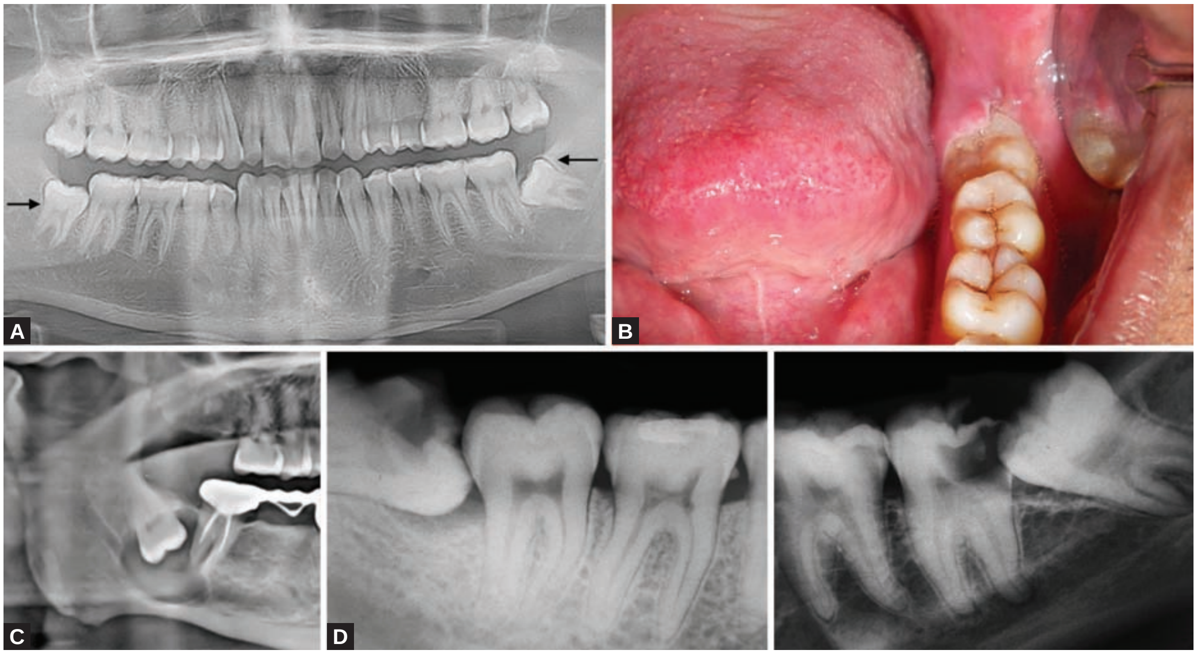
ROOT

Number

They have two roots which may be fused.



Figures 13.28A and B Mandibular 3rd molar—variations



Figures 13.29A to D (A) Impacted mandibular 3rd molars; (B) Pericoronitis of partially erupted mandibular 3rd molar; (C) Dentigerous cyst developing around an unerupted mandibular 3rd molar; (D) Caries in the partially impacted mandibular 3rd molar or its adjacent tooth

Size

- The roots are generally small, poorly developed and shorter than that of mandibular 2nd molar
- Even when the crown is oversized, the roots tend to be shorter.

Form

- The mesial and distal roots may be separated or fused for all or part of their length
- The roots are inclined distally to a greater extent than seen in the mandibular 2nd molars
- Both the roots taper more rapidly from cervix to their apical ends
- May be curved in a distal direction.

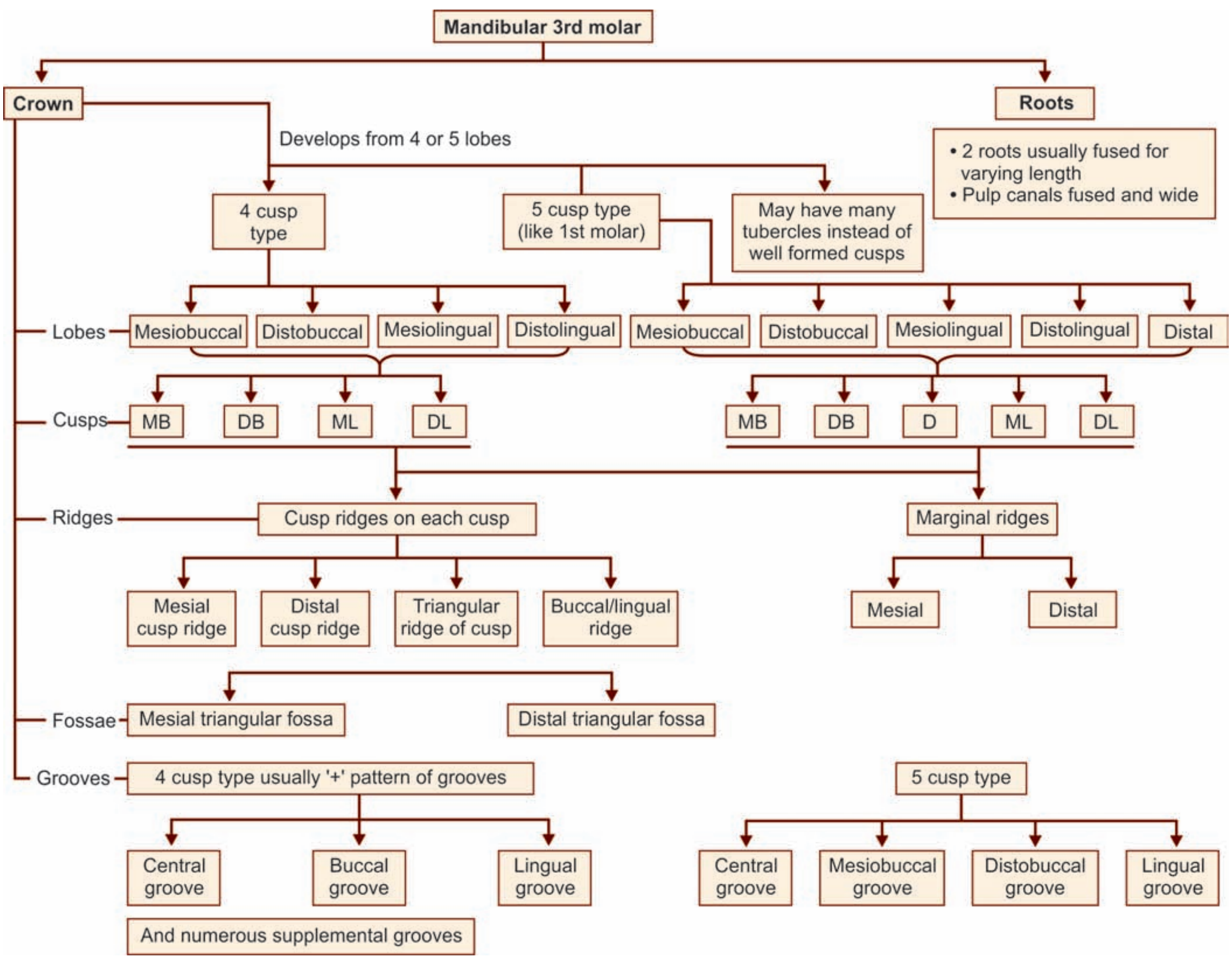
Apices

The apices of roots are more pointed than those of other mandibular molars.

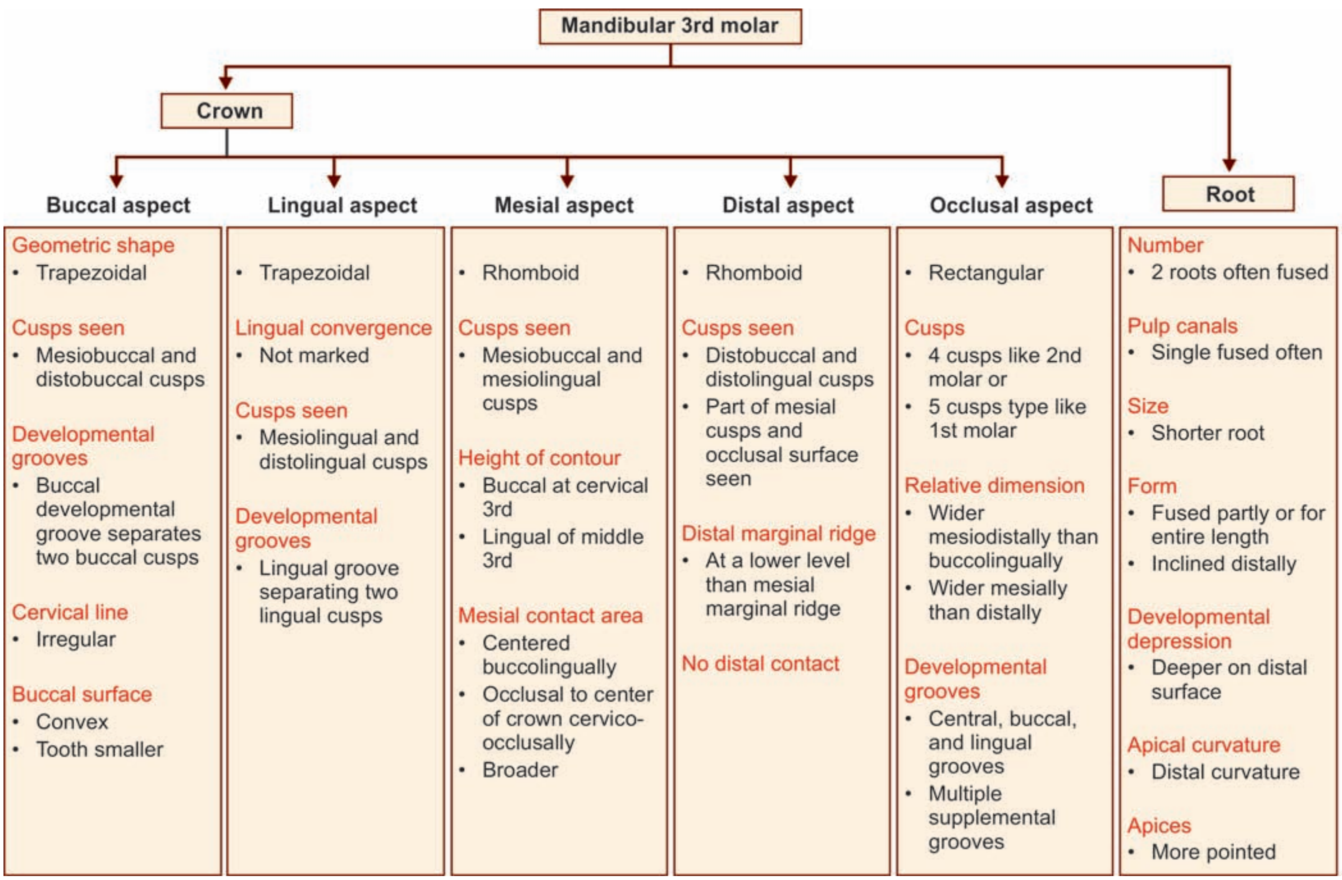
VARIATIONS (FIGS 13.28A AND B)

- 3rd molars show greatest variation inform
- The mandibular 3rd molars may resemble 2nd molar or sometimes the mandibular 1st molar

Flow chart 13.5 Mandibular 3rd molar—major anatomic landmarks



Flow chart 13.6 Mandibular 3rd molar—summary



- The crowns can be oversized having five or more than five cusps
- The roots can be bifurcated at their apical ends
- The roots may be very short.

DEVELOPMENTAL ANOMALIES

- Dilacerations
- Concrescence.

CLINICAL CONSIDERATIONS (FIGS 13.29A TO D)

- The mandibular 3rd molars are the most commonly impacted teeth either partially or completely often due to lack of space in the jaw (**Fig. 13.29A**)
- When the tooth is partially erupted, the surrounding mucosa may get inflamed which is called as *pericoronitis* (**Fig. 13.29B**). This condition can be quite painful and may cause difficulty in opening the mouth.
- Impacted 3rd molars are often associated with cyst development (dentigerous cyst) (**Fig. 13.29C**)

Box 13.3 Mandibular 3rd molar—identification features

Identification features of mandibular 3rd molar
- Usually, the mandibular 3rd molars are similar to mandibular 2nd molars but a little smaller in size
- The occlusal surface shows more number of supplemental grooves
- The roots are shorter and more pointed and have an extreme distal tilt
- They often have fused roots.

- When partly erupted (**Fig. 13.29D**), food impaction and inaccessibility to cleaning may cause caries of the tooth or its adjacent tooth
- The impacted tooth may also cause resorption of the roots of mandibular 2nd molar when it is in close approximation with the latter tooth.
- The maxillary and mandibular 3rd molars can be congenitally absent.

Flow charts 13.5 and 13.6 summarize the mandibular 3rd molar anatomy. **Box 13.3** gives identification features of the tooth.

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.
2. Brand RW, Isselhard DE. Anatomy of orofacial structures, 5th edn. St Louis: CV Mosby; 1994.
3. Sicher H, DuBrul EL. Oral anatomy, 7th edn. St Louis: CV Mosby; 1975.
4. Woelfel JB, Scheid RC. Dental Anatomy: Its relevance to dentistry, 5th edn. Baltimore; Williams and Wilkins; 1997.

MULTIPLE CHOICE QUESTIONS

1. In mandibular arch, the size of the molar teeth:
   a. Increases from 1st molar to 3rd molar
   b. Decreases from 1st molar to 3rd molar
   c. Remains same for all three molars
   d. None of the above
2. Mandibular molar crowns are:
   a. Wider mesiodistally than buccolingually
   b. Wider buccolingually than mesiodistally
   c. Equal in mesiodistal and buccolingual dimensions
   d. None of the above
3. The largest tooth of mandibular arch in permanent dentition is:
   a. Mandibular 2nd premolar
   b. Mandibular 1st molar
   c. Mandibular 2nd molar
   d. Mandibular 3rd molar
4. Mandibular 1st molar has:
   a. 3 cusps
   b. 4 cusps
   c. 5 cusps
   d. 6 cusps
5. Mandibular 1st molar has:
   a. 2 roots; buccal and lingual
   b. 2 roots; mesial and distal
   c. 3 roots; 2 buccal and lingual
   d. 3 roots; 2 mesial and distal
6. Buccal and lingual aspects of mandibular 1st molar are:
   a. Triangular
   b. Rhomboidal
   c. Trapezoidal with shorter uneven side towards the cervix
   d. Trapezoidal with shorter uneven side towards the occlusal portion
7. Buccal surface of the mandibular 1st molar has:
   a. No developmental groove
   b. One developmental groove
   c. Two developmental grooves
   d. Three developmental grooves
8. In permanent mandibular 1st molars, the cusps visible from buccal view are:
   a. Two buccal cusps only
   b. Two buccal cusps and the distal cusp
   c. Two buccal cusps and two lingual cusps
   d. All five cusps can be seen
9. The cusps present in permanent mandibular 1st molar:
   a. Mesiobuccal, distobuccal, mesiolingual, distolingual and distal
   b. Mesiobuccal, middle distal, mesiolingual, and distolingual
   c. Mesiobuccal, distobuccal, mesiolingual, distolingual and cusp of Carabelli
   d. None of the above
10. The 2 buccal cusps of mandibular 1st molar are separated by:
    a. The central developmental groove
    b. The oblique developmental groove
    c. The mesiobuccal developmental groove
    d. The distobuccal developmental groove

Answers

1. b 2. a 3. b 4. c 5. b 6. c 7. c 8. d 9. a 10. c

CHAPTER

14 Pulp Morphology

Dental pulp is the only soft tissue component of the tooth; the other three components of tooth being the hard mineralized tissues namely, enamel, dentin and cementum. The dental pulp harbors neurovascular bundles and lymphatic channels. Various functions have been attributed to the pulp including formative, nutritive, sensory and defensive. Although its initial function is to form dentin during the developmental period of tooth, the dental pulp remains active throughout life and responds to various stimuli such as caries, trauma and restorative procedures by forming secondary and reparative dentin as may be required to maintain vitality of the pulp.

Knowledge of pulp morphology is essential for sound clinical practice. For instance, it is important to avoid exposing the pulp while removing caries and restoring the tooth. When the pulp is diseased or a tooth is non-vital the entire pulp tissue is removed and the pulp cavity is filled using an inert material such as gutta-percha (root canal treatment).

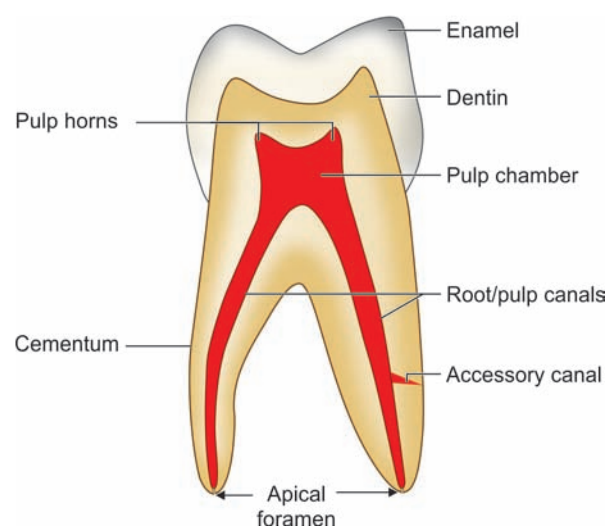


Figure 14.1 Mesiodistal section of a mandibular molar

THE TERMINOLOGY

The terminology related to the pulp morphology is explained before proceeding further towards describing the pulp anatomy of each tooth in detail (**Fig. 14.1**).

Pulp Cavity

The dental pulp occupies the central cavity within the tooth, the *pulp cavity*. The pulp cavity is encased by rigid dentinal walls all around except at the apical foramen through which the blood vessels and nerves enter and leave the pulp. At the apical foramen the pulp becomes continuous with the periodontal ligament.

For descriptive purposes, the pulp cavity is devided into a coronal portion—the *pulp chamber* and a radicular portion—the *root canal(s)*. All teeth have single pulp chamber while the number of root canals vary accordingly to the tooth type and class. The pulp cavity confines to the external form of the tooth in basic shape. The pulp chamber follows the external shape of the crown while the root canals take the basic shape of roots.

Pulp Chamber

As mentioned above, the pulp chamber is that portion of the pulp present within the crown portion of the tooth. The pulp chamber closely follows the external crown morphology especially in a younger tooth.

All teeth have a single pulp chamber that has a roof and four walls. Pulp chamber of multirooted teeth have a single pulp chamber that has four walls and a roof. Extension of the roof of the pulp chamber directly under a cusp or developmental lobe is called as the *Pulp Horn/Cornua*. Pulp horns are at a higher level in primary teeth.

In permanent teeth pulp horns are especially prominent under buccal cusp of premolars and mesiobuccal cusp of molar teeth. During cavity preparation and restoration of teeth, it is important to avoid the pulp horns to prevent exposure of pulp tissue. The walls of the pulp chamber derive their names from the corresponding walls of the tooth surface, e.g. buccal wall/lingual wall of the pulp chamber.

In anterior teeth, the pulp chamber gradually merges into the single root canal and the division becomes indistinct. In multirooted teeth, the pulp chamber opens into two or more root canals. The entrance (orifices) to the root canals is located on the floor of the pulp chamber, usually below the center of the cusp tips.

Root Canals

Both the terms *root canal* and *pulp canal* are accepted; the term root canal is commonly used though the term *root canal system* is appropriate for multirooted teeth.

The root canal is the portion of the pulp from the canal orifice to the apical foramen. Each root has at least one root canal, many have two (e.g. mandibular molars have two root canals in their mesial root). When roots are fused, the tooth still maintains the usual number of root canals.

Small *accessory canals* can be found at the apical third of the root and furcation areas of multirooted teeth in varying frequencies. The term "*lateral canals*" is often used for the small canals that lead from main canal to the lateral aspect of the root. Both accessory and lateral canals develop due to a break in Hertwig's epithelial root sheath or when the sheath grows around existing blood vessels during root formation.

The apical foramen and lateral/accessory canals form channels of communication between the main body of the root canal and the periodontal ligament space. Thus they can act as route of extension of inflammation from one tissue to the other. Infection in pulp can produce changes in the periodontal tissue and more rarely the vice versa.

Classification of Root Canals

Root canal morphology is quite complex. The root canal configurations have been classified by various researchers (Weine, Vertucci, etc.) according to the number of canals, intra-canal branching, and fusion and exit from the canal. Weine's classification is considered here.

Weine's Classification of Root Canals (Fig. 14.2)

- *Type I*: Single canal from pulp chamber to apex.
- *Type II*: Two canals leaving from the chamber and merging to form a single canal short of the apex.
- *Type III*: Two separate and distinct canals from chambers to apex.
- *Type IV*: One canal leaving the chamber and dividing into two separate and distinct canals.

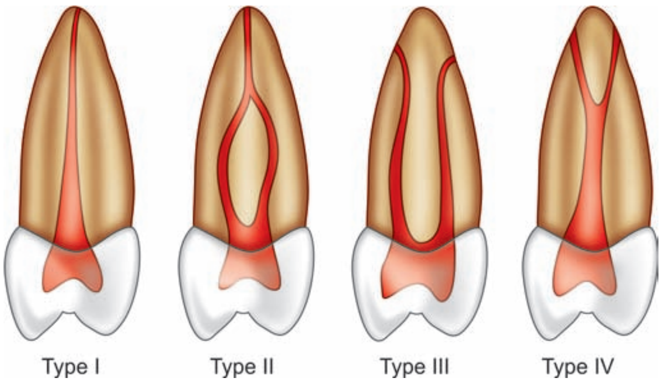


Figure 14.2 Weine's classification of root canal configurations: Type I: Single canal from pulp chamber to apex; Type II: Two canals leaving the chamber and merging to form a single canal short of the apex; Type III: Two separate and distinct canals from chamber to apex; Type IV: One canal leaving the chamber and dividing into two separate and distinct canals

Apical Foramen and Accessory Foramina

Opening from pulp canal to outside of tooth include apical foramen at/near root apex and the accessory foramina. In the young, developing tooth, the apical foramen is large, funnel shaped and centrally located (**Fig. 14.3**). The wide foramen is filled with periodontal tissue that is later replaced by dentin and cementum.

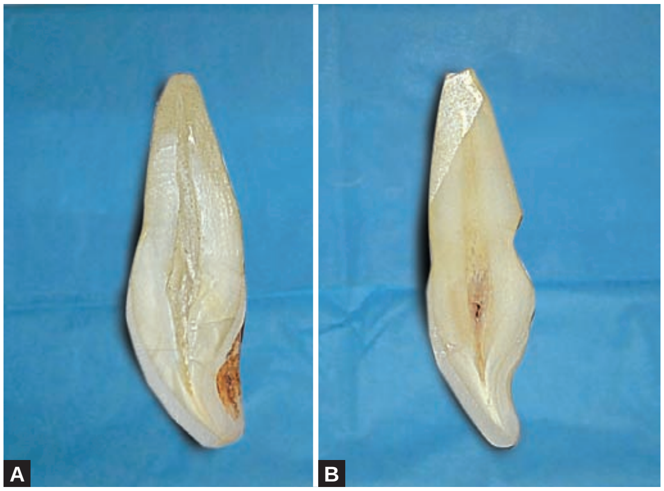
Figure 14.3 In developing tooth, apical foramen is large, funnel shaped and centrally located (arrows). It becomes small and eccentrically placed after root completion

As the root completes its development, the apical foramen becomes smaller in diameter and more eccentric in position. After root completion, the apical foramen is seldom located at the very end, i.e. anatomic apex. It may be located on mesial, distal, labial/lingual surfaces of root usually slightly eccentrically.

Knowledge of the age at which calcification and closure of root apex occurs is essential for endodontic practice, especially when treating pulp involved teeth of children and adolescents. In general, the root apex is completely formed about 2 to 3 years after eruption of the tooth (refer **Tables 3.1 and 3.2**).

AGE RELATED CHANGES IN PULP MORPHOLOGY

The size and shape of the pulp cavity are influenced by age. The dental pulp gets smaller with age, because of secondary dentin deposition that occurs throughout life. In addition, tertiary/reparative dentin that is formed in response to various stimuli such as caries, trauma, etc. that also contribute to decreasing size of the pulp. In a young person, the pulp horns are long, pulp chambers are large, root canals are wide and apical foramina are widely open. With advancing age, pulp horns recede, pulp chambers becomes smaller in height and root canals become narrower (**Figs 14.4A and B**). The floor of the pulp chamber is nearly flat in young teeth, later become convex. The incidence of pulp stones/calcifications also increase with age. They appears as radiopacities in pulp cavity on a radiograph (**Fig. 14.5**).



Figures 14.4A and B Longitudinal sections of maxillary central incisor from young (A) and Old (B). Individuals to show shrinkage of pulp size with age due to secondary dentin formation

CLINICAL APPLICATIONS

A thorough understanding of root canal anatomy with all the variations and complexities is essential for the clinicians to successfully localize, disinfect and seal root canal system.

Figures 14.6A and B give ideal access opening for maxillary and mandibular teeth.

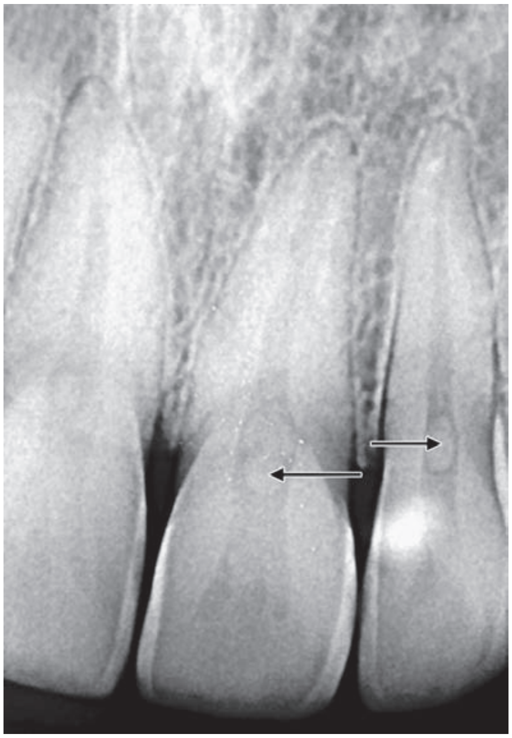
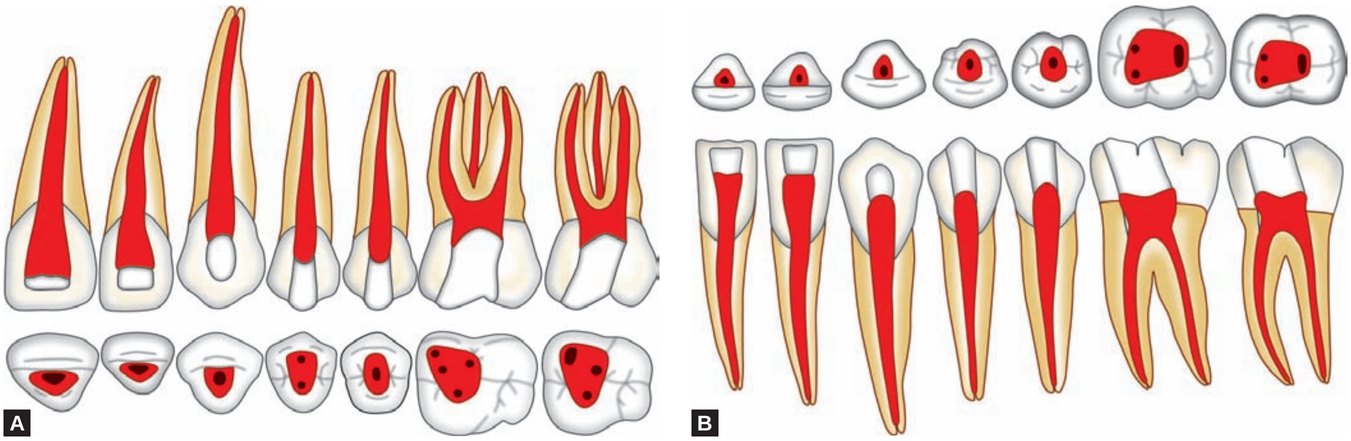


Figure 14.5 Pulp stones



Figures 14.6A and B Ideal design of access opening for maxillary and mandibular permanent teeth

DETAILED DESCRIPTION OF PULP ANATOMY OF PERMANENT TEETH

MAXILLARY TEETH

Permanent Maxillary Central Incisor (Fig. 14.7)

Pulp Chamber

- Viewed proximally (labiolingual section), the pulp chamber of maxillary central incisor is wider at cervix and taper towards the incisal ridge.
- Viewed labially (mesiodistal section), the pulp chamber follows the crown outline and may show three pulp horns that correspond to the developmental mamelons in a young tooth. The pulp chamber is wider in the mesiodistal section than in the labiolingual section, with widest dimension incisally.
- The division between root canal and pulp chamber is indistinct.

Root Canal

- The maxillary central incisor has one root with one root canal
- The root canal is conical in shape, broader labiolingually and centrally located
- The root canal tapers gradually towards the apical foramen, where it may curve slightly either distally or labially.

Cross-section

- In a young tooth, cross-section of the root at cervix shows a roughly triangular outline with the base of the triangle at the labial aspect of the root
- The cross-section of the root canal becomes oval/round at mid root level and round at apex.

Access Opening

Inverted triangular shaped access cavity is cut with its base at the cingulum to give a straight line access.

Permanent Maxillary Lateral Incisor (Fig. 14.8)

Pulp Chamber

- Pulp chamber of maxillary permanent lateral incisor is similar but smaller than that of maxillary permanent central incisor
- It is broad mesiodistally, with its broadest part incisally
- The division between root canal and pulp chamber is indistinct.

Root Canal

The root canal is conical like that of central incisor but is of smaller diameter.

Cross-section

In cross-section, the canal is ovoid labiolingually at cervical level and mid root level it becomes round at the apical third.

Access Opening

The access cavity is similar to that of central incisor but is smaller and more ovoid.

Permanent Maxillary Canine (Fig. 14.9)

Pulp Chamber

- The pulp chamber of maxillary permanent canine is the largest among all anterior teeth.
- The pulp chamber is broader labiolingually than is mesiodistally

Figure 14.7 Maxillary central incisor. Sections of natural specimen: Mesiodistal, labiolingual, cross-section of root at cervical, mid root and apex

Figure 14.8 Maxillary lateral incisor. Sections of natural specimen: Mesiodistal, labiolingual, cross-section of root at cervical, mid root and apex

Figure 14.9 Maxillary canine. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

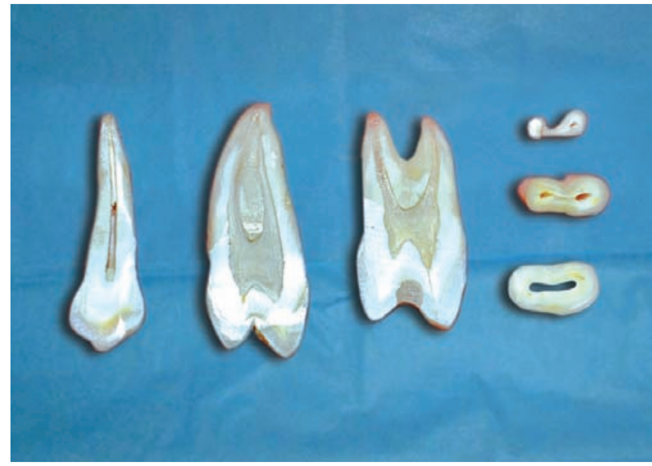


Figure 14.10 Maxillary 1st premolar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

- Viewed proximally (on labiolingual section), the pulp chamber is wider cervically and single pulp horn extends towards the single cusp
- On mesiodistal section, the pulp chamber is narrow resembling a flame
- The division between the pulp chamber and root canal is indistinct.

Root Canal

- The single root canal of maxillary permanent canine is larger and longer than that of maxillary incisors.
- It is wider labiolingually than in mesiodistal dimension.
- The pulp canal may show sudden narrowing at middle third of root and from this level tapers gradually to apical foramen abrupt constriction of root canal should be born in mind during root canal treatment to avoid over instrumentation.

Cross-section

Cross-section of the root canal at cervix and mid root level is oval with greater diameter labiolingually may become round at apex.

Access Opening

Oval shaped access cavity is cut that reflects the shape of the root canal.

Permanent Maxillary 1st Premolar (Fig. 14.10)

Pulp Chamber

- Viewed proximally (buccolingual section), the pulp chambers of maxillary 1st premolar is broad with two pulp horn pointing towards the buccal and lingual cusps. The buccal pulp horn is more prominent than the lingual/palatal pulp horn in young teeth
- The floor of the pulp chamber is located in coronal 3rd of root below cervical line. It is convex, generally has two canal orifices, one buccal and one lingual
- Viewed from buccal aspect, the mesiodistal dimension of pulp chamber is much narrower. The pulp horns are superimposed on one another and appear blunted. The pulp chamber cannot be differentiated from root canal from this view.

Root Canals

- The maxillary 1st premolar generally has two roots (85%), although fused or partially fused roots are not uncommon. When roots are fused a groove may be seen that divides the root into buccal/lingual portions. Regardless of whether maxillary 1st premolars have one or two roots, they usually have two root canals that exit by separate apical foramina. A single root and single root canal is present in less than 10 percent of the cases. A small number (5%) of maxillary 1st premolars may have three roots and three root canals
- The two canals take the shape of their respective roots and get tapered towards apex.

Cross-section

- Cross-section at cervical level shows a typical kidney shaped appearance with indentation on mesial aspect that is formed by mesial developmental groove and depression
- The root canal is also kidney shaped/oval at cervical level.

- At mid root level and two round/oval shaped canals can be seen
- The root canals are round and small at apex.

Access Cavity

An oval shaped access cavity is cut on occlusal surface between the cusp tips to gain access to buccal and lingual canals.

Permanent Maxillary 2nd Premolar (Fig. 14.11)

Pulp Chambers

- The pulp chamber of maxillary 2nd premolar is wider buccolingually than mesiodistally
- Shows two pulp horns similar to maxillary 1st premolar
- The pulp chamber extends apically well below the cervical margin.

Pulp Canals

The maxillary 2nd premolar generally has single root and single root canal (90% cases). The tooth can sometimes have two root canals.

Cross-section

The cervical cross-section of the root shows flattened oval canal. The root canal is slightly oval at mid root level and becomes round at apical third.

Access Cavity

The access cavity preparation is oval similar to the 1st premolars.

Permanent Maxillary 1st Molar (Fig. 14.12)

Pulp Chamber

- The pulp chamber of maxillary 1st molar is the largest in the maxillary arch. It is rhomboidal in shape, its buccolingual dimension wider than the mesiodistal dimension
- The root of the pulp chamber projects to form four pulp horns one to each of the major cusps. The mesiobuccal pulp horn is longest, more nearer to tooth surface than other pulp horns
- The floor of the pulp chamber lies below the cervical margin. Generally, three openings of root canal can be located at three angles of the floor.

Root Canals

- The maxillary 1st molar generally has three roots and respective three canals namely the mesiobuccal, distobuccal and palatal
- Sometimes, a fourth canal can be found in the mesiobuccal root.
- The distobuccal canal is narrower than the mesiobuccal root canal. The palatal root canal is the widest and longest of the three root canals.

Cross-section

- The cervical cross-section of the root shows rhomboidal shaped pulp cavity with three canal orifices
- Cross-section at mid root level shows, larger round shaped palatal canal, small oval shaped distobuccal canal and oval elongated/kidney shaped mesiobuccal canal.

Figure 14.11 Maxillary 2nd premolar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Figure 14.12 Maxillary 1st molar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Access Cavity

- The access opening is triangular, with rounded corner extending towards mesiobuccal cusp tip, mesial marginal ridge and oblique ridge
- When accessory canal MB-2 is present, the access preparation is modified into a rhomboid shaped cavity.

Permanent Maxillary 2nd Molar (Fig. 14.13)

Pulp Chamber

- The pulp chamber of maxillary 2nd molar is similar to that of maxillary 1st molar but is smaller
- Mesiodistal dimension is much narrower than bucco-lingual. Thus, pulp chamber is more rhomboidal and the mesiobuccal and distobuccal canals are more closely placed
- The floor of the pulp is apical to the cervical line.

Root Canal

- The three roots of maxillary 2nd molar are less divergent than those of maxillary 1st molar. Thus, the canal orifices are closely placed on the pulpal floor
- The mesiobuccal and distobuccal roots may be fused. Then only two root canals may be present, the buccal and palatal.

Cross-section

The cervical cross-section shows rhomboidal pulp floor with three/two canal orifices.

Access Cavity

The access opening for maxillary 2nd molar is same as that of maxillary 1st molars.

Permanent Maxillary 3rd Molar (Fig. 14.14)

The maxillary 3rd molar has the most variable anatomy among the maxillary teeth. It is smaller than the other molars. The roots are short and often fused. Anatomy of pulp chamber and root canals of the maxillary 3rd molars vary and cannot be generalized. Often they have three roots and three canals.

MANDIBULAR TEETH

Permanent Mandibular Central Incisor (Fig. 14.15)

Pulp Chamber

- Being the smallest tooth in permanent dentition, the pulp chamber of mandibular central incisor is small and narrower mesiodistally than labiolingually. It is constricted at cervical margin
- Viewed proximally (labiolingual section), the pulp chamber is wider cervically and tapers incisally
- The division between pulp chamber and root canal is indistinct.

Pulp Canal

The mandibular central incisor generally has a single root with single root canal. Some teeth may show two root canals. However, they fuse at apex and exit by a single foramen.

Cross-section

Cervical cross-section shows a labiolingually oval pulp cavity. The canal becomes round at apex.

Access Cavity

The access opening is long and oval incisogingivally.

Figure 14.13 Maxillary 2nd molar sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Figure 14.14 Maxillary 3rd molar: Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Permanent Mandibular Lateral Incisor (Fig. 14.16)

Pulp Chamber

- In contrast to maxillary incisor, the tooth and pulp cavity of mandibular lateral incisor is larger than that of mandibular central incisor
- The pulp chamber is similar in shape to that of mandibular central incisor but is larger.

Figure 14.15 Mandibular central incisor. Sections of natural specimen: Mesiodistal, labiolingual, cross-section of root at cervical, mid root and apex

Pulp Canals

- The mandibular lateral incisor has one root and one canal
- Two root canals occur more frequently than seen in mandibular central incisor. When present, the two canals exit by separate foramina.

Cross-section

The cervical cross-section of the pulp is oval and round at mid root and apex.

Access Cavity

Access opening is oval similar to mandibular central incisor.

Permanent Mandibular Canine (Fig. 14.17)

Pulp Chamber

- The pulp chamber of mandibular permanent canine is similar to that of maxillary canine but is smaller in dimension
- The pulp chamber is narrower mesiodistally than labiolingually. It has single pulp horn that extends towards the cusp tip
- Pulp chamber and root canal are not well-demarcated.

Root Canal

- The mandibular canine usually has single root and single root canal
- A common variation is to exhibit bifurcated root with two root canals that exit by two separate foramina.

Figure 14.16 Mandibular lateral incisor. Sections of natural specimen: Mesiodistal, labiolingual, cross-section of root at cervical, mid root and apex

Figure 14.17 Mandibular canine. Sections of natural specimen: Mesiodistal, labiolingual, cross-section of root at cervical, mid root and apex

Cross-section

Cervical cross-section shows oval shaped pulp canal. It becomes small and round apex.

Access Cavity

Access opening is oval shaped similar to maxillary canine.

Permanent Mandibular 1st Premolar (Fig. 14.18)

Pulp Chamber

- The pulp chamber is wider buccolingually than mesiodistally than unlike other premolar, it has only one pulp horn under well-developed buccal cusp. Small lingual pulp horn may be visible in a young tooth, but soon becomes indistinct with age. This gives the pulp chamber a resemblance to that of mandibular canine
- Lingual inclination of the crown over root base is also reflected in the pulp chamber form
- The division between pulp chamber and root canal is indistinct.

Root Canal

- The mandibular 1st premolar has one root with one root canal
- The root canal becomes constricted towards the middle third of the root
- In 25 percent of the cases the main root canal may divide into two canal at apex.

Cross-section

The root canal is slightly oval at cervical and mid root level and becomes small and round at apex.

Access Cavity

An oval access opening gives access to the pulp canal. Lingual tilt of the crown has to be borne in mind to prevent preparations.

Permanent Mandibular 2nd Premolar (Fig. 14.19)

Pulp Chamber

The pulp chamber of mandibular 2nd premolar is similar to that of mandibular 1st premolar; however, the tooth has a prominent lingual horn under well-formed lingual cusps in addition to buccal pulp horn.

Root Canal

- The mandibular 2nd premolar root is wider buccolingually than the mandibular 1st premolar and it often shows a distal curvature
- The root canal is wider buccolingually, becomes constricted at mid root level and then gets tapered towards apex.

Cross-section

- The cervical cross-section shows oval shaped pulp cavity buccolingually
- It is round at mid root level and apex.

Figure 14.18 Mandibular 1st premolar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Figure 14.19 Mandibular 2nd premolar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Access Cavity

It is similar to that of mandibular 1st molar oval-shaped opening is needed.

Permanent Mandibular 1st Molar (Fig. 14.20)

Pulp Chamber

- The pulp chamber of mandibular 1st molar is wider mesiodistally than buccolingually
- The pulp chamber is rectangular when viewed from buccal and lingual aspects
- It has four pulp horns under four major cusps
- The mesiobuccal, distobuccal, mesiolingual and distolingual. The lingual horns are longer and at a higher level than the buccal pulp horns
- The floor of the pulp chamber is broad and is at or below cervical margin.

Root Canals

- The mandibular 1st molar has two roots and three root canals. The mesial root has two canals, the mesiobuccal and mesiolingual
- The distal root canal is more oval and wider buccolingually than the mesial roots
- Rarely, the mandibular 1st molar can have three roots. The distal root sometimes may shows two canals.

Cross-section

- The cross-section at the tooth at cervix is quadrilateral in shape with mesial wall of pulp wider than the distal
- At mid root level, the distal root canal is long oval-shaped. The mesial root canal are slightly oval.

Access Cavity

- The access opening is trapezoidal with round corners, wider towards mesial surface of the crown.
- The access cavity is made rectangular in a second distal canal is present.

Permanent Mandibular 2nd Molar (Fig. 14.21)

Pulp Chamber

The pulp chamber of mandibular 2nd molar closely located.

Root Canal

- The tooth has two roots and three canals similar to mandibular 1st molars.
- A common variation seen is the presence of only two canals the mesial and distal.

Cross-section

- Cervical cross-section is quadrilateral with small canal orifices closely placed.
- The root canals at mid root level are oval in shape.

Permanent Mandibular 3rd Molar (Fig. 14.22)

The mandibular 3rd molar pulp morphology varies greatly. The pulp cavity resembles that of mandibular 2nd molar but the roots are short, often fused and curved. The tooth may

Figure 14.20 Mandibular 1st molar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Figure 14.21 Mandibular 2nd molar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

Figure 14.22 Mandibular 3rd molar. Sections of natural specimen: Mesiodistal, buccolingual, cross-section of root at cervical, mid root and apex

have one to four roots and one to six canals. C-shaped canals can be seen due to fusion of roots.

BIBLIOGRAPHY

1. Barker BC, et al. Anatomy of root canals I. Permanent incisors, canines and premolars. Aust Dent. 1973;18:320.
2. Barker BC, et al. Anatomy of root canals II. Permanent maxillary molar. Aust Dent J. 1974;19:46.
3. Barker BC, et al. Anatomy of root canals III. Permanent mandibular molar. Aust Dent J. 1974;19:408.
4. Okumura T. Anatomy of the root canals. J Am Dent Assoc. 1927;14:632.
5. Vertucci FJ, Williams RG. Furcation in the human mandibular 1st molars. Oral Surg. 1974;38:308.
6. Vertucci FJ, et al. Root canal morphology of the human maxillary 2nd premolar. Oral Surg. 1974;88:456.
7. Vertucci FJ, et al. Root canal morphology of the human maxillary 1st premolar. Oral Surg. 1979;99:194.

MULTIPLE CHOICE QUESTIONS

1. The only soft tissue component of the tooth is:
   a. Dental pulp
   b. Enamel
   c. Dentin
   d. Cementum
2. The hard mineralized components of tooth are the following except:
   a. Dental pulp
   b. Enamel
   c. Dentin
   d. Cementum
3. The functions of pulp include:
   a. Formative
   b. Nutritive
   c. Sensory and defensive
   d. All of the above
4. Which of the following tissues of tooth remains active throughout the life by responding to various stimuli such as caries and by forming secondary dentin:
   a. Dentin
   b. Enamel
   c. Pulp
   d. Cementum
5. The pulp cavity is encased by rigid dentin walls all around except:
   a. At the center of the root
   b. At the cervix of the root
   c. At apical foramen through which the blood vessels enters and leaves the pulp
   d. None of the above
6. The coronal portion of the pulp cavity is termed as:
   a. Pulp chamber
   b. Root canal
   c. Both of the above
   d. None of the above
7. The radicular portion of the pulp cavity is termed as:
   a. Pulp chamber
   b. Root canal
   c. Both of the above
   d. None of the above
8. Which of the following statements is correct?
   I. All teeth have single pulp chambers
   II. Number of root canals differs from tooth to tooth
   a. Statement I and II are incorrect
   b. Statement I and II are correct
   c. Only statement I is correct
   d. Only statement II is correct
9. The extension of the roof of the pulp chamber directly under a cusp or developmental lobe is called as the:
   a. Pulp chambers
   b. Pulpal extension
   c. Pulp stones
   d. Pulp horns
10. During cavity preparation and restorations of tooth, it is important to avoid the pulp horns to prevent:
    a. Exposure of the pulp tissue
    b. Morphology of the tooth crown
    c. Super-infection of the tooth
    d. All of the above

Answers

1. a	2. a	3. d	4. c	5. c	6. a	7. b	8. b	9. d	10. a

SECTION

5

Class, Arch and Type Traits of Teeth

CHAPTER

15

Class, Arch and Type Traits of Incisor Teeth

This chapter gives the common characteristics of incisor teeth—*Class traits*, major differences between the maxillary and mandibular incisors—*Arch traits* (**Table 15.1**) and the differences between central and lateral incisors of each arch—*Type traits* (**Tables 15.2 and 15.3**).

COMMON CHARACTERISTICS (CLASS TRAITS) OF INCISORS

- All incisors develop from four lobes; three labial lobes and one lingual lobe for cingulum
- They have single, cone shaped tapering roots
- Their labial and lingual aspects are trapezoidal and the proximal aspects are triangular in shape
- The incisal portions of the incisor are designed like the edges of blades
- The newly erupted incisors have three rounded eminences on their incisal portion called the mamelons, which represent the three labial lobes
- All incisors have cingulum at the cervical portion of their lingual aspects and concave lingual fossa at the center of lingual surfaces
- The contact areas are relatively smaller and are nearly at the same level, especially so in the mandibular incisors
- Their labial surfaces are convex and lingual surface are concavoconvex
- The crests of both labial and lingual contours are at the same level, in the cervical third of the crown, facing each
- Positioned at the center of dental arches, the incisors are important for the esthetics and phonetics
- The cervical lines on their proximal surface exhibit greater curvature than on other teeth.

Table 15.1 Differences between maxillary and mandibular permanent incisors (Arch traits)

CHARACTERISTICS	*MAXILLARY PERMANENT INCISORS*	*MANDIBULAR PERMANENT INCISORS*
Tooth nomenclature		
Universal system	7, 8, 9, 10	26, 25 , 24 and 23
Zsigmondy/Palmer system	2┘, 1┘, └1 , └2	2┐, 1┐, ┌1 , ┌2
FDI system	11, 12, 21 and 22	31, 32, 41 and 42
Chronology		
Eruption	7–9 years They erupt after the eruption of permanent mandibular incisors	6–8 years They are first permanent teeth to erupt along with 1st molars (6–7 years)
Root completion	10–11 years	9–10 years
General features		
Lobes	4 lobes	4 lobes
Mamelons	Present in newly erupted	Present in newly erupted
General size	• Widest of incisor class • Maxillary permanent central incisor is larger than the lateral incisor	• Narrowest of incisors class • Mandibular permanent lateral incisor is larger than the central incisor

Contd...

Contd...

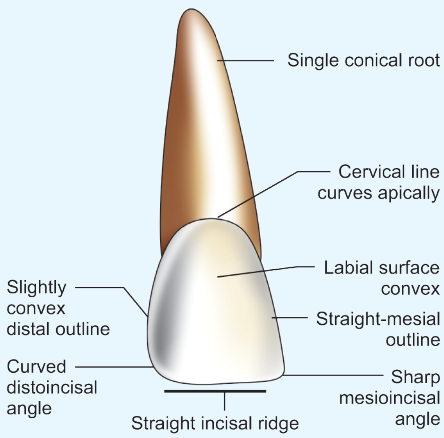
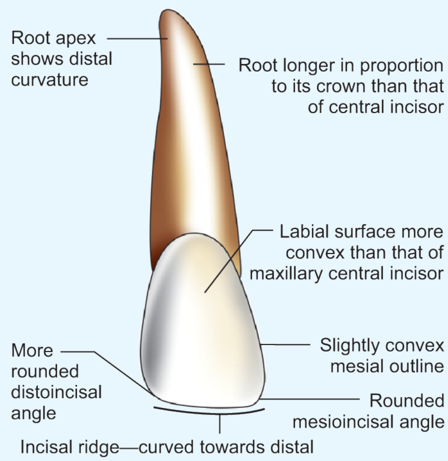
CHARACTERISTICS	*MAXILLARY PERMANENT INCISORS*	*MANDIBULAR PERMANENT INCISORS*
Function	Upper incisors form fixed cutting edge	Form movable cutting edge during mastication
Variations	Variations are numerous especially the lateral incisor	Variations are not common
CROWN		
Mesiodistal width	Wider than mandibular permanent incisors	Mesiodistally narrower than all other permanent teeth
Crown symmetry	Wider, less symmetrical crown	More symmetrical crown (especially in mandibular permanent central incisor)
Incisal edge	More rounded distoincisal angles	Both mesial and distal incisal angles are relatively sharp
Contact areas	Mesial and distal contact areas are at different levels	Mesial and distal contact areas are at the same level
Labial surface	More convex	Less convex
Lingual aspect		
Marginal ridges	More well defined	Ill defined
Cingulum	Larger	Smaller
Lingual fossa	Deeper, well circumscribed often with grooves	Shallower fossa without grooves
Developmental grooves	Often present in lingual fossa	Usually not seen
Lingual pit	Often present	No lingual pit
Proximal aspect (Mesial and distal views)		
Incisal ridge/location	Placed labial to/on line with vertical root axis	Lingual to vertical root axis
Incisal edge slope	On wearing of tooth, incisal edge slopes lingually	Incisal edge slopes labially
Convexity of cingulum	More pronounced	Less pronounced
Height of contour		
Labially	At the cervical third	At the cervical third
Lingually	At the cervical third	At the cervical third
Incisal aspect/view		
Crown dimension	Crown wider mesiodistally than labiolingually	Crown wider labiolingually than mesiodistally
Incisal edge	Centered over the crown labiolingually	Placed lingual to the bisecting line
ROOT		
Number	Single	Single
Form	Thick, conical shaped	Conical shaped
Size	Root relatively wider mesiodistally	Thin mesiodistally markedly, wider labiolingually
Cross-section	Triangular or rounded in cross-section	Oval shaped labiolingually
Developmental depressions	Smooth proximal root surface	Developmental depressions on both mesial and distal surfaces

Table 15.2 Differences between maxillary permanent central and lateral incisors (Type traits)

CHARACTERISTICS	*MAXILLARY PERMANENT CENTRAL INCISOR*	*MAXILLARY PERMANENT LATERAL INCISOR*
Tooth nomenclature		
Universal system	Right 8; Left 9	Right 7; left 10
Zsigmondy/Palmer system	1⌋ Right; Left ⌊1	2⌋ Right; Left ⌊2
FDI system	Right 11; Left 21	Right 12; Left 22

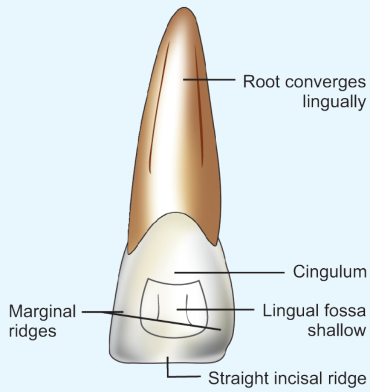
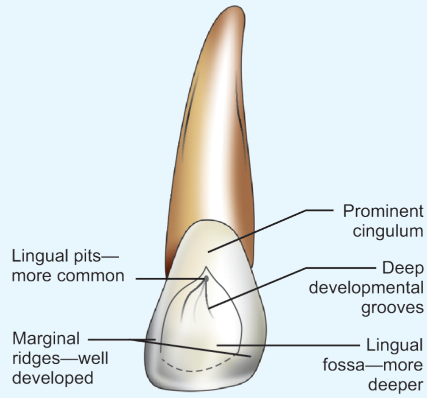
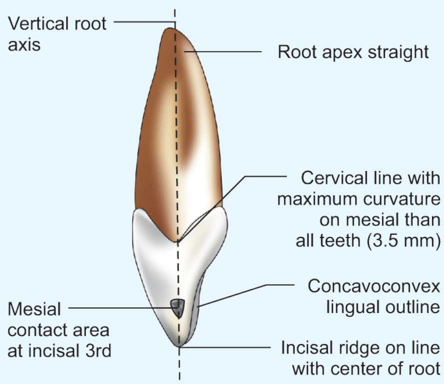
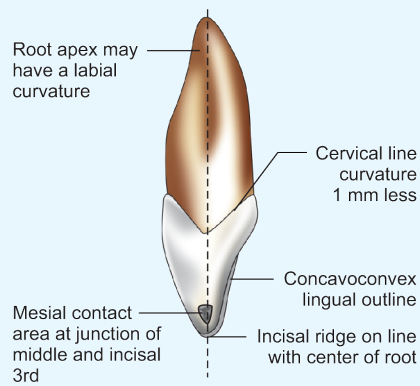
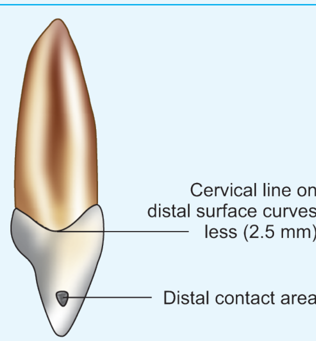
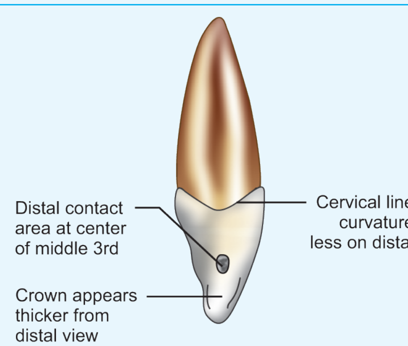
Contd...

Contd...

CHARACTERISTICS	*MAXILLARY PERMANENT CENTRAL INCISOR*	*MAXILLARY PERMANENT LATERAL INCISOR*
Chronology		
Calcification begins	3–4 months	10–12 months
Eruption	7–8 years	8–9 years
Root completion	10 years	11 years
General features		
Lobes	4 lobes	4 lobes
Dimension	Crown is larger, root is thicker	Smaller than central incisor in all dimension except root length. Crown smaller, root slender and comparatively longer
Variations	Develops regularly with few variations	Most common tooth to exhibit variation in form and development next to 3rd molars, e.g. peg shaped lateral and agenesis
CROWN		
Labial aspect		
Mesiodistal width	Comparatively wider	Comparatively narrow
Cervicoincisal length	Longest crown among incisors	Short crown
Mesial profile	Straight	Convex
Distal profile	Slightly convex	More convex
Incisal ridge	Makes straight line	Rounded incisal ridge, slopes cervically towards distal
Incisal angle		
– Mesioincisal angle	Sharp, right angle	Both the angles are rounded
– Distoincisal angle	Rounded	
Proximal contact areas		
– Mesial contact area	At the incisal third	Junction of incisal and middle third
– Distal contact area	Junction of incisal and middle third	At the middle third
Labial surface	Slightly convex	More convex

Contd...

Contd...

<table>
<tr><th>CHARACTERISTICS</th><th>MAXILLARY PERMANENT CENTRAL INCISOR</th><th>MAXILLARY PERMANENT LATERAL INCISOR</th></tr>
<tr><td>Lingual aspect</td><td>
</td><td>
</td></tr>
<tr><td>Cingulum</td><td>Moderately pronounced</td><td>Comparatively more prominent</td></tr>
<tr><td>Marginal ridge</td><td>Moderately developed</td><td>More prominent</td></tr>
<tr><td>Lingual fossa</td><td>Moderately deep</td><td>Deeper and well circumscribed</td></tr>
<tr><td>Grooves</td><td>Few grooves in lingual fossa</td><td>Deep palatogingival groove may be present</td></tr>
<tr><td>Lingual pits</td><td>Less common</td><td>More common</td></tr>
<tr><td>Mesial aspect</td><td>
</td><td>
</td></tr>
<tr><td>Labial and lingual contours</td><td>More curved</td><td>Less curved</td></tr>
<tr><td>Height of contour</td><td>Both at cervical third</td><td>Both at cervical third</td></tr>
<tr><td>Incisal ridge</td><td>On line with vertical root axis</td><td>On line with vertical root axis</td></tr>
<tr><td>Curvature of cervical line</td><td>Shows the maximum curvature on mesially 3.5 mm, distally 2.5 mm</td><td>1 mm less than that of central incisor</td></tr>
<tr><td>Distal aspect</td><td>
</td><td>
</td></tr>
</table>

Contd...

Contd...

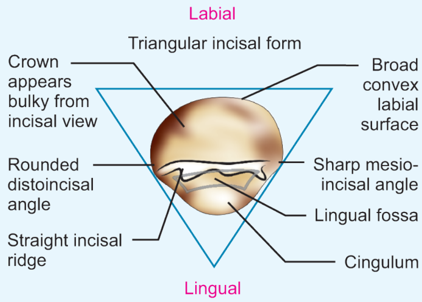
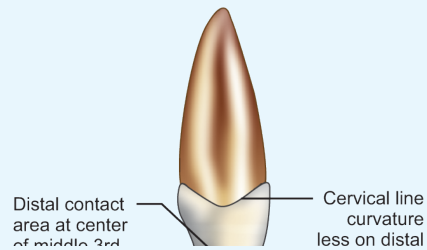
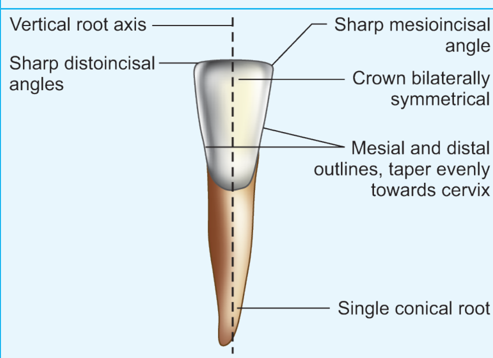
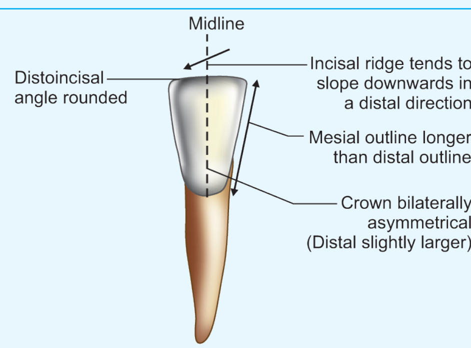
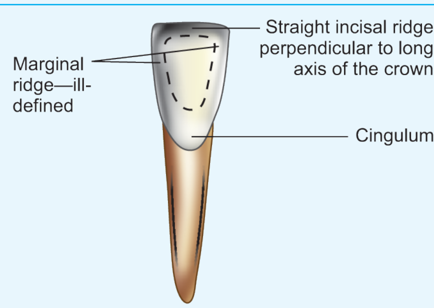
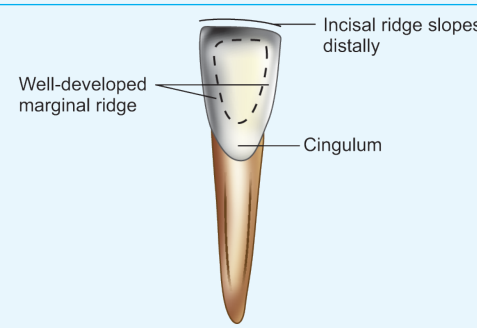
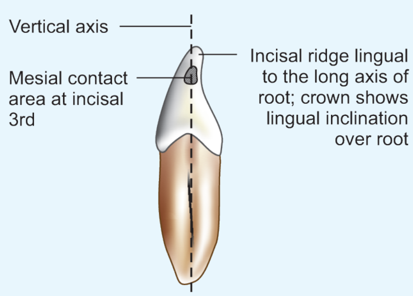
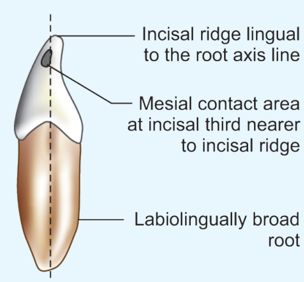
CHARACTERISTICS	*MAXILLARY PERMANENT CENTRAL INCISOR*	*MAXILLARY PERMANENT LATERAL INCISOR*
Cervical line	Less curved than mesial —2.5 mm	Less curved
Distal contact area	At incisal 3rd	At middle 3rd
Incisal aspect		
Geometric form	Triangular	Ovoid/round
Relative dimension	Crown markedly wider mesiodistally	Mesiodistal and labiolingual dimensions of crown nearly same
ROOT		
Number	Single	Single
Size	Thick conical root	Delicate and slender root, comparatively longer root
Developmental groove	Usually not present	May present on mesial and distal surfaces
Curvature	Usually straight	Distal and labial curvature of apical third is common
Cross-section of root at cervix	Triangular	Oval
Pulp horns	3 pulp horns from labial view	Usually 2 from labial view
Pulp canals	One canal	One canal, apical accessory canals are more frequent

Table 15.3 Differences between mandibular permanent central and lateral incisors (Type traits)

CHARACTERISTICS	*MANDIBULAR PERMANENT CENTRAL INCISOR*	*MANDIBULAR PERMANENT LATERAL INCISOR*
Tooth nomenclature		
Universal system	Right 25; Left 24	Right 26; Left 23
Zsigmondy/Palmer system	Right $\overline{1\|}$; Left $\overline{\|1}$	Right $\overline{2\|}$; Left $\overline{\|2}$
FDI system	Right 41; Left 31	Right 42; Left 32
Chronology		
Eruption	6–7 years, First tooth to erupt along with 1st molar	7–8 years
Root completion	9 years	10 years
Dimensions	Smallest tooth in permanent dentition	Slightly larger than the mandibular central incisor in all dimensions
CROWN		
Labial aspect		

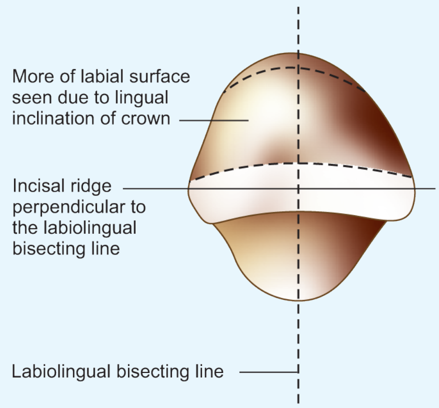
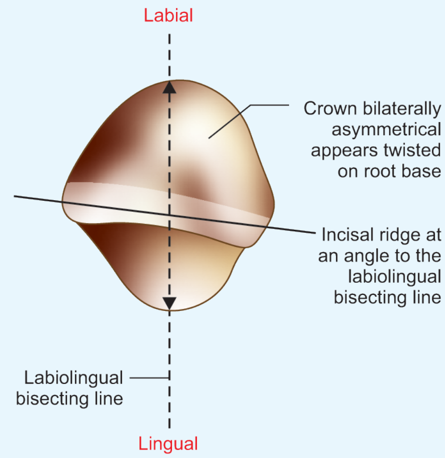
Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR PERMANENT CENTRAL INCISOR*	*MANDIBULAR PERMANENT LATERAL INCISOR*
Symmetry	Crown bilaterally symmetrical	Asymmetrical bilaterally
Mesial profile	Both mesial and distal outlines are straight	Straight
Distal profile		Slightly curved
Proximal contacts	Both contact areas are at same level, very near to incisal ridge	Not exactly same level. Though still in incisal third are cervically located than those of central incisors
• Mesial	Incisal third	Incisal third
• Distal	Incisal third	Incisal third
Incisal angle		
• Mesioincisal angle	Sharp and right angled	Sharp and right angled
• Distoincisal angle	Sharp and right angled	Slightly rounded
Incisal ridge	Straight	Slopes downwards distally
Lingual aspect		
		
	No major differences seen except that the lateral incisor is wider	
Marginal ridge	Ill-defined	Well defined
Incisal ridge/edge	Located lingual to the vertical root axis	Lingual to vertical root axis
Proximal surface (Mesial and distal views)		

Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR PERMANENT CENTRAL INCISOR*	*MANDIBULAR PERMANENT LATERAL INCISOR*
Incisal aspect		
It is mainly from incisal view that the mandibular central and lateral incisors can be differentiated from one another		
Incisal ridge/edge	Is at right angles to the labiolingual bisecting line	Is at an angle to the labiolingual bisecting line. It is twisted distolingually on the root base to conform to the mandibular arch curvature
Cingulum	Cingulum is centered mesiodistally	Positioned distally (Cingulum is off center to distal)
ROOT		
Number	Single	Single
Size	Shorter and smaller	Longer and larger
Developmental grooves	On both mesial and distal surfaces Deeper on distal surface	On both mesial and distal surfaces
Pulp canals	Usually 1, 2 possible	1

BIBLIOGRAPHY

1. Brand RW, Isselhard DE. Anatomy of orofacial structures, 5th edn. St Louis: CV Mosby; 1994.
2. Sicher H, DuBrul EL. Oral anatomy, 7th edn. St Louis: CV Mosby; 1975.
3. Woelfel JB, Scheid RC. Dental Anatomy: Its relevance to dentistry, 5th edn. Baltimore: Williams and Wilkins;1997.

MULTIPLE CHOICE QUESTIONS

1. The following are the first permanent teeth to erupt along with the first permanent molars:
   a. Maxillary central incisors
   b. Mandibular central incisors
   c. Maxillary lateral incisors
   d. Mandibular lateral incisors
2. Smallest tooth in permanent dentition is:
   a. Maxillary central incisor
   b. Maxillary lateral incisor
   c. Mandibular central incisor
   d. Mandibular lateral incisor
3. Among incisor teeth, the crowns are more symmetrical in:
   a. Maxillary incisors
   b. Mandibular incisors
   c. Both of the above
   d. None of the above
4. The mesial and distal contact areas are nearly at the same level in:
   a. Maxillary incisors
   b. Mandibular incisors
   c. Both of the above
   d. None of the above
5. Which of the following statement is true?
   a. In the maxillary arch, central incisor is larger than the lateral
   b. In the mandibular arch, lateral incisor is larger than the central
   c. Both of the above
   d. None of the above
6. In the incisor group, which tooth exhibits greatest variation in its morphology?
   a. Maxillary central incisor
   b. Maxillary lateral incisor

c. Mandibular central incisor
d. Mandibular lateral incisor

7. Both the contact areas are very much nearer to incisal edge in:
   a. Maxillary incisors
   b. Mandibular incisors
   c. Both of the above
   d. None of the above
8. When compared to maxillary incisors, the lingual fossa of mandibular incisors is:
   a. Deeper
   b. Exhibit more developmental grooves
   c. Shallower without developmental grooves
   d. Both a and b
9. Lingual pits are often present in:
   a. Maxillary incisors
   b. Mandibular incisors
   c. Both of the above
   d. None of the above
10. When viewed from proximal aspect, the incisal ridge/edge of maxillary incisors is placed:
    a. In line with the vertical root axis
    b. Labial to the line with the vertical root axis
    c. Lingual to the line with the vertical root axis
    d. None of the above

Answers

1. b	2. c	3. b	4. b	5. c	6. b	7. b	8. c	9. a	10. a

CHAPTER

16

Class and Arch Traits of Canine Teeth

This chapter elaborates the common characteristics—*Class traits* and differences between the maxillary and mandibular canines—*Arch traits* (**Table 16.1**). In canine class, there is only one tooth per quadrant. Thus there are no type traits.

COMMON CHARACTERISTICS (CLASS TRAITS) OF CANINES

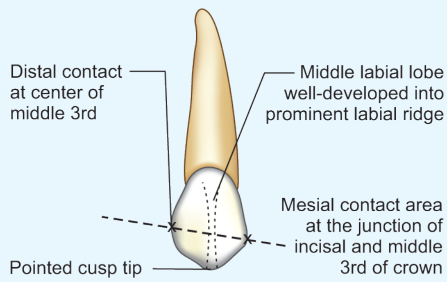
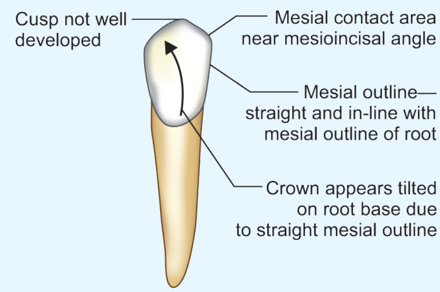
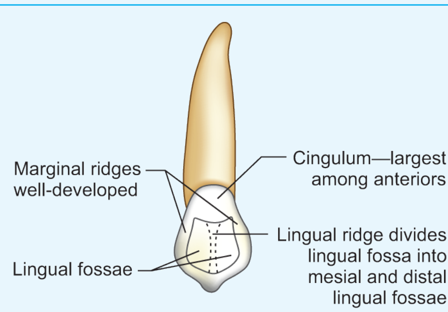
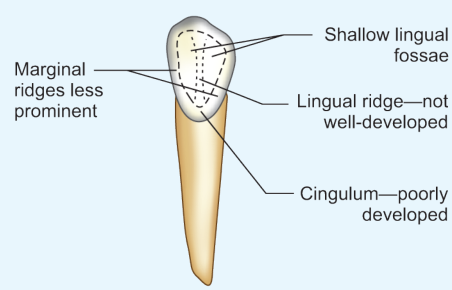
- The canines develop from four lobes: Three labial and one lingual
- They are wider buccolingually than mesiodistally
- Their middle labial lobes are highly developed into well formed cusps
- Their labial surfaces have labial ridges extending from cusp tip to the cervical line
- Lingual aspect shows well formed cingulum and a lingual fossa which may be divided by a lingual ridge
- Their distal cusp slopes are longer than the mesial cusp slopes
- The canines typically have their contact areas at different levels cervico-occlusally. This is because the adjacent teeth of canines, with which they make contact, are of different classes (lateral incisor mesially and the first premolar distally)
- They have single, longest and strongest root of all teeth providing the best anchorage among anteriors.

Table 16.1 Differences between maxillary and mandibular permanent canines

CHARACTERISTICS	*MAXILLARY PERMANENT CANINE*	*MANDIBULAR PERMANENT CANINE*
Tooth nomenclature		
Universal system	Right 6; Left 11	Right 27; Left 22
Zsigmondy/Palmer system	Right 3┘; Left └3	Right 3┐; Left ┌3
FDI system	Right 13; Left 23	Right 43; Left 33
Chronology		
Eruption	11–12 years Usually erupt after maxillary premolars	9–10 years Erupts before mandibular premolars and well before maxillary canine
Root completion	13–15 years	12–14 years
General features		
Lobes	Develops from 4 lobes middle labial lobe is very well-developed into labial ridge	From 4 lobes Middle labial lobe is not so well-developed
General size	• Longest tooth of all • Bulkier crown • Longest root of all	• 2nd longest tooth • Crown longer by 1 mm and slender • Root shorter by 1 mm

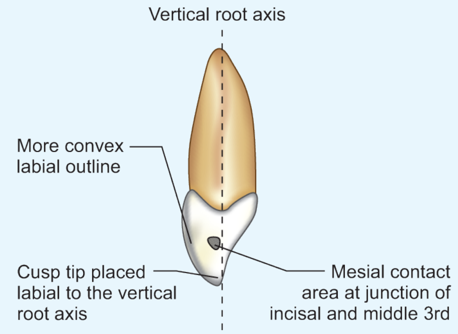
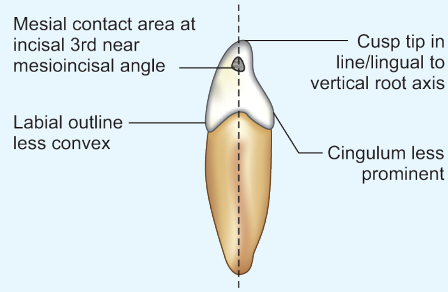
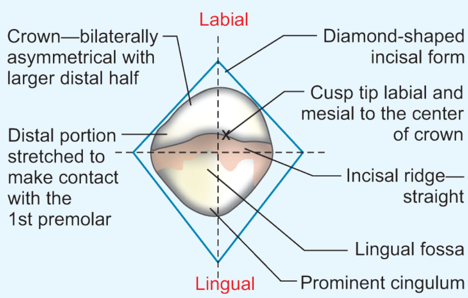
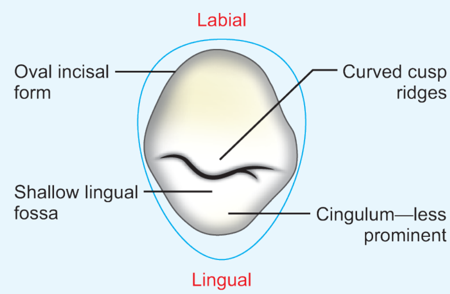
Contd...

Contd...

CHARACTERISTICS	*MAXILLARY PERMANENT CANINE*	*MANDIBULAR PERMANENT CANINE*
CROWN		
Labial aspect		
Mesiodistal width	Crown is broader and shorter	Crown is longer and narrower mesiodistally
Labial surface	The labial surface more convex	Labial surface convex
The cusp	The cusp is sharp and very well-developed Incisal portion of cusp and cusp ridges occupy 1/3rd of crown length	The cusp is not so well-developed Incisal portion occupies 1/5th of crown length
Cusp ridges	Mesial cusp ridge is usually concave	Cusp ridges are straight
Labial ridge	Labial ridge is very prominent	Labial ridge is less prominent
Crown outline	Mesial outline is generally convex	Mesial outline is straight following mesial outline of root. So crown looks bent distally on root base
Mesioincisal angle	Mesioincisal angle is less pronounced	Mesioincisal angle is more pronounced
Crown tilt	Crown is upright on root base	From this aspect crown appears to be tilted distally on root base
Contact area		
• Mesial • Distal	Mesial is at the junction of incisal and middle 3rd Distal is at center of middle 3rd	Mesial is near mesioincisal angle Distal is at the junction of incisal and middle 3rd
Lingual aspect		
Lingual surface Cingulum	Lingual surface is more irregular The cingulum is large, very well developed; sometimes may even be pointed like a small cusp	Smooth and is similar to that of mandibular lateral incisors The cingulum is smooth and poorly developed
Marginal ridges	Marginal ridges are strongly developed	Marginal ridges are thin and less distinct
Lingual fossa	Lingual fossa is more concave	Lingual fossa is shallow and smooth
Lingual ridge	Lingual ridge is more prominent	Lingual fossa is less prominent

Contd...

Contd...

CHARACTERISTICS	*MAXILLARY PERMANENT CANINE*	*MANDIBULAR PERMANENT CANINE*
Mesial aspect		
Crown bulk	Crown is more bulky labiolingually	Crown appears less bulkier
Labial outline	More convex due to prominent labial ridge	Labial outline is less convex
Lingual outline	Lingual outline is more convex near cingulum and more concave near lingual fossa	Lingual outline shows curvatures of lesser degree
Position of cusp tip	Cusp tip is labial to the vertical root axis	Cusp tip is lingually placed to the vertical root axis
Incisal edge	Incisal edge is lingually sloping	Incisal edge is labially sloping
Distal aspect		
Cervical line	Less curved	Less curved
Incisal aspect		
Dimension	Labiolingual dimension is greater among all the anteriors	Crown is less bulkier labiolingually
Crown symmetry	Crown appears asymmetrical with the mesial half of the crown bigger than the distal half	Crown is symmetrical
Cusp tip	Cusp tip is labial to the center of crown labiolingually and mesial to the center mesiodistally	Cusp tip is in the center or lingually placed
Cusp ridges	Cusp ridges with contact area extensions form a straight line mesiodistally Large cingulum forms a more pronounced convexity of lingual surface Labial ridge prominently seen on labial surface Lingual ridge is more prominent	Cusp ridges (especially distal) are inclined lingually Less convex lingual surface Labial ridge less prominent Lingual ridge less prominent
ROOT		
Number	Single conical root and is never bifurcated	Usually single root may be bifurcated
Size	Longest root with extra anchorage Lingual surface is narrower than labial	Root is 1–2 mm shorter Lingual surface is much more narrower about ½ of the width of labial surface

Contd...

Contd...

CHARACTERISTICS	*MAXILLARY PERMANENT CANINE*	*MANDIBULAR PERMANENT CANINE*
Apex curvature	Apex is blunt Apical 3rd of the root shows distal curvature	Apex is slightly sharp Root is usually straight sometimes has mesial curvature
Developmental grooves	Developmental groove on distal surface of root is more deeper	Developmental groove on mesial surface is more pronounced
Pulp canals	Single canal	Single canal

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion. 8th edn. St Louis: Saunders; 2003.
2. Brand RW, Isselhard DE. Anatomy of orofacial structures, 5th edn. St Louis: CV Mosby; 1994.
3. Sicher H, DuBrul EL. Oral anatomy, 7th edn. St. Louis: CV Mosby; 1975.
4. Woelfel JB, Scheid RC. Dental Anatomy: Its relevance to dentistry, 5th edn. Baltimore: Williams and Wilkins; 1997.

MULTIPLE CHOICE QUESTIONS

1. The permanent maxillary canine erupts:
   a. After the eruption of mandibular canine
   b. Before eruption of both the maxillary premolars
   c. After the eruption of one or both maxillary premolars
   d. Both a and c
2. The labial ridge is prominent in:
   a. Maxillary canine
   b. Mandibular canine
   c. Both
   d. None
3. Among the permanent canines:
   a. The maxillary canine crown is bulkier and broader
   b. Mandibular canine crown is longer and narrower
   c. Crowns of both the canines are of same size
   d. Both a and b
4. Which of the following statements is true about permanent canines?
   a. The cusp is sharp and well developed in maxillary canine
   b. Angle formed by the mesial and distal cusp ridges is wider in mandibular canine
   c. The occlusal portion occupies 1/3rd of the crown length in maxillary canine ; while it occupies 1/5th of the crown length in mandibular canine
   d. All of the above
5. Which of the following statements is true regarding contact areas of permanent canines?
   a. Mesial and distal contact areas are markedly at dissimilar levels in maxillary canine
   b. Contact areas are placed more incisally in mandibular canine
   c. Contact areas are placed at same level in maxillary and mandibular canines
   d. Both a and b
6. When permanent mandibular canine is viewed from labial aspect, the crown is:
   a. Upright on the root base
   b. Tilted mesially on the root base
   c. Tilted distally on the root base
   d. None of the above
7. The cingulum is:
   a. More prominent in maxillary canine
   b. More prominent in mandibular canine
   c. Small in both the canines
   d. Prominent in both the canines
8. Lingual ridge is often seen dividing the lingual fossa into two small fossae in:
   a. Maxillary canine
   b. Mandibular canine
   c. Maxillary central incisor
   d. Maxillary lateral incisor
9. When maxillary canine is viewed proximally, the cusp tip is:
   a. On line with the vertical root axis
   b. Labial to the vertical root axis
   c. Lingual to the vertical root axis
   d. Distal to the vertical root axis
10. When mandibular canine is viewed proximally, the cusp tip is:
    a. On line with the vertical root axis
    b. Labial to the vertical root axis
    c. Lingual to the vertical root axis
    d. Distal to the vertical root axis

Answers

1. d	2. a	3. d	4. d	5. d	6. c	7. a	8. a	9. b	10. c

CHAPTER 17

Class, Arch and Type Traits of Premolar Teeth

This chapter gives the common characteristics—*Class traits*, differences between maxillary and mandibular premolars—*Arch traits* (**Table 17.1**) and the differences between 1st and 2nd premolars of each arch—*Type traits* (**Tables 17.2 and 17.3**).

COMMON CHARACTERISTICS (CLASS TRAITS) OF PREMOLARS

- The premolars develop from four lobes with an exception of the mandibular 2nd premolar which develops from five lobes
- All premolars have single root except maxillary 1st premolar which is frequently bifurcated
- They generally have two cusps, the buccal and the lingual except for mandibular 2nd premolars which often exhibit three cusps
- Their buccolingual dimension is greater than the mesiodistal dimension
- The contact areas are broader than that of the anteriors and are placed nearly at the same level. Contact areas are buccal to center of the crowns buccolingually
- Crests of buccal and lingual contours are more occlusal than seen on anterior teeth
- Marginal ridges are at a higher level (occlusally placed) mesially than distally; exception is in case of mandibular 1st premolar where the distal marginal ridge is more occlusally placed than the mesial marginal ridge.

Table 17.1 Differences between maxillary and mandibular permanent premolars (Arch traits)

CHARACTERISTICS	*MAXILLARY PERMANENT PREMOLARS*	*MANDIBULAR PERMANENT PREMOLARS*
Tooth nomenclature		
Universal system	Right 4, 5; Left 12, 13	Right 28, 29; Left 20, 21
Zsigmondy/Palmer system	Right $4\rfloor$, $5\rfloor$; Left $\lfloor 4$, $\lfloor 5$	Right $4\rceil$, $5\rceil$; Left $\lceil 4$, $\lceil 5$
FDI system	Right 14, 15; Left 24, 25	Right 44, 45; Left 34, 35
General features		
Eruption sequence	Usually erupt before maxillary permanent canine	Erupt after mandibular permanent canine
Lobes	Develop from 4 lobes	4 lobes—for 1st permanent premolar and 5 lobes—for 2nd permanent premolars
Number of cusps	Two	Two—1st premolar 3 common for 2nd premolar, or two cusps
Number of roots	Two—1st premolar One—2nd premolar	Usually one
Sizes of cusps	Buccal and lingual cusps are almost equal in size and height Buccal and lingual cusps nearly equally well developed and of equal prominence	Lingual cusps much shorter, especially in mandibular 1st premolar which is nonfunctional Buccal and lingual cusps of uneven development and prominence
Crown form	1st and 2nd premolars are similar in form	1st and 2nd premolars are widely different in form

Contd...

Contd...

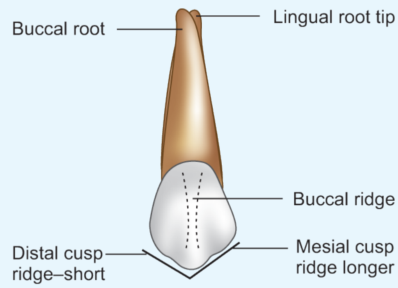
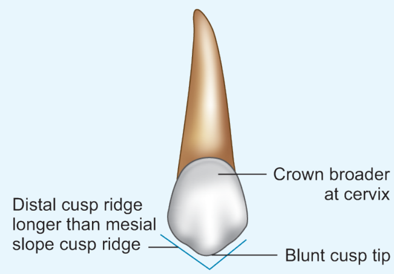
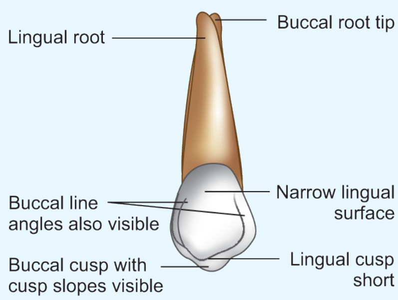
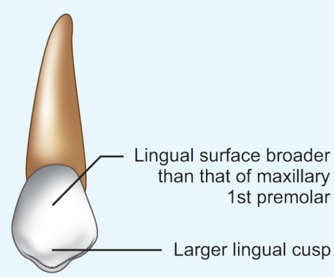
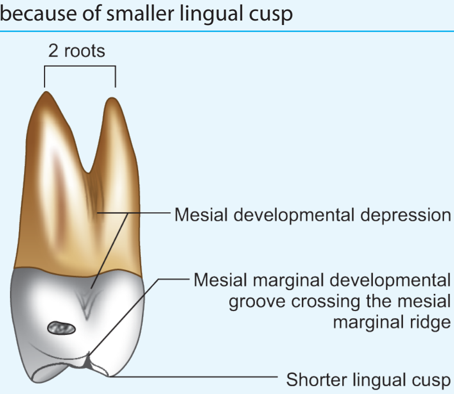
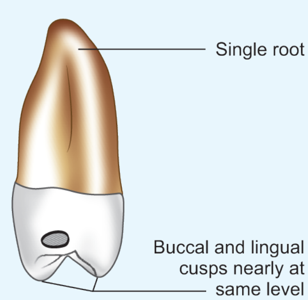
CHARACTERISTICS	*MAXILLARY PERMANENT PREMOLAR*	*MANDIBULAR PERMANENT PREMOLAR*
Buccal aspect		
Buccal cusp tip	Mesial and distal cusp ridges at the cusp tip meet at sharp angle	Cusp ridges meet at more obtuse angle
Buccal ridge	More prominent on maxillary premolars (especially on 1st premolar)	Less prominent on mandibular premolars
Buccal cusp slope/ridge	1st premolar—mesial cusp slope is longer 2nd premolar—distal cusp slope is longer	Distal cusp slope is longer in both premolars
Lingual aspect		
Lingual convergence	Maxillary premolars show marked lingual convergence, especially the 1st premolars	Lingual convergence not present, especially in 2nd premolar
Mesial and distal aspects		
Geometric form	Trapezoidal	Rhomboidal
Crown inclination	Crown nearly upright on root base	Crown show marked lingual inclination on root base
Cusp height	Buccal and lingual cusps nearly of equal height	Lingual cusp much shorter and small in 1st premolar.It is non-functional cusp
Cusp tips spacing	Buccal and lingual cusp tips wide apart	Buccal and lingual cusps are more nearer
Buccal cusp tip location	Buccal cusp located buccal to the vertical root axis	Buccal cusp is centered over root base, because lingual tilt of crowns, the buccal cusp tip is in line with the vertical root axis
Lingual cusp tip	Located lingual to the root axis line	On or lingual to the lingual confines of root
Crown outlines	Buccal and lingual crown outlines well within confines of root base	Lingual crown outline out of confines of root base
Occlusal aspect		
Crown dimension	Much wider buccolingually than mesiodistally	Buccolingual and mesiodistal dimesions nearly same
Geometric form	Ovoid/oblong	Round/squarish
Tapers to lingual	Marked in 1st premolars	Marked in 1st premolars
Cusps	Relatively wider buccolingually	Wider mesiodistally

Table 17.2 Differences between maxillary 1st and 2nd permanent premolars (Maxillary premolar type traits)

CHARACTERISTICS	*MAXILLARY 1ST PERMANENT PREMOLAR*	*MAXILLARY 2ND PERMANENT PREMOLAR*
Tooth nomenclature		
Universal system	Right 5, Left 12	Right 4; Left 13
Zsigmondy/Palmer system	Right 4┘, Left └4	Right 5┘, Left └5
FDI system	Right 14; Left 24	Right 15; Left 25
Chronology		
Eruption	10–11 years	10–12 years
Lobes	From 4 lobes	Also from 4 lobes
General tooth size and form	No much variation in tooth size More angular and lingual cusp is shorter	Crown may be smaller or bigger than the 1st premolar. Root may be slightly longer Crown is less angular. Both the cusps are of almost same size

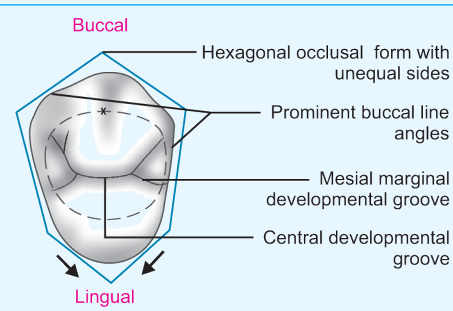
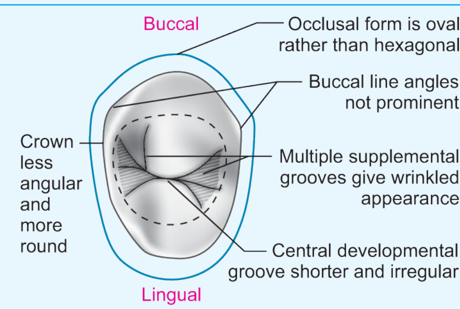
Contd...

Contd...

CHARACTERISTICS	*MAXILLARY 1ST PERMANENT PREMOLAR*	*MAXILLARY 2ND PERMANENT PREMOLAR*
CROWN		
Buccal aspect		
Crown width	Crown is narrow at cervix	Crown appears thicker at cervical portion
Crown height	Larger and longer	Smaller and shorter crown
Cusp tip	More pointed with sharp angle between cusp slopes (105 degree)	Less pointed, blunt. Cusp angle (125 degree)
Slopes/ridges of buccal cusp	Mesial slope is longer than the distal	Distal slope is longer
Buccal line angles	Crown is more angular Buccal line angles are sharp	Crown is more rounded and less angular
Buccal surface	More convex	Less convex
Lingual aspect		
Lingual cusp	It is shorter and narrower than the buccal cusp	Lingual cusp is of the same length and width as buccal cusp
Crown length	The crown appears shorter from lingual aspect	Crown appears comparatively longer from lingual aspect
Lingual surface	Less convex	More convex
Lingual convergence	Marked lingual convergence present Crown tapers more towards lingual aspect because of smaller lingual cusp	Crown does not tapers much lingually
Mesial aspect		

Contd...

Contd...

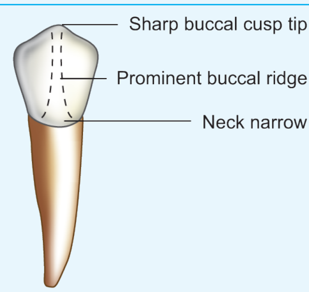
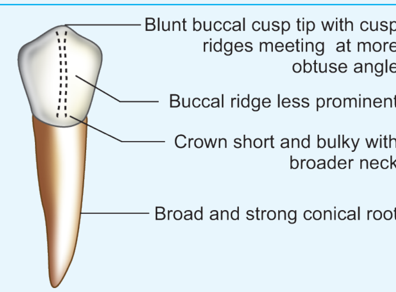
CHARACTERISTICS	*MAXILLARY 1ST PERMANENT PREMOLAR*	*MAXILLARY 2ND PERMANENT PREMOLAR*
Cusps height	Lingual cusp is shorter by 1–2 mm	The two cusps are same height
Intercuspal width	Distances between buccal and lingual cusp tip is less	Distances between the two cusp tips is more
Cusp tips	More sharp	More blunt
Height of contour		
• Buccal	At cervical third	At cervical third
• Lingual	At middle third	At middle third
Developmental depression	Marked concavity present in the center of mesial surface called "*mesial developmental depression*". This mesial concavity extends onto root trunk	No developmental depression, mesial surface is smoothly convex
Developmental grooves	*Mesial marginal developmental grooves* extending from central groove of occlusal surface crosses the mesial marginal ridge to reach the mesial surface of crown	No developmental groove crossing the mesial marginal ridge
Contact areas	Contact area is narrower on mesial surface rather than on the distal surface as the tooth contacts with maxillary canine mesially	Both the contact area are broader. As it is in contact with posterior teeth on both sides
Distal aspect		
Cervical line	Less curved	Less curved
Distal contact area	Broader than mesial	Both contacts are broader
Occlusal aspect		
General shape	Hexagonal outline	Oval outline
Line angles	Crown is angular with well defined buccal line angles	Crown appears more rounded with less pronounced buccal line angles
Occlusal table	The occlusal table is smaller buccolingually because of a lesser distance between the cusp tips	Wider occlusal table because a greater distance between the cusp tips
Location of cusp tips	Lingual cusp tip positioned off center to the mesial	Both cusp tips centered mesiodistally
Crown width (mesiodistal)	Crown is wider buccally than lingually because of a smaller lingual cusp	Crown is equally wide both bucally and lingually
Crown width buccolingual	Wider distally than mesially. Crown appears to curve mesially due to mesial marginal developmental groove	Equally wide mesially and distally
Marginal ridges	Mesial marginal ridge is shorter	Both marginal ridges equal length
Central developmental groove	Longer	Shorter
Supplementary grooves	Very few supplementary grooves. Occlusal surface is more regular	Multiple supplementary grooves radiate from central distal groove giving the occlusal surface a "*wrinkled appearance*"

Contd...

Contd...

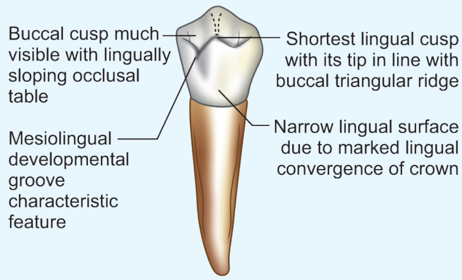
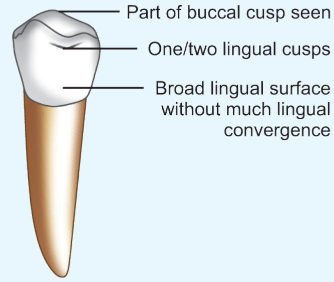
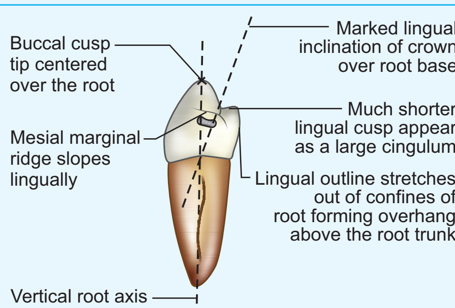
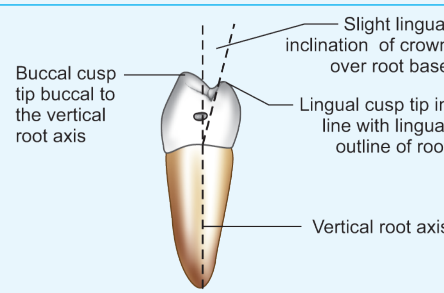
CHARACTERISTICS	*MAXILLARY 1ST PERMANENT PREMOLAR*	*MAXILLARY 2ND PERMANENT PREMOLAR*
ROOT		
Number	2 roots: buccal and lingual Sometimes single	1 root
Size	Comparatively shorter. Both buccal and lingual roots are of same length	Root is often slightly longer than the maxillary 1st premolar
Root form	Long root trunk with bifurcation at middle 3rd of the root. The two roots diverge from bifurcation point and later face each other at apical ends	Conical root tapers evenly from cervix to apex
Developmental grooves and depressions	More deeper on mesial surface	More deeper on distal side
Variations	Root form is variable The root is frequently bifurcated but can be single or laminated (fused bifurcated roots)	Root formed is less variable
Root canals	2 canals	1 canal

Table 17.3 Differences between mandibular 1st and 2nd permanent premolars (Mandibular premolar type traits)

CHARACTERISTICS	*MANDIBULAR 1ST PERMANENT PREMOLAR*	*MANDIBULAR 2ND PERMANENT PREMOLAR*
Tooth nomenclature		
Universal system	Right 28, left 21	Right 29; left 20
Zsigmondy/Palmer system	Right $\overline{4|}$; Left $\overline{|4}$	Right $\overline{5|}$; Left $\overline{|5}$
FDI system	Right 44; Left 34	Right 45; Left 35
Chronology		
Developmental lobes	4 lobes, 3 labial and 1 lingual lobe Lingual lobe not well developed	5 lobes—frequently (3 labial and 2 lingual lobes) or 4 lobes Lingual lobe well developed
Eruption	10–12 years	11–12 years
Root completion	12–13 years	13–14 years
Variation in form	No much variation in form	3 cusp type or two cusp type
CROWN		
Buccal aspect		
Crown height	Longer crown	Shorter crown
Crown width	Narrow	Wider and bulky crown
Neck of the tooth	Narrow at cervix	Crown wider at cervix
Buccal ridge	More prominent	Less prominent
Contact area	Mesial contact area cervically located than distal	Distal contact area cervically located than the mesial

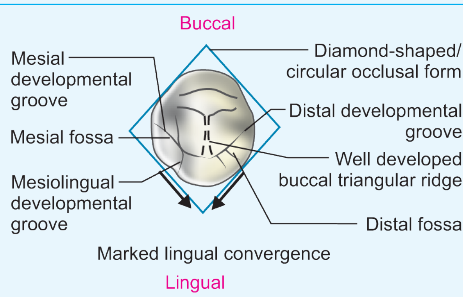
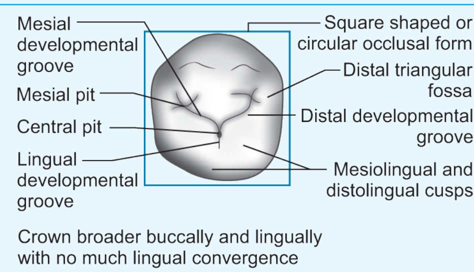
Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR 1ST PERMANENT PREMOLAR*	*MANDIBULAR 2ND PERMANENT PREMOLAR*
Lingual aspect		
Number of lingual cusps	1 lingual cusp	1 or 2 lingual cusps (Mesiolingual cusp wider than distolingual cusp)
Lingual cusp(s)	Very small, non-functional lingual cusp	Functional lingual cusp or cusps
Lingual cusp height	Very short	Nearly of same height as buccal cusp
Lingual convergence	Marked lingual convergence of crown due to small lingual cusp	Crown on lingual is as wide as buccal (Very little lingual convergence)
Visibility of buccal profile and proximal surfaces	All of buccal profile Proximal walls of crown are visible from lingual view	Only buccal cusp tip and part of proximal walls seen
Occlusal surface visibility	Most of occlusal surface visible along with buccal triangular ridge and marginal ridges	No much occlusal surface visible
Developmental grooves	*Mesiolingual developmental groove* extends from occlusal surface onto lingual surface mesially	No mesiolingual grove A short lingual developmental groove separating 2 lingual cusps may be seen (In 3 cusp type).
Lingual surface	Narrow, notched by mesiolingual groove mesially	Broad and smooth spheroidal
Mesial aspect		
Similarity to canine	Appears similar to canine from proximal view	No similarity to canine
Lingual inclination of crown	Crown more lingually inclined on root base	Lingual tilt not so pronounced
Lingual cusp	Much shorter than buccal cusp	Lingual cusps are slightly shorter than buccal cusp
Occlusal plane	Tilted lingually due to very small lingual cusp	Horizontal, no lingual tilt
Lingual overhang on root	Lingual outline stretches out of confines of root. Creates overhang over root trunk	Lingual overhang of crown not so pronounced
Marginal ridges		
Length	Mesial marginal ridge is shorter than distal	Both marginal ridges of same size
Tilt	Marginal ridges lingually tilted	Marginal ridges are horizontal
Location	Mesial marginal ridge more cervically placed than distal (In general, distal marginal ridge is more cervically located in all teeth, mandibular 1st premolar is an exception)	Distal marginal ridge is more cervically placed than the mesial

Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR 1ST PERMANENT PREMOLAR*	*MANDIBULAR 2ND PERMANENT PREMOLAR*
Visibility of occlusal surface	More of occlusal surface is visible from mesial aspect	More of occlusal surface visible from distal aspect
Cusp tip		
• Buccal cusp tip	In line with vertical root axis (centered over root base)	Buccal to the vertical root axis
• Lingual cusp tip	In line with lingual outline of root	In line with or lingual to the lingual outline of root
Proximal surfaces	Mesial surface has mesiolingual groove	Smooth
Distal aspect		
Distal marginal ridge	At higher level than mesial ridge	At lower level than mesial ridge
Cervical line	Less curved	Less curved
Occlusal aspect		
Geometric form	Diamond shaped	Square shaped (3 cusp) circular (2 cusp type)
Occlusal table	Small, non-functional occlusal surface	Large functional occlusal surface
Mesiodistal crown dimension	Greater buccally than lingually	Nearly equal buccally and lingually Can be wider on lingually than buccally (3 cusp type)
Visibility of buccal and lingual surfaces	Because of lingual crown tilt, most of buccal surface and very little lingual surface visible from occlusal view	Less of buccal and lingual surfaces are visible
Occlusal anatomy	Do not vary much	Varies according to 3 cusp type or 2 cusp type
Cusps	Large buccal and small non-functional lingual cusp	Buccal and 1 lingual or 2 lingual cusps (Mesiolingual and distolingual)
Transverse ridge	Present	Not present
Occlusal groove pattern	No variability	Varies "Y" pattern—3 cusp type "U" or "H" pattern—2 cusp type
Developmental grooves	Mesial developmental groove Distal developmental groove Mesiolingual developmental groove	In 3 cusp type • Mesial developmental groove • Distal developmental groove • Lingual developmental groove In 2 cusp type • Mesial developmental groove • Distal developmental groove • Central developmental groove
Fossae	Circular fossae near marginal ridges called mesial and distal fossae	In 3 cusp type, Mesial and distal triangular fossae, In 2 cusp type, Mesial and distal irregular fossae
Marginal ridges	Mesial marginal ridge is shorter and constricted because of mesiolingual developmental groove	Both mesial and distal marginal ridge equally well developed

Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR 1ST PERMANENT PREMOLAR*	*MANDIBULAR 2ND PERMANENT PREMOLAR*
ROOT		
Number	Single (Sometimes bifurcated)	Single
Size	Narrow and relatively Wider buccolingually than mesiodistally	Broader, stronger and longer than that of mandibular 1st premolars (Wider buccolingually than mesiodistally)
Lingual taper	Root shows marked lingual taper	No much lingual tapering
Apex curvature	Pointed often distal curvature	Straight or distal curvature
Pulp canals	1 canal	1 canal

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.
2. Kraus B, Jordan R, Abrams L. Dental anatomy and occlusion. Baltimore: Williams and Wilkins; 1969.
3. Osborn JW. Dental anatomy and embryology. Oxford: Blackwell; 1981.
4. Woelfel JB, Scheid RC. Dental Anatomy: Its relevance to dentistry, 5th edn. Baltimore: Williams and Wilkins; 1997.

MULTIPLE CHOICE QUESTIONS

1. Which of the following statements is true regarding the premolar teeth?
   a. Maxillary 1st and 2nd premolars are similar in form
   b. Mandibular 1st and 2nd premolars are similar in form
   c. Mandibular 1st and 2nd premolars are widely different in form
   d. Both a and c
2. The distal cusp ridge is longer than the mesial cusp ridge in all the premolars except:
   a. Maxillary 1st premolar
   b. Maxillary 2nd premolar
   c. Mandibular 1st premolar
   d. Mandibular 2nd premolar
3. From proximal aspect, the maxillary premolar crowns appear:
   a. Triangular
   b. Trapezoidal
   c. Rhomboidal
   d. Ovoid
4. From proximal aspect, the mandibular premolar crowns appear:
   a. Triangular
   b. Trapezoidal
   c. Rhomboidal
   d. Ovoid
5. When viewed proximally, the maxillary premolar crowns are:
   a. Upright on the root base
   b. Tilted buccally on the root base
   c. Tilted lingually on the root base
   d. Tilted mesially on the root base
6. When viewed proximally, mandibular premolar crowns are:
   a. Upright on the root base
   b. Tilted buccally on the root base
   c. Tilted lingually on the root base
   d. Tilted distally on the root base
7. Compared to maxillary premolars, the buccal and lingual cusp tips of mandibular premolars are:
   a. Wide apart
   b. More nearer
   c. Blunt/flattened
   d. None of above
8. When viewed proximally, buccal cusp tip of maxillary premolars is located:
   a. Buccal to the vertical root axis
   b. Lingual to the vertical root axis
   c. On line with vertical root axis
   d. Both b and c
9. When viewed proximally, the buccal cusp tip of mandibular premolars is:
   a. Buccal to the vertical root axis
   b. Lingual to the vertical root axis
   c. On line with the vertical root axis
   d. Distally to the vertical root axis
10. When viewed proximally, compared to maxillary premolars the mandibular premolars have:
    a. Buccal and lingual crown outlines well within the confines of root base
    b. Buccal crown outlines out of the confines of root base
    c. Lingual crown outline out of the confines of root base
    d. Buccal and lingual crown outlines out of the confines of root base

Answers

1. d	2. a	3. b	4. c	5. a	6. c	7. b	8. a	9. c	10. c

CHAPTER

18

Class, Arch and Type Traits of Molar Teeth

This chapter elaborates the common characteristics of molar teeth—*Class traits*, major differences between maxillary and mandibular molars—*Arch traits* (**Table 18.1**) and the differences between 1st, 2nd and 3rd molar of each arch—*Type traits* (**Tables 18.2 and 18.3**).

COMMON CHARACTERISTICS (CLASS TRAITS) OF MOLARS

- The molars develop from four to five lobes: one lobe for each cusp
- They are generally the largest teeth in their dental arches
- Their crowns are shorter cervico-occlusally although they are wider in all other aspects. Usually the distal halves of the crowns are shorter
- The molars have four or five cusps and two or three roots
- The bifurcated/trifurcated roots are strong, well formed are usually well spaced to have the best anchorage
- The crowns usually taper from mesial to distal aspect so that the buccolingual width of the mesial half is greater than that of the distal half
- The contact areas are broader and at the same level
- Usually, their distal marginal ridges are at a lower level than the mesial marginal ridges
- The cervical lines on proximal and other surface are rather straight without much curvature
- The crests of curvature on buccal surface is at the cervical third, whereas that of the lingual curvature in the middle third of the crown
- The lingual cusps (especially the mesiolingual cusp) are longer than the buccal cusps
- Their occlusal tables are larger and best suited for communition of food.

Table 18.1 Differences between maxillary and mandibular molars (Arch traits)

CHARACTERISTICS	*MAXILLARY MOLARS*	*MANDIBULAR MOLARS*
Tooth nomenclature		
Universal system	Right 1, 2, 3; Left 14, 15, 16	Right 30, 31, 32; Left 17, 18, 19
Zsigmondy/Palmer system	Right 6┘, 7┘, 8┘; Left └6, └7, └8	Right 6┐, 7┐, 8┐; Left ┌6, ┌7, ┌8
FDI system	Right 16, 17, 18; Left 26, 27, 28	Right 46, 47, 48; Left 36, 37, 38
General features		
Development	4 to 5 lobes One lobe for each cusp	4 to 5 lobes One lobe for each cusp
Number of cusps	In general, 3 large cusps and 1 small cusp—the distolingual cusp 3 large cusps make the *Maxillary molar primary cusp triangle* (They are mesiobuccal, mesiolingual and distobuccal cusps) An accessory cusp is present only in 1st molar—cusp of Carabelli	In general, 4 large cusps—2 buccal, 2 lingual 1st molar has 5 cusps; the additional small cusp is the distal cusp No cusp of Carabelli
Size of the cusps	2 buccal cusps are unequal—mesiobuccal cusp is larger than distobuccal cusp	2 main buccal cusps—mesiobuccal and distobuccal are equal in size
	2 lingual cusp are unequal, distolingual is smallest of all cusps	2 lingual cusps are of equal size

Contd...

Contd...

CHARACTERISTICS	*MAXILLARY MOLARS*	*MANDIBULAR MOLARS*
Number of roots	3 roots; 2 buccal and 1 palatal Tripod arrangement—gives good anchorage in alveolar bone	2 roots—1 mesial and 1 distal
Crown dimensions	Buccolingual diameter is greater than the mesiodistal diameter	Mesiodistal diameter is larger than buccolingual
Oblique ridge	Oblique ridge on occlusal surface is a characteristic feature of maxillary molars	No oblique ridge
CROWN		
Buccal aspect		
Geometric form	Trapezoid	Trapezoid
Crown width	Mesiodistal width is greater than cervicoincisal crown height	Mesiodistal width is much greater than crown height
Buccal cusps	Sharper	Blunt and often attrited
Lingual cusp visibility	Only a part of lingual cusps is visible from buccal view	All the cusps are visible from buccal view due to blunt buccal cusps
Visibility of distal surface	Distal surface is visible because of crown form	Not visible from this view
Developmental grooves on buccal surface	One buccal groove separating the buccal cusps	Two buccal grooves—on 1st molar (and 3rd molar) One buccal groove—2nd and 3rd molars
Contact areas		
• Mesial • Distal	At or near the junction of occlusal and middle 3rd At middle 3rd	At or near the junction of occlusal and middle 3rd At middle 3rd
Buccal surface	Relatively vertical	Buccal surface bends lingually from middle 3rd
Lingual aspect		
Geometric form	Trapezoid	Trapezoid
Lingual convergence	1st molar—no lingual taper Less lingual convergence in 2nd and 3rd molars	Marked lingual tapering of crown, especially in 1st molar
Visibility of proximal surfaces from lingual view	Portion of mesial surface visible from this view	Portion of both mesial and distal surfaces visible from this view
Proximal aspect		
Geometric form	Trapezoid	Rhomboid
Lingual crown tilt	Crown upright over root base	Crown tilted lingually over the root base (a feature common to all the mandibular teeth)
Buccal cervical ridge	Less prominent	More prominent, especially on 1st molar
Proximal surfaces	Distal surface narrower than mesial	Distal surface narrower than mesial
Occlusal aspect		
Geometric form	Rhomboid—with 2 acute and 2 obtuse angles	Quadrilateral
Crown dimension	Buccolingual diameter greater than mesiodistal	Mesiodistal diameter greater than buccolingual
Lingual convergence	No marked lingual convergence Crown converges towards buccal in 1st molar	Marked lingual convergence in all molars
Mesiodistal width	Mesiodistal width at lingual is greater than that at buccal in 1st molar	Mesiodistal dimension greater buccally than lingually
Crown taper	Crown tapers from mesial towards distal aspect	Crown tapers from mesial towards distal aspect
Buccolingual width	Greater mesially than distally	Greater mesially than distally
Number of cusps	1st molar—5 cusp 2nd and 3rd molars—4 cusps	1st molar—5 cusps 2nd molar—4 cusps 3rd molar—4 or 5 cusps

Contd...

Contd...

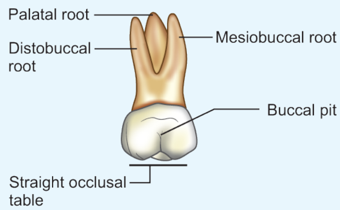
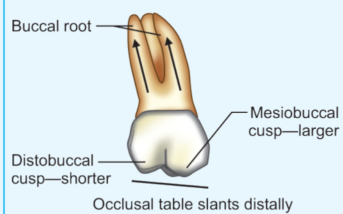
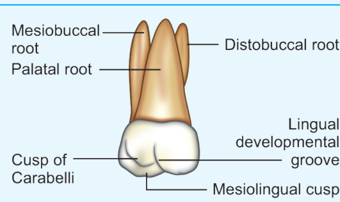
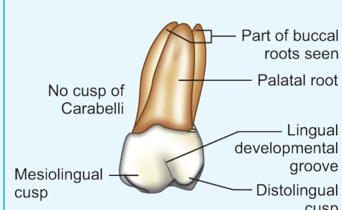
CHARACTERISTICS	*MAXILLARY MOLARS*	*MANDIBULAR MOLARS*
Accessory cusp	Cusp of Carabelli on 1st molar	No accessory cusp
Largest cusp	Mesiopalatal cusp	Mesiobuccal cusp
Size of lingual cusps	Unequal in size	Equal in size
Buccal cusps	Sharp	Blunt and often attrited
Centric holding cusps	Lingual cusps	Buccal cusps
Primary cusp triangle	Developmentally only 3 major cusps (2 buccal and mesiolingual cusps) are considered as primary They make a triangular arrangement	No primary cusp triangle present
3rd molars	When not of normal size, tends to be smaller	When not of normal size, tends to be larger
3rd molars resemblance	3rd molars resemble 2nd molar	3rd molars resemble 1st or 2nd molar
Distolingual cusp size	Decreases from 1st molar to 3rd molar in which it may be absent completely	No significant decrease in size
Oblique ridge	Ridge running obliquely on occlusal surface Formed by union of distal ridge of mesiopalatal cusp and triangular ridge of distobuccal cusp Most prominent on 1st molar and barely visible on 3rd molar	No oblique ridge
Fossae	4 fossae— 2 major fossae—central and distal 2 minor fossae—mesial and distal triangular fossae	3 fossae— 1 major central fossa 2 minor—mesial and distal triangular fossae
Groove pattern	No 'Y' or '+' pattern	'Y' or '+' pattern
ROOT		
Number	3 roots—2 buccal and 1 palatal	2 roots—1 mesial and 1 distal
Size	Palatal root—strongest and longest	Two roots are equal in size and length
Root trunk	Long	Short, nearer to cervical line especially in 2nd molar

Table 18.2 Differences between maxillary 1st, 2nd and 3rd molars (Type traits)

CHARACTERISTICS	*MAXILLARY 1ST MOLAR*		*MAXILLARY 2ND MOLAR*		*MAXILLARY 3RD MOLAR*	
Synonym	6-year molar		12-year molar		Wisdom tooth	
Tooth nomenclature	Right	Left	Right	Left	Right	Left
Universal system	3	14	2	15	1	16
Zsigmondy/Palmer system	6┘	└6	7┘	└7	8┘	└8
FDI system	16	26	17	27	18	28
Chronology						
1st evidence of calcification	At birth		2.5–3 years		7–9 years	
Eruption	6 years		12–13 years		17–21 years	
Root completion	9–10 years		14–16 years			
General features						
Tooth size	Largest tooth in the arch		Smaller than 1st molar		Smallest molar	
Variation in form, eruption pattern, timing	Least variable		2 crown forms: i. Rhomboidal (4 cusp type) ii. Heart shaped like 3rd molar (3 cusp type)		Most variable tooth in the arch May be congenitally missing (agenesis), impacted, Crown form may be irregular, looking like anomaly	

Contd...

Contd...

CHARACTERISTICS	*MAXILLARY 1ST MOLAR*	*MAXILLARY 2ND MOLAR*	*MAXILLARY 3RD MOLAR*
Developmental lobes	5 lobes	4 lobes	3 or 4 lobes
Number of cusps	5	4	4 or 3 cusps
CROWN			
Buccal aspect			
Crown width	Widest of three	Moderate width	Smallest of the three
Height of buccal cusps	Mesiobuccal and distobuccal cusps of same height	Distobuccal cusp slightly shorter than mesiobuccal cusp	Distobuccal cusp much shorter than mesiobuccal cusp
Crown height	Crown height on distal slightly lesser than on mesial	Distal crown height much shorter than mesial	Distal crown height much more shorter than mesial
Distal crown tilt	Crown nearly upright on the root base	Crown shows slight distal tilt on root base due to shorter distobuccal cusp	More distal tilt on root base
Mesial and distal profiles	Mesial and distal crown outlines nearly equal sized	Distal crown outline shorter than mesial crown outline	Distal outline much shorter than mesial outline form
Occlusal surface slant	Nearly horizontal	Slants cervically from mesial to distal	Slants more cervically towards distal
Buccal dental groove (separating 2 buccal cusps)	Relatively longer	Relatively shorter	Shortest
Buccal pit	More pronounced, buccal groove often ends here in buccal pit (often site of caries)	Less marked	May be absent
Proximal contacts			
• Mesial • Distal	At junction of occlusal and middle third Middle third	Middle third Middle third	Middle third No distal contact
Visibility of distal surface from buccal view	Portion of distal surface visible, as the distal surface tapers buccally	Distal surface of crown not visible	Distal surface of crown not visible
Cervical ridge on buccal surface	Prominent cervical ridge	Less prominent cervical ridge	Least prominent cervical ridge
Lingual aspect			
Crown width	Lingually crown is as wide or wider than buccal surface	Lingual width narrower than on buccal	Narrower on lingual than buccal
Lingual convergence	Least or no lingual convergence present	Slight lingual convergence	More lingual convergence
Number of cusps on lingual aspect	2 lingual cusps + 1 accessory cusp (cusp of Carabelli)	2 (in 4 cusp type/rhomboid shaped); 1 (in 3 cusp type/heart shaped 2nd molar)	Usually 1 (distolingual cusp absent)

Contd...

Contd...

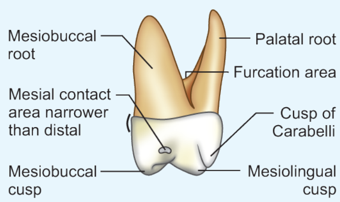
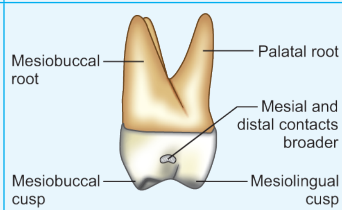
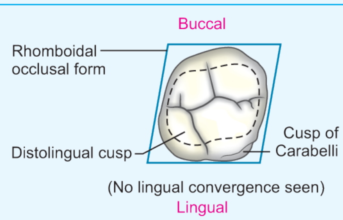
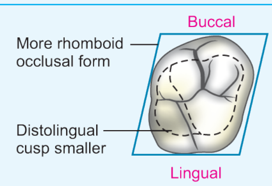
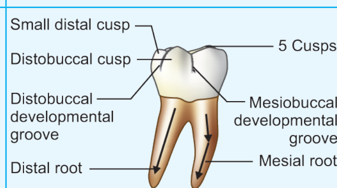
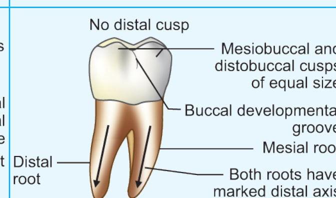
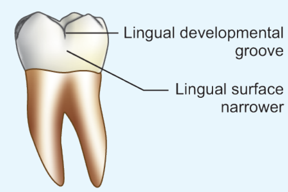
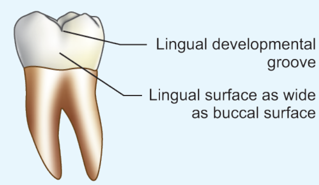
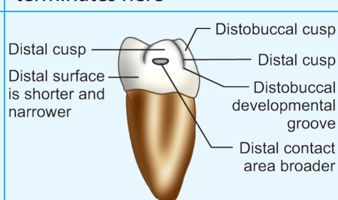
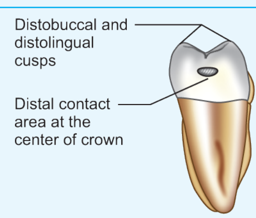
CHARACTERISTICS	*MAXILLARY 1ST MOLAR*	*MAXILLARY 2ND MOLAR*	*MAXILLARY 3RD MOLAR*
Distolingual cusp	Never missing	Distolingual cusp is absent in 3 cusp type	Usually absent
Size of distolingual cusps	Distolingual cusp smaller than mesiolingual cusp	Distolingual cusp much smaller than mesiolingual cusp	Least in size or entirely absent
Accessory cusp (Cusp of Carabelli)	Cusp of Carabelli is additional cusp lingual to mesiolingual cusp Carabelli's trait may be expressed as a well formed cusp, a tubercle, groove or a pit Carabelli's trait is the characteristic feature of maxillary 1st molar	Rarely present	Not present
Lingual developmental groove	Present between two lingual cusp, relatively long	Present in 4 cusp type/ rhomboid form of 2nd molar	Absent
Mesial aspect			
Number of cusps visible from mesial aspect	Mesiobuccal, mesiolingual and cusp of Carabelli	Mesiobuccal, mesiolingual	Mesiobuccal, mesiolingual
Buccolingual width	Crown is narrower buccolingually on distal than mesial side	Crown is more narrower buccolingually on distal side	Crown is much narrower buccolingually on distal side
Contact areas	Mesial contact area narrower than distal	Mesial and distal contact areas are equally broader	Broad mesial contact No distal contact
Height of contour			
Buccal	At cervical 3rd (prominent cervical ridge)	Cervical 3rd	Cervical 3rd
Lingual	Middle 3rd (when cusp is large, lingual crest of contour more occlusally	Middle 3rd	Middle 3rd
Distal aspect			
Distal surface area	Shorter	Shorter and narrower	Shorter and narrower
Occlusal aspect			
• Geometric shape	Rhomboidal	Rhomboidal/Heart shaped	Heart shaped
• Cusp of Carabelli	Present	Absent	Absent
• Oblique ridge	Prominent	Less prominent	Varied
• Distolingual cusp size	Relatively large	Smaller	Smallest/absent

Table 18.3 Differences between mandibular 1st, 2nd and 3rd molars (Type traits)

CHARACTERISTICS	*MANDIBULAR 1ST MOLAR*	*MANDIBULAR 2ND MOLAR*	*MANDIBULAR 3RD MOLAR*
Synonym	6-year molar	12-year molar	Wisdom tooth
Tooth nomenclature	Right Left	Right Left	Right Left
Universal system	30 19	31 18	32 17
Zsigmondy/Palmer system	6┐ ┌6	7┐ ┌7	8┐ ┌8
FDI system	46 36	47 37	48 38
Chronology			
1st evidence of calcification	At birth	2.5–3 years	8–10 years
Eruption	6–7 years	11–13 years	17–21 years
Root completion	9–10 years	14–15 years	18–25 years
Development	5 lobes	4 lobes	4 and 5 lobes
Tooth size	Largest tooth in mandibular arch	Smaller than 1st molar	Smallest of mandibular molars
Number of cusps	Five	Four	Four
	2-buccal; 2-lingual; 1-distal	2-buccal; 2-lingual	2-buccal; 2-lingual
Variations	Least variable	Less variable	Highly variable Can be 4 or 5 cusps (like 1st molar) Small or large May be congenitally missing Impaction common
Buccal aspect			
Number of cusps on buccal aspect	Three: Mesiobuccal Distobuccal Distal cusp	Two: Mesiobuccal Distobuccal	Two: Mesiobuccal Distobuccal
Size of buccal cusps	Mesiobuccal cusp is largest	Both the buccal cusps nearly same size	Both the buccal cusps nearly same size
Mesiodistal crown width	Greatest mesiodistal width among all permanent teeth	Mesiodistal width less than 1st molar	Mesiodistal width less
Mesiodistal width at cervix	Crown narrower at cervix	Crown appear broader at cervix due to absence of distal cusp	Broader at cervix
Relative crown dimensions	Mesiodistal crown width is much greater than cervico-occlusal height	Mesiodistal crown width is slightly greater than cervico-occlusal height	Mesiodistal crown width may be equal to or greater than cervico-occlusal height
Crown height	Crown appears shorter due to its greater mesiodistal width Crown is shorter at distal than mesial side	Crown appears longer. Its length nearly same; both mesially and distally	Crown height varies
Developmental groove on buccal surface	Two developmental grooves—mesiobuccal and distobuccal, long groove	One buccal development groove-relatively shorter Also distobuccal developmental groove	Varies 1 buccal developmental groove (in 4 cusp type) 2 buccal developmental groove (in 5 cusp type)

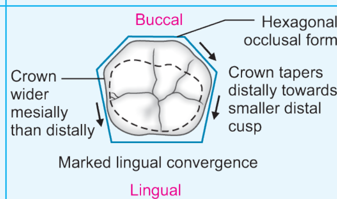
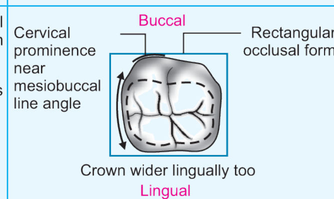
Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR 1ST MOLAR*	*MANDIBULAR 2ND MOLAR*	*MANDIBULAR 3RD MOLAR*
Buccal pit	Commonly present, caries can occur Mesiobuccal developmental groove terminates in this pit	Less common	Varies
Visibility of lingual cusps	Since buccal cusps are blunt, the lingual cusp are visible from buccal view	The lingual cusp are visible	The lingual cusp are visible
Proximal contact areas			
• Mesial • Distal	At junction occlusal and middle 3rd At middle 3rd	Middle 3rd At middle 3rd	Middle 3rd No distal contact
Crown taper to cervical	Mesial and distal outlines taper noticeably from contact areas to cervical line	Less tapering mesial and distal crown outlines	May or may not taper to cervical
Distal crown tilt	Crown appears to be tilted to distal on root base due to shorter crown height distally	Not much distal tilt	May or may not show distal crown tilt
Occlusal surface tilt	Occlusal surface slopes cervically from mesial to distal direction	Occlusal surface is horizontal	May be horizontal or slanting
Lingual aspect			
Lingual convergence	Marked lingual convergence	No much tapering towards lingual	Can vary
Lingual surface	Narrower than the buccal surface since crown tapers towards lingual	Nearly of same width as buccal surface	Narrower or of same width
Visibility of buccal profile	Buccal profile and portion of proximal surfaces visible from lingual aspect	Not visible	May or may not be visible
Lingual cusps	Longer and more pointed than the buccal cusps		
Cusp visibility	Lingual cusp and a part of distal cusp visible	Only lingual cusps visible	Only lingual cusps (like 3rd molar—4 cusp type)
Developmental groove on lingual surface	Lingual groove separates mesiolingual and distolingual cusps	Lingual groove shorter	Shorter or not present
Lingual pit	Often present lingual groove terminates here	May be present	Usually absent
Proximal aspect (Mesial and Distal aspects)			
Crown height	Shorter on distal aspect than mesial	Crown height nearly same on mesial and distal aspect	

Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR 1ST MOLAR*	*MANDIBULAR 2ND MOLAR*	*MANDIBULAR 3RD MOLAR*
Lingual crown inclination over root base	Crown more tilted lingually	Moderately tilted lingually	Less tilt lingually
Contact areas	Mesial contact area is smaller than distal, as tooth contacts with a premolar on mesial side	Both contact areas are broader as the tooth contacts with molar on both sides	Broad mesial contact No distal contact
Height of contours			
• Buccal contour • Lingual contour	At cervical 3rd At middle 3rd	At cervical 3rd At middle 3rd	At cervical 3rd At middle 3rd
Buccal cervical ridge	More prominent	Less prominent	Least prominent
Occlusal surface visibility	Greater occlusal surface visible from distal view	Some portion of occlusal surface visible from distal view	Can vary
Cusps seen from distal aspect	Distal, distobuccal, distolingual cusp	Distobuccal, distolingual cusp	Distobuccal, distolingual cusp
Occlusal aspect			
Occlusal form	Hexagonal with unequal size	Rectangular with opposing sides equal	Varies
Relative crown dimensions	Mesiodistal dimension much greater than buccolingual dimension	Mesiodistal dimension slightly greater than buccolingual dimension	Varies
Lingual convergence	More pronounced taper	Less taper	Less taper
Mesiodistal crown width	Greater on buccal side than on lingual	Nearly equal on buccal and lingual	Nearly equal on buccal and lingual or greater on buccal
Crown taper to distal	Marked tapering towards distal	Less taper	Varies
Buccolingual width	Greater mesially than distally	Nearly equal both on mesial and distal	Varies
Cervical bulge	Not present	Prominent cervical bulge at mesiobuccal line angle	Not present
Occlusal table	Broadest of all teeth in the arch	Smaller than 1st molar	Smaller/bigger
Marginal ridges			
• Mesial • Distal	Straight and converge lingually Distal shorter, not well developed	Curved and do not converge to lingual Mesial and distal marginal ridge of same length	More curved Equal or vary
Distal cusp	Present	Not present	Absent (in 4 cusp type) Present (in 5 cusp type)
Groove pattern	Main developmental grooves form 'Y' pattern	Main developmental grooves form '+' pattern	'+' pattern or 'Y' pattern
ROOT			
Number	Two: Mesial and distal	Two: Mesial and distal	Two or fused to one root
Size	Broader buccolingually	Narrower than 1st molar	Much narrower
Length	Mesial and distal roots of same length	Shorter than that of 1st molar	Much shorter

Contd...

Contd...

CHARACTERISTICS	*MANDIBULAR 1ST MOLAR*	*MANDIBULAR 2ND MOLAR*	*MANDIBULAR 3RD MOLAR*
Spacing between roots	Spread wide apart	Closely spaced/sometimes partly fused	Very close/fused
Vertical axis of roots	Mesial root straight for half length, then curved distally; Distal root slants distally for whole length	Both nearly parallel Both roots have more distal inclination	Straight or curved distally
Developmental depression on root	Extend longitudinally on both roots for entire length	Extend for only apical half of root length	Less marked depression/absent
Variations	Less likely	Less likely	More commonly vary—super-numerary root, crooked root

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.
2. Kraus B, Jordan R, Abrams L. Dental anatomy and occlusion. Baltimore: Williams and Wilkins; 1969.
3. Osborn JW. Dental anatomy and embryology. Oxford: Blackwell; 1981.
4. Woelfel JB, Scheid RC. Dental Anatomy: Its relevance to dentistry, 5th edn. Baltimore: Williams and Wilkins; 1997.

MULTIPLE CHOICE QUESTIONS

1. The cusp of Carabelli is a feature of:
   a. Permanent maxillary 1st molar
   b. Primary maxillary 1st molar
   c. Primary maxillary 2nd molar
   d. Both a and c
2. Which of the following statements is true regarding the molars?
   a. Maxillary molars have 2 roots; mandibular molars have 3 roots
   b. Maxillary molars have 3 roots; mandibular molars have 2 roots
   c. Both maxillary and mandibular molars have 3 roots
   d. Both maxillary and mandibular molars have 2 roots
3. Maxillary molars have 3 roots. They are:
   a. Buccal, lingual and distal
   b. 1 buccal, 2 lingual
   c. Mesiobuccal, distobuccal and palatal
   d. 2 mesial and 1 distal
4. The mandibular molars have 2 roots. They are:
   a. Mesial and distal
   b. Buccal and lingual
   c. Buccal and palatal
   d. Both b and c
5. Oblique ridge is a feature of:
   a. Maxillary premolars
   b. Maxillary molars
   c. Mandibular premolars
   d. Mandibular molars
6. The following are the features of maxillary molars except:
   a. Cusp of Carabelli on 1st molar
   b. Oblique ridge on occlusal surface
   c. Trifurcated roots
   d. Rectangular occlusal crown outline
7. Maxillary molar crowns have:
   a. Mesiodistal dimension greater than the buccolingual dimension
   b. Buccolingual dimension greater than the mesiodistal dimension
   c. Mesiodistal and buccolingual dimensions nearly equal
   d. None of the above
8. Mandibular molar crowns have:
   a. Mesiodistal dimension greater than the buccolingual dimension
   b. Buccolingual dimension greater than the mesiodistal dimension
   c. Mesiodistal and buccolingual dimensions nearly equal
   d. None of the above
9. Compared to maxillary molars, the buccal surface of mandibular molar crowns:
   a. Is more vertical
   b. Bends buccally from middle third
   c. Bends lingually from cervical third
   d. Bends mesially
10. Compare to mandibular molars, the maxillary molar crowns exhibit:
    a. Less lingual convergence
    b. Greater lingual convergence
    c. No lingual convergence in 1st molar, which may show a buccal taper
    d. Both a and c

Answers

1. d	2. b	3. c	4. a	5. b	6. d	7. b	8. a	9. c	10. d

SECTION

6

Dento-osseous Structures: Temporomandibular Joint

CHAPTER

19

Dento-osseous Structures: Blood Supply, Lymphatics and Innervation

Maxilla and mandible are the osseous structures that support the teeth by their alveolar processes. They form the *viscerocranium/splanchanocranium/face* of the skull. The cranial vault and the cranial base form the *neurocranium* of the skull. The anatomy of the dento-osseous structures along with blood supply, lymphatic drainage and innervations are discussed in this chapter.

The skull/craniofacial complex is divided into neurocranium and viscerocranium/face (**Fig. 19.1**):

- Neurocranium made up of:
  - The cranial vault (calvarium)
  - The cranial base.
- Viscerocranium (face) made up of:
  - The nasomaxillary complex
  - The mandible.

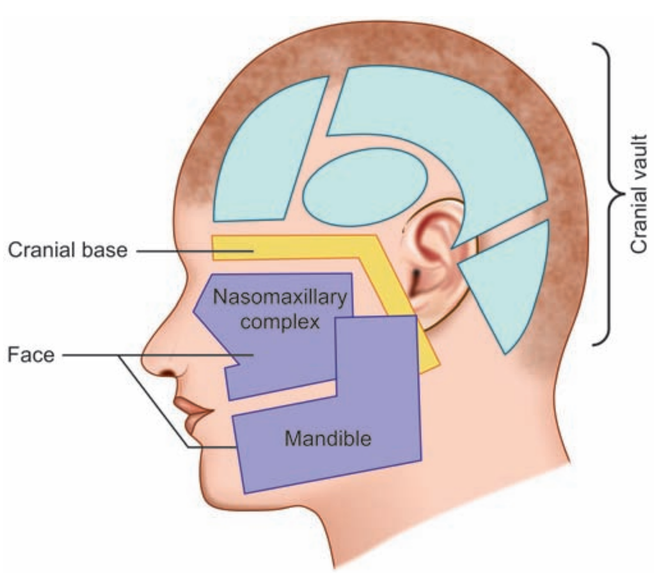


Figure 19.1 The skull is divided into neurocranium and viscerocranium (face)

SKULL AND JAWS AT BIRTH

The skull at birth is far different from that of the adult skull. There are differences in shape and proportion of the face and cranium and the degree of development and fusion of the individual bones. At birth, the infant skull consists of 45 bony elements, separated by cartilage or connective tissue. This number is reduced to 22 bones in the adult life after the completion of ossification of skull. Some bones, which are single bones in adulthood, appear as separate constituent parts at birth, for example frontal, occipital and mandible bones. Other skull bones are widely separated from their neighboring bones at birth by loose connective tissue. Open spaces between the adjacent flat bones of skull are called "*fontanelle*" (**Fig. 19.2**), which allow significant growth of brain and also provide the cranium sufficient flexibility to pass through the birth canal during parturition.

The relative sizes of face and cranium at birth and in adult life is noticeably different. The cranium grows rapidly in prenatal period, accommodating the rapidly developing brain. In contrast, the face appears small in vertical dimension because the nasomaxillary complex and mandible with their alveolar bones are relatively small at birth (**Fig. 19.3**).

DEVELOPMENT OF SKULL/CRANIOFACIAL COMPLEX

The neurocranium, especially the cranial base develops from endochondral ossification, where a primary cartilage is converted into bone.

The facial bones, i.e. bones of viscrocranium are formed by intramembranous ossification, where bone is directly formed from undifferentiated mesenchymal tissue with no cartilagenous precursor. The membranous bones may later develop secondary cartilages to provide rapid growth for example, condylar cartilage of the mandible.

Cranium and facial skeleton (maxilla and mandible) grow at different rates. Growth of the brain being intimately associated with growth of brain follows the neural growth curve, where most of the growth occurs in first few years of life. Growth of the facial skeleton on the other hand, follows general somatic growth curve.

BONES OF NEUROCRANIUM

The neurocranium is the portion which functions to support, house and protect the brain. It consists of the cranial vault and the cranial base.

The cranial vault covers the upper and outer surface of the brain. It consists of a number of flat bones, which are formed by intramembranous ossification. They include following:

- Frontal bone
- Temporal bone (paired)
- Parietal bone (paired)
- Occipital bone.

Adaptive growth occurs at the coronal, sagittal parietal, temporal and occipital sutures to accommodate the rapidly expanding brain. As the brain expands, the separate bones of the cranial vault are displaced in an outward direction. This intramembranous sutural growth replaces the fontanels that are present at birth.

The cranial base develops from endochondral ossification. It is formed by the following three bones:

1. Ethmoid bone
2. Sphenoid bone
3. Occipital bone.

Figure 19.2 Fetal skull showing fontanelle

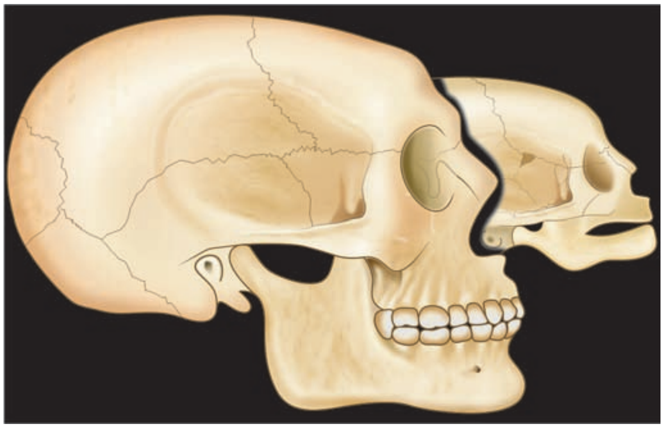


Figure 19.3 Relative sizes of face and cranium at birth and adult life

VISCEROCRANIUM/FACE

The facial skeleton gives us our appearance and functions both respiration and digestion. The maxilla or the upper jaw is joined to the other bones of the cranium and is not movable. The mandible or lower jaw on the other hand is a separate bone and is movable. The maxilla and mandible are discussed in detail in the following sections:

MAXILLA

The maxilla consists of two bones; the right and the left maxillae that are sutured together at the midline. The maxillae join to form the whole of the upper jaw, the roof of the mouth—hard palate, floor and the lateral wall of nasal cavity and orbital floors.

Each maxilla is an irregular bone that consists of the following parts (**Fig. 19.4**):

- A body
- Four processes:
  1. Zygomatic process
  2. Frontal process
  3. Palatine process
  4. Alveolar process.

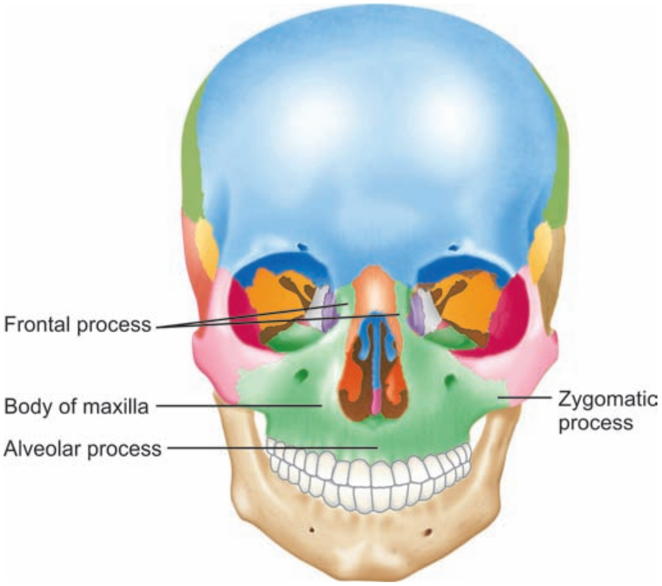


Figure 19.4 Skull illustration showing parts of maxilla

The maxillae join other cranial and facial bones including frontal, nasal, ethmoidal and molar bones by way of sutures.

Body of the Maxilla

The body of the maxilla is hollow and contains maxillary air sinus space which is also called the *antrum of Highmore* (**Fig. 19.5**).

The body of the maxilla has the following four surfaces:
1. Anterior (facial)
2. Posterior (infratemporal)
3. Orbital
4. Nasal.

There are several important landmarks on the body of the maxilla (**Fig. 19.6**):
- The *infraorbital foramen* through which the infraorbital nerve and vessels pass is on the anterior surface of the body just above the canine fossa
- The alveolar ridge over the root of the canine tooth is pronounced and is called the *canine eminence*
- The shallow concavity anterior to the canine eminence, overlying the root of maxillary lateral incisor is known as the *incisive fossa*
- A deeper concavity that lies posterior to the canine eminence, over the roots of maxillary premolars is named the *canine fossa*
- The inferior portion of the infratemporal surface that overhangs the root of the 3rd molar is more prominent and is called the *maxillary tuberosity*
- The nasal surface forms the lateral wall of the nasal fossa
- The orbital surface of the maxillary body is smooth and forms most of the orbital floor
- The junction of the orbital surface and the anterior surface forms the *infraorbital margin*.

Process of Each Maxilla

Zygomatic Process

The zygomatic process extends laterally to articulate with the zygomatic bone. It is a pyramidal projection where anterior, infratemporal and orbital surfaces of the maxillary bone converge. This process along with the zygomatic bone and zygomatic process of temporal bone, form the zygomatic arch. Zygomatic arch serves as the origin of masseter muscle.

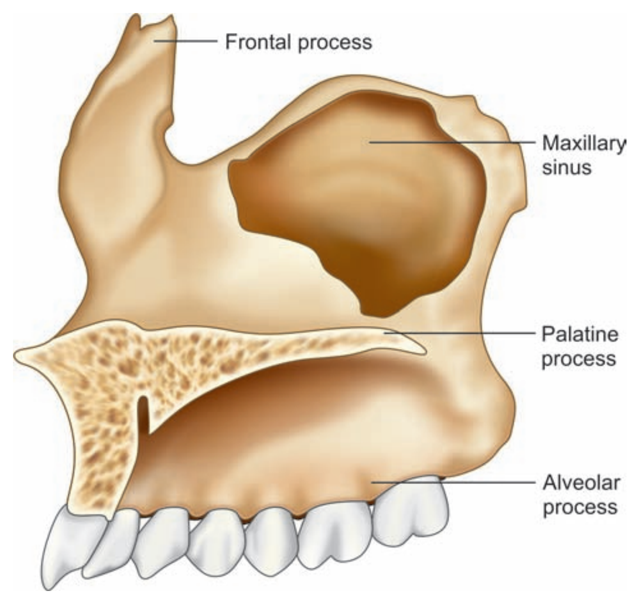


Figure 19.5 Body of the maxilla houses maxillary sinus

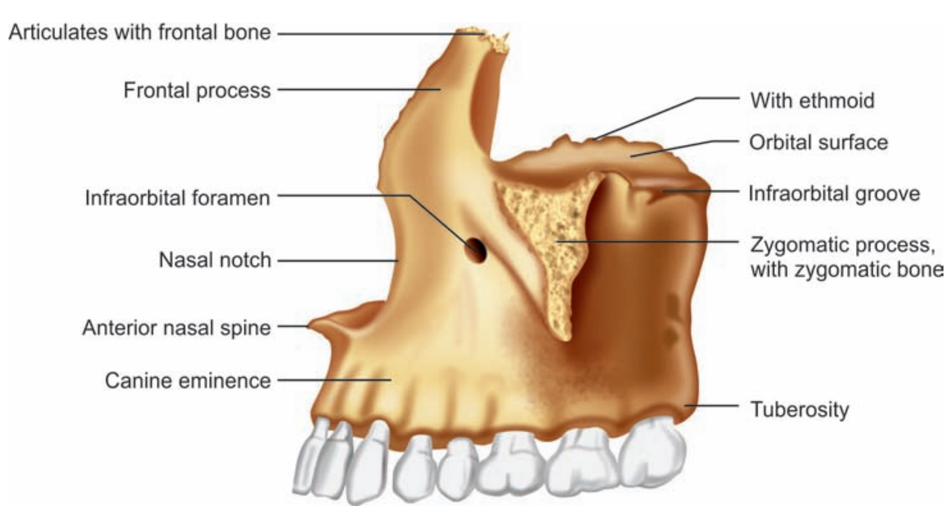


Figure 19.6 Body of the maxilla

Frontal (Frontonasal) Process

Frontal process of maxilla extends posterosuperiorly between the nasal and lacrimal bones. It articulates superiorly with the frontal bone, anteriorly with the nasal bone and posteriorly with the lacrimal bone. It also forms the lateral wall of the nose.

Palatine Process (Fig. 19.7)

The right and left palatine processes of maxillae extend horizontally from the medial surface of respective maxilla and join in the midline at the *median palatine suture*. The inferior surface of the palatine process forms the anterior two-thirds of the hard palate. The inferior surface of the palatine processes is rough and pitted for palatine mucous glands and exhibits numerous small foramina. The smoother superior surface of palatine processes forms the floor of the nasal cavity.

The palatine process of each maxilla articulates posteriorly with the horizontal plates of the palatine bones at the *transverse palatine suture*. The horizontal plates of palatine bones form the posterior one-third of the hard palate. The posterior border of the horizontal palatine plates is concave and in the midline form a sharp ridge called the *posterior nasal spine*.

The palatine process of maxilla blends smoothly with the palatal portion of the maxillary alveolar process. *Incisive fossa/canal* lies in the midline just posterior to the central incisors. Two lateral incisive canals are seen in the incisive fossa which transmits the *greater palatine artery* and the *nasopalatine nerves*.

The mucosa over the median palatine suture in the mouth is a smooth ridge called *midpalatine raphe*. In a person born with cleft palate, a part or all of the palatine process of maxilla are absent. Sometimes, the bony margins are raised in the midline to form palatine torus.

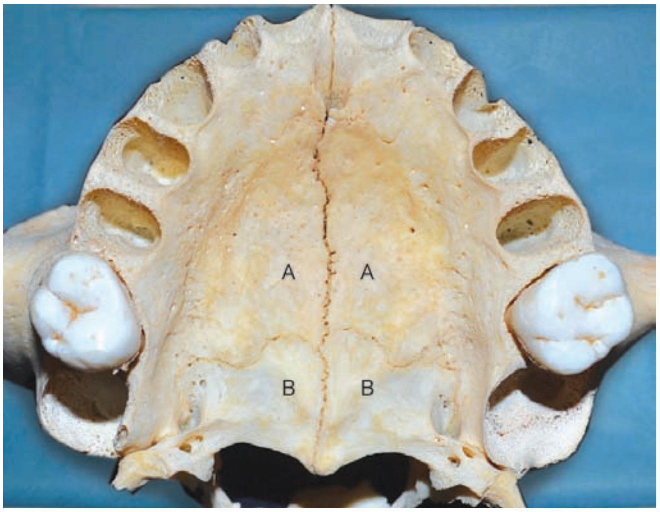


Figure 19.7 Palatine process of maxilla (A) along with the horizontal plates of palatine bones (B) form the hard palate

Alveolar Process

The alveolar process extends inferiorly from the bodies of the maxillae, surround the roots of maxillary teeth and give them osseous support within bony sockets. The alveolar process merges smoothly with the palatine process medially and with the zygomatic process laterally.

The maxilla can contain 8 permanent teeth or 5 primary teeth on each side. The shape of the alveolus or socket varies and corresponds exactly with the shape of the root of the tooth that each socket surrounds. For instance, sockets for incisors are single, that of canine is deepest and those for molars are widest and subdivided into two/three by septa.

The form of the alveolus is related to the functional demands put upon the teeth. When a tooth is lost, the alveolus that supports the missing tooth undergoes resorption. If all the teeth are lost, the alveolar process eventually gets completely resorbed.

The alveolar process of the jaw has a buccal/labial surface and lingual surfaces. The alveolar process is composed of two parallel plates of dense compact/cortical bone: *The outer and inner cortical plates*. Spongy/cancellous bone of varying thickness lies between the outer and inner cortical plates. The individual sockets are separated by plates of bone termed *the interdental septa*. In multi-rooted teeth, the roots are divided by *inter-radicular septa* (**Fig. 19.8A**).

The floor of the socket is called the *fundus* and its rim is called *alveolar crest*. The alveolar bone proper which forms the inner wall of the socket is perforated by many openings that carry nerve and blood vessels into periodontal ligament, and thus is also called the *cribriform plate*.

The alveolar bone proper also contains *bundle bone* into which the bundles of principal fibers of periodontal ligament are anchored and continue into the bone as *Sharpey's fibers*. Radiographically, it is also referred as the *lamina dura* (**Fig. 19.8B**).

Maxillary Sinus

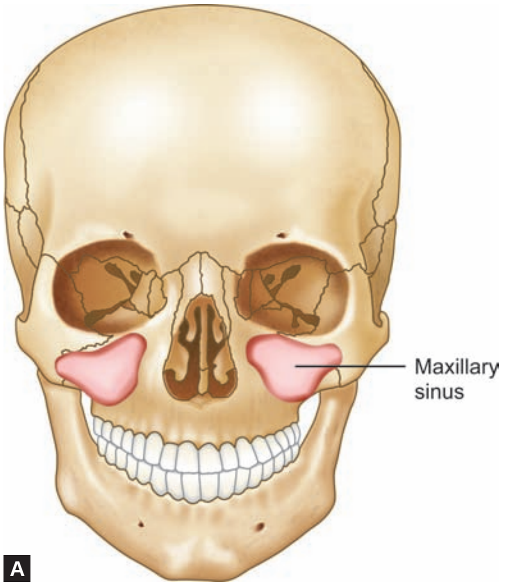
The maxillary sinus is the largest paranasal air sinuses and is situated in the body of the maxilla. It is shaped as a four sided pyramid, the base of which faces medially towards the nasal cavity and apex is pointed laterally towards the zygomatic bone (**Fig. 19.9A**).

The roots of the posterior teeth, especially the 1st and 2nd molars and sometimes premolars are closely related to the floor of the maxillary sinus (**Fig. 19.9B**). The alveoli of these teeth are separated from the sinus floor by only a thin layer of bone. Thus care must be taken when extracting the fractured roots in the region to avoid creating an oroantral fistula.

MANDIBLE

The mandible is the largest and strongest bone of the skull. It consists of horizontal component—the horseshoe shaped

Figures 19.8A and B (A) Alveoli of maxillary teeth; (B) Lamina dura



Figures 19.9A and B (A) Maxillary sinus is shaped as a four-sided pyramid; (B) Maxillary 1st and 2nd molars roots are closely related to floor and maxillary sinus. (*Courtesy*: Dr Master Department of Human Anatomy, SSG Medical College, Vadodara, Gujarat, India)

body and two vertical components—the *rami*. The rami join the body posteriorly at an oblique angle at the angle of the mandible. The body of the mandible carries the mandibular teeth and their associated alveolar process (**Fig. 19.10**).

The mandible is attached to the cranial bone only by ligaments and muscles. It articulates with the cranium through the *temporomandibular joint*. The mandible is the only bone in the skull that moves. All the muscles of mastication have their insertion into the mandible.

Mandibular Body

The mandibular body has two surfaces—internal and external, two borders—superior and inferior.

External Surface of Mandibular Body (Fig. 19.11)

Prenatally, the mandibular body develops as two lateral halves (**Fig. 19.12**). They join at midline during the first year after

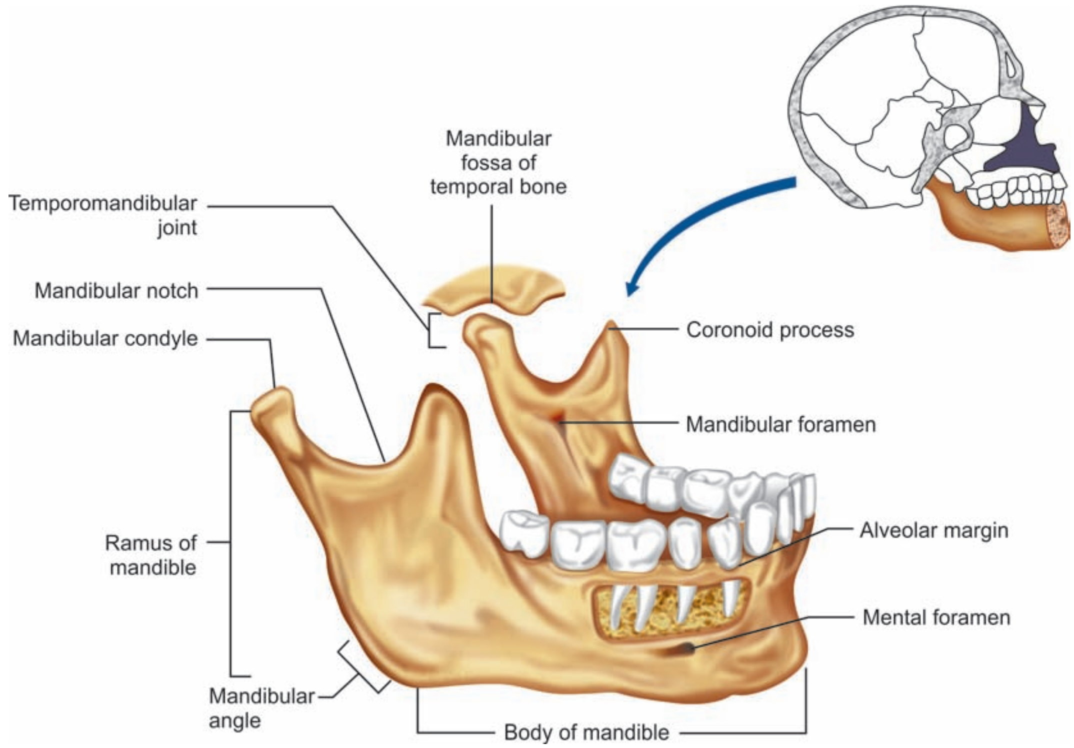


Figure 19.10 Mandible has a horseshoe-shaped body and two rami. It articulates with cranium through temporomandibular joint

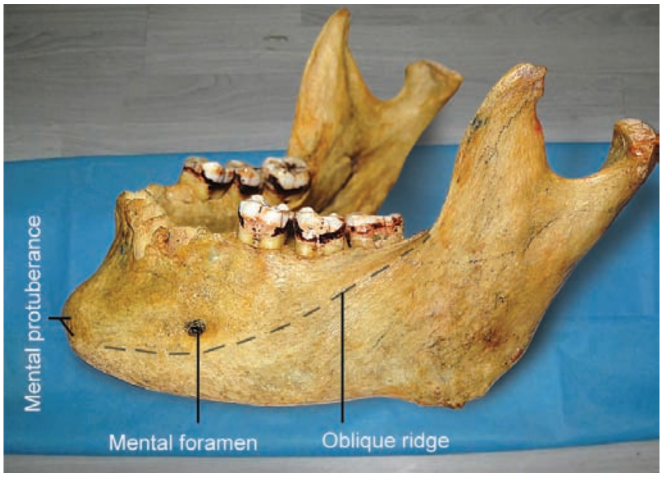


Figure 19.11 External surface of mandibular body

Figure 19.12 Prenatally mandible develops as two lateral halves which join later at midline after birth

birth. The line of fusion appears as a median ridge on external surface of the body-called *symphysis*. Inferiorly, this ridge/ symphysis forms a prominent triangular surface with base towards the lower border-called the *mental protuberance*. The *mental tubercles* and the mental protuberance together form the human *chin*, a unique feature that is absent in other mammals. Posterior to the symphysis and above the mental protuberance, there is a shallow depression just below the alveolar border of central and lateral incisor called incisive fossa.

Alveolar process over the root of the canine is prominent and forms the *canine eminence of mandible*. The *oblique* *ridge* extends obliquely form the mental tubercles where it is faint, ascends backwards sloping below the mental foramen, becoming more prominent near molar area as it continues into the anterior border of the ramus.

Mental foramen, through which the mental branches of inferior alveolar nerve and artery pass is an important landmark on the external surface of mandible. It is positioned between the apices of premolars or directly below the apex of 2nd premolar.

Internal Surface of Mandibular Body (Fig. 19.13)

On the rear side of the mandible along the midline, there are two small eminences called the *superior and inferior genial spines/tubercles*. They give attachment to *geniohyoid and genioglossus* muscles respectively. The *digastric fossae* are two depressions on the inferior surface of the mandible near midline, into which the *anterior belly of digastric muscles* are inserted.

The *mylohyoid line/ridge* arises near genial tubercles and passes obliquely to end on the anterior surface of the ramus. The *mylohyoid muscle* that forms the floor of the mouth takes origin from the mylohyoid ridge. The mylohyoid ridge separates two shallow fossae—the *sublingual fossa* above against which the *sublingual salivary gland* rests, the *submandibular fossa* below against the *submandibular salivary gland* rests.

The alveoli of mandibular teeth are shown in **Figure 19.14**.

Mandibular Ramus (Fig. 19.15)

The mandibular ramus is a quadrilateral bone with two processes along its superior border—the *coronoid and condylar processes*. The coronoid process provides attachments to the *temporalis muscle* at its anterior border.

The head of the condyle fits into the mandibular fossa of the temporal bone to form a moveable synovial joint *the temperomandibular joint*. The concavity between the coronoid and condylar process is called the *mandibular notch/sigmoid notch*. The lateral surface of the ramus provides attachment for *masseter muscle*.

The medial surface of the ramus presents an irregular *mandibular foramen* that leads into the *mandibular canal* curving downwards and inferior alveolar nerve and vessels pass through the mandibular canal. A triangular bony process, *lingula* is seen overlapping the mandibular foramen anterosuperiorly. It gives attachment to the *sphenomandibular ligament*. The *mylohyoid groove* may be

Figure 19.14 Alveoli of mandibular teeth

Figure 19.13 Internal surface of mandibular body

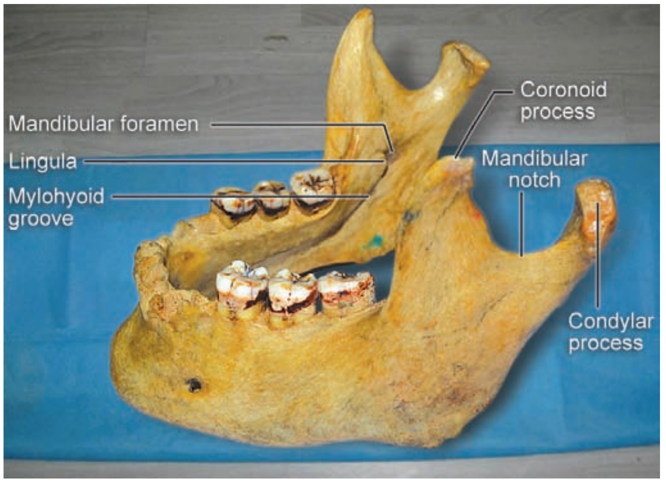


Figure 19.15 Mandibular ramus

seen running forwards from behind the lingula, along which the mylohyoid nerve and vessels pass.

BLOOD SUPPLY (FIG. 19.16)

Blood Supply to Maxillary Teeth and Periodontium (Table 19.1 and Flow chart 19.1)

Maxillary artery is a branch of *external carotid artery* which in turn is a branch of *common carotid artery*. Maxillary artery gives off first branch posterosuperior alveolar artery, which supplies maxillary molars, alveolar bone, supporting soft tissue structures. Maxillary artery gives of infraorbital artery, which in turn gives of two branches, anterosuperior alveolar artery and middle superior alveolar artery.

Middle superior alveolar artery runs downward between the sinus mucosa and bone and then supplies the maxillary premolar teeth and their supporting structures.

Anterosuperior alveolar artery arises from the infraorbital artery just before this vessel leaves the foramen and it runs down in the anterior aspect of the maxilla to supply the maxillary anterior teeth and their supporting structures such as alveolar mucosa, gingival and interdental septa.

Blood Supply to Mandibular Teeth and Periodontium (Table 19.2 and Fig. 19.16)

The blood supply to jaw bones and teeth is derived from the maxillary artery which is a branch of external carotid artery. Maxillary artery gives off mylohyoid branch as it crosses the

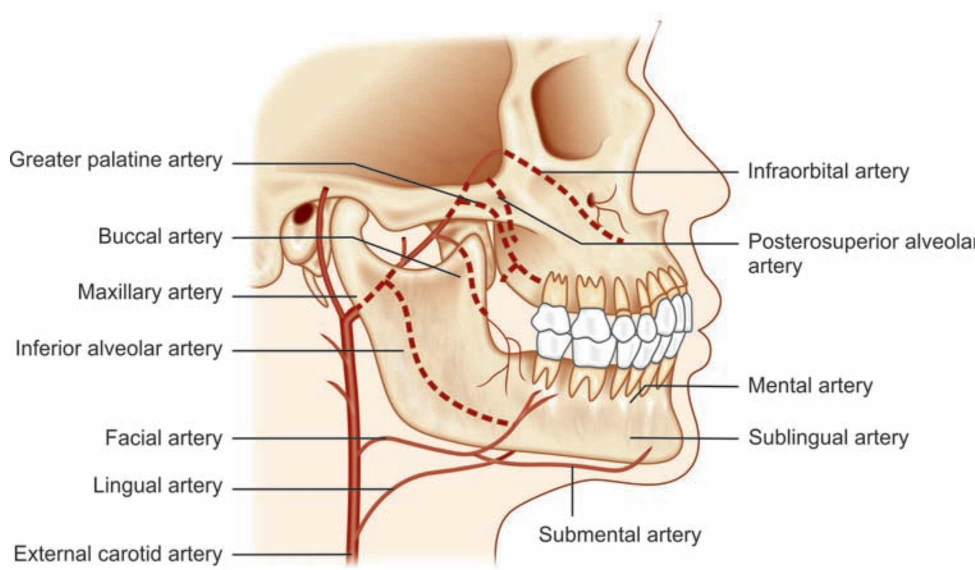


Figure 19.16 Arterial supply of dento-osseous structures

Table 19.1 Blood supply to maxillary teeth and periodontium

Structures	*Blood supply*
• Maxillary posterior teeth • Alveolar bone of maxillary posteriors • Membrane of sinus	Posterosuperior alveolar artery
• Gingiva of posterior teeth • Alveolar mucosa of posterior teeth • Cheek	Branches of posterosuperior alveolar artery
• Maxillary premolar teeth • Alveolar bone of premolars • Gingival of premolars	Middle superior alveolar artery
• Maxillary anterior teeth and their supporting structures	Anterosuperior alveolar artery

Flow chart 19.1 Branches of maxillary artery

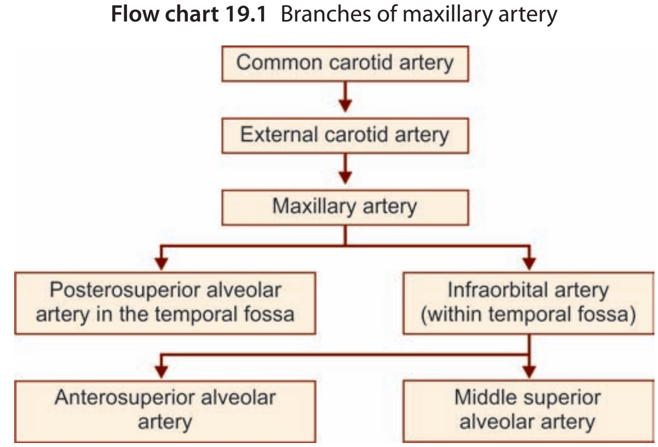


Table 19.2 Blood supply to mandibular teeth and periodontium

Structures	*Blood supply*
Anterior labial gingiva	• Mental artery • Perforating branch of incisive artery
Posterior buccal gingiva	Buccal artery
Lingual gingiva (Anterior and posterior)	Lingual artery and perforating branches of inferior alveolar artery
Tissue of chin	Mental artery
Individual tooth roots	Dental branches
• Individual septa • Alveolar mucosa, periodontal membrane	Branches of dental artery

infratemporal fossa and then it traverses to give off inferior alveolar artery which enters the mandibular foramen in the ramus of the mandible.

Inferior alveolar artery gives off mental branch and incisive branch. Mental artery passes through mental foramen to supply anterior labial gingiva and incisive branch enters incisive foramen to supply labial gingiva anteriorly and tissues of the chin. The anastomosis of mental artery and incisive artery serves as a good collateral blood supply for the mandible and teeth.

Third part of inferior alveolar artery is dental branches to the individual teeth, which serves the blood supply to the individual tooth root and other branches enters adjacent periodontal membrane and terminate in the gingiva. Numerous anastomosis of these arteries supply the alveolar mucosa.

BLOOD SUPPLY TO PALATE, CHEEK, TONGUE AND LIPS (TABLE 19.3)

Palate

The palate derives its blood supply from the greater and lesser palatine branches of maxillary artery. The greater palatine artery enters the palate through the greater palatine foramen and runs forward along with its nerve and vein in a groove at the junction of the palatine and alveolar process.

Cheeks

The cheek derives its blood supply from the buccal branch of maxillary artery.

Tongue

The tongue and floor of the mouth derives its blood supply from lingual artery.

Table 19.3 Blood supply to palate, lips, cheek and tongue

Structures	*Blood supply*
Palate	• Greater palatine artery • Lesser palatine artery
Tongue	Lingual artery
Cheek	Buccal branch of maxillary artery
Upper lip	Superior labial branch of facial artery
Lower lip	Inferior labial branch of facial artery

Lips

The lips (upper and lower lips) derive blood supply from superior and inferior labial branches of facial artery, where upper lip gets blood supply from superior labial branches of facial artery whereas lower lip obtains its blood supply from inferior labial branches of the facial artery.

VENOUS DRAINAGE OF ORODENTAL TISSUES (FIG. 19.17)

The facial vein is the main vein for the venous drainage of orodental tissues. It begins at the medial corner of the eye by the confluence of supraorbital and supratrochlear veins and passes across the face behind the facial artery. It joins with the anterior branch of the retromandibular vein to form the common facial vein below the mandible.

Teeth and Periodontium

Small veins from the teeth and alveolar mucosa pass into larger vein of each toot surrounding the root apex or into the veins of interdental septa.

Mandible

In the mandible, inferior alveolar vein is the prime vein for the venous drainage. Anteriorly, inferior alveolar vein drains through the mental foramen to join the facial vein while in the posterior region, it drains through mandibular foramen to join the pterygoid plexus of veins in the infra-temporal fossa.

Maxilla

Anteriorly venous drainage in maxilla is from facial vein and posteriorly into the pterygoid plexus.

Palate

The veins of the palate are rather diffuse and variable. However, those of the hard palate generally pass into the pterygoid venous plexus, those of the soft palate into the pharyngeal venous plexus (**Flow chart 19.2**).

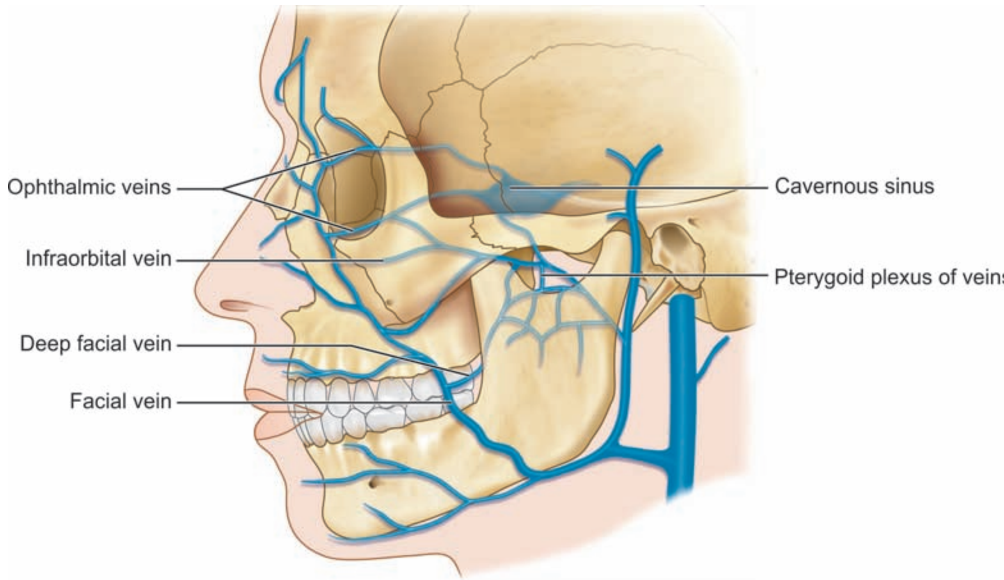
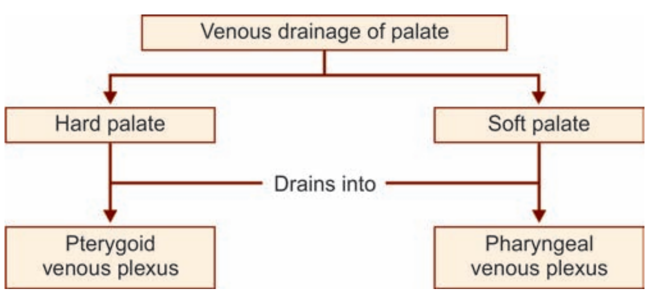
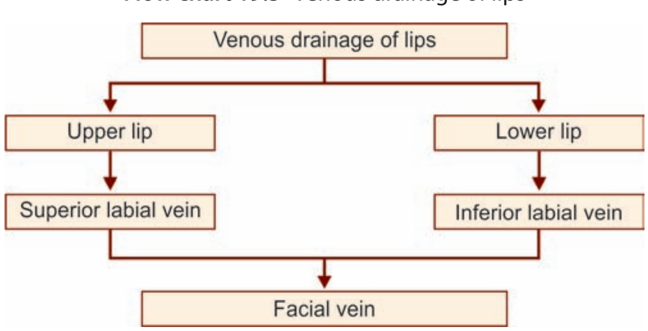


Figure 19.17 Venous drainage of dento-osseous structures

Flow chart 19.2 Venous drainage of palate



Flow chart 19.3 Venous drainage of lips



Lips

Venous drainage of the lips is mainly from the facial vein. Venous blood from upper lip drains into superior labial vein, whereas venous blood from lower lip drains into inferior labial veins (**Flow chart 19.3**).

Tongue

Venous drainage of tongue is quite peculiar and is from two different routes for two different part of the tongue. The part of the tongue from dorsum surface and sides of the tongue drains into lingual vein; those of the ventral surface from the deep lingual veins. Venous blood from lingual vein drains into facial vein and later into internal jugular veins (**Flow chart 19.4**).

LYMPHATIC DRAINAGE OF ORODENTAL TISSUES (TABLE 19.4 AND FIG. 19.18)

Lower Part of the Face

Lymphatic drainage of the lower part of the face drains into submandibular lymph nodes and medial portion of lower lip into submental lymph nodes.

Maxillary and Mandibular Teeth

- The lymph vessels from the teeth usually drain into the submental lymph nodes
- The lymph vessels from the mandibular anterior teeth drain into the submental group of lymph nodes
- The lymph vessels from the labial and buccal gingiva of the maxillary and mandibular teeth unite to drain into the submandibular lymph nodes
- The lymph vessels from the labial gingival of mandibular anterior teeth drain into the submental group of lymph nodes
- The lymph vessels from the lingual and palatal gingival drains into the jugulodigastric group of nodes, either direct or indirectly through the submandibular lymph nodes.

Flow chart 19.4 Venous drainage of tongue

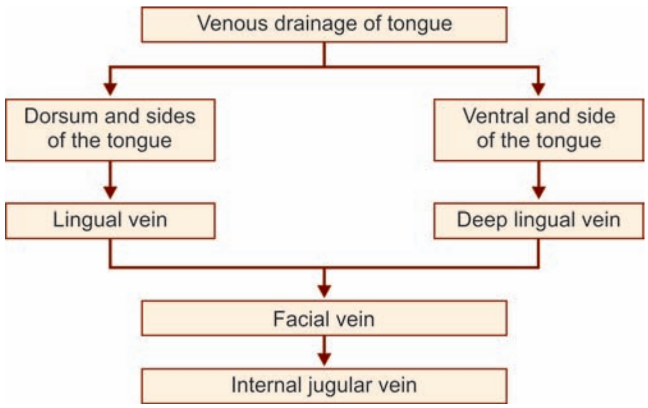


Table 19.4 Lymphatic drainage of orodental tissues

Orodental tissues	*Lymphatic drainage*
Lower part of the face	Submandibular lymph nodes
Medial part of lower lip	Submental group of lymph nodes
Posterior teeth	Submandibular lymph nodes
Anterior teeth	Submental group of lymph nodes
Labial/buccal gingival of mandibular and maxillary teeth	Submandibular lymph nodes
Labial gingival of mandibular anterior teeth	Submental group of lymph nodes
Lingual and palatal gingival of teeth	Jugulodigastric lymph nodes
Hard palate	Jugulodigastric lymph nodes
Soft palate	Pharyngeal group of lymph nodes

Lymphatic Drainage of Palate

- The lymph vessels from most part of palate especially the hard palate drains into the jugulodigastric group of lymph nodes
- The lymph vessels from soft palate drains into the pharyngeal lymph nodes.

NERVE SUPPLY TO ORODENTAL TISSUES (FIG. 19.19)

Nerves of the Oral Cavity

There are 12 cranial nerves that are responsible for the following functions.

Types of Nerve Fibers Based on their Functions

Following are types of nerve fibers based on their function.

Sensory Fibers or Afferent Fibers

These fibers convey impulses from peripheral organs to the central nervous system. They supply the skin of the entire face, the mucous membrane of the oral cavity and nasal cavity, the pharynx and the base of the tongue and the teeth and their supporting structures (i.e. periodontal ligament, the alveolar process and gingival).

Motor Fibers or Efferent Fibers

These fibers convey impulses from the central nervous system to the peripheral organs. They supply the four pairs of muscles

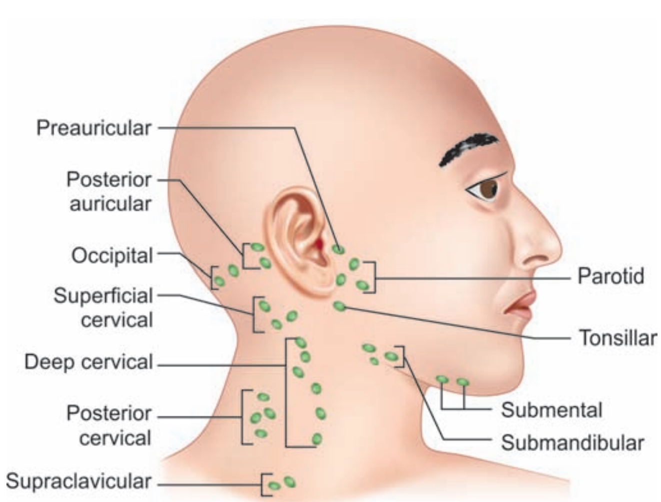


Figure 19.18 Lymphatic drainage of dento-osseous structures

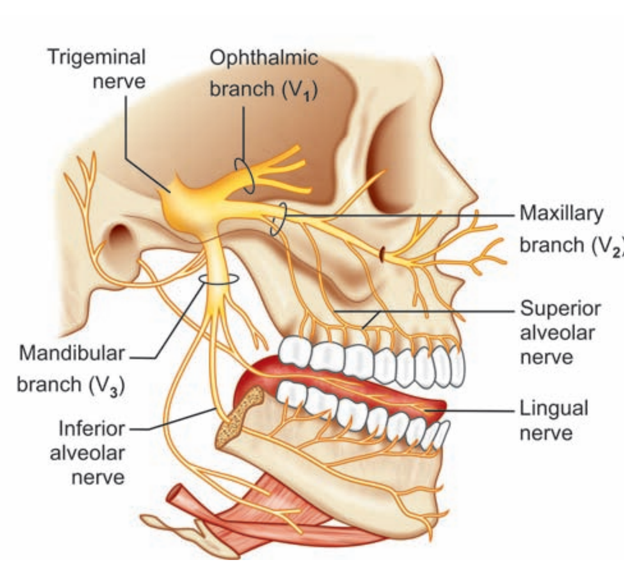


Figure 19.19 Nerve supply of dento-osseous structures

of mastication and several other muscles in the region of the mouth (mylohyoid, anterior belly of the digastric, tensor veli palatini and the tensor tympani).

Secretory Fibers

These are specialized fibers which upon stimulation increases secretory activity of a salivary gland.

TRIGEMINAL NERVE (FIFTH CRANIAL NERVE)

Trigeminal nerve is the fifth cranial nerve and is the largest of sensory nerve of the face and scalp. It originates in the large semilunar or trigeminal ganglion within the above the carotid canal medial to the foramen ovale on the internal surface of the temporal bone.

The trigeminal nerve gives off following three branches (**Flow chart 19.5**):
1. Ophthalmic nerve
2. Maxillary nerve
3. Mandibular nerve.

Ophthalmic Nerve

The ophthalmic nerve comes out from skull via superior orbital fissure. This nerve gives of following three main branches:
1. Lacrimal
2. Frontal
   - Supraorbital
   - Infraorbital
3. Nasociliary.

This nerve along with its branches supplies to sensory innervations to the eyeball, the upper eye lid, the skin of the nose, the skin of the forehead, the skin of the scalp, part of nasal mucosa, and maxillary sinus and lacrimal glands. This nerve does not supply to any part of the oral cavity.

Maxillary Nerve (Flow chart 19.6)

The maxillary nerve is the second division of trigeminal nerve and it exist from the skull through foramen rotundum.

The maxillary nerve has following four principle branches:
1. Pterygopalatine nerve
   - Nasopalatine nerve
   - Palatine nerve
2. Posterosuperior alveolar nerve
3. Infraorbital nerve
   - Middle superior alveolar nerve
   - Anterosuperior alveolar nerve
   - Anastomoses of infraorbital nerve
4. Zygomatic nerve.

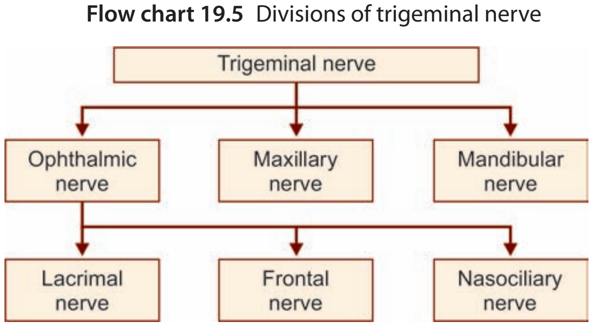
Pterygopalatine Branch of Maxillary Nerve

Pterygopalatine branch of maxillary nerve is the closest nerve as compared to other divisions of maxillary nerve; it gives of nasopalatine and palatine nerve.
- *Nasopalatine nerve*: Nasopalatine nerve exist to the palate through the incisive foramen to supply palatal and labial gingival of maxillary and mandibular molar and premolar teeth.
- *Palatine nerve*: Palatine nerve gives off following three branches:
  1. Anterior palatine nerve
  2. Middle palatine nerve
  3. Posterior palatine nerve.
- *Anterior palatine nerve:* This nerve enters the oral cavity through greater palatine foramen and runs anteriorly to supply the anterior part of mucosa of hard palate and palatal gingival of premolar and molar teeth.
- *Middle palatine nerve:* This nerve enters the oral cavity through lesser palatine foramen to supply mucosa of soft palate and tonsils.
- *Posterior palatine nerve:* This nerve like middle palatine nerve enters the lesser palatine foramen to supply the tonsils and the mucosa of the soft palate.

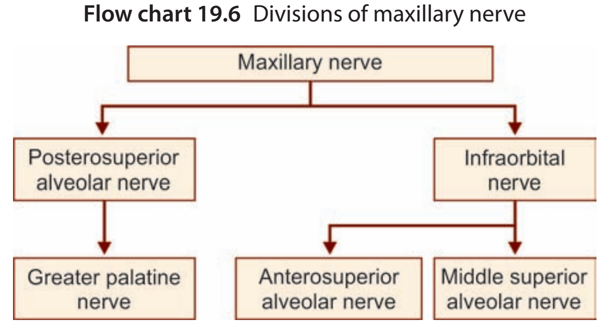
Posterosuperior Alveolar Nerve

Posterosuperior alveolar nerve is the first terminal branch of maxillary nerve which enters via alveolar canal to supply following structures:

Flow chart 19.5 Divisions of trigeminal nerve



Flow chart 19.6 Divisions of maxillary nerve



- The pulp of the maxillary motor teeth through the apical foramen except mesiobuccal root of the maxillary 1st molar
- Maxillary teeth and their supporting hard and soft tissue structures
- The mucosa of the maxillary sinus and cheek in part.

Infraorbital Nerve

Infraorbital nerve enters the infraorbital canal and comes out through the infraorbital foramen onto the face. The Infraorbital nerve gives off following three branches:

1. Middle superior alveolar nerve
2. Anterosuperior alveolar nerve
3. Anastomoses of infraorbital nerve.

- *Middle superior alveolar nerve*: Middle superior alveolar nerve originates from infraorbital nerve in the infraorbital groove. It travels down through the lateral wall of the maxillary sinus and supplies the pulp of the maxillary premolars through the apical foramen and pulp in the mesiobuccal root of the maxillary first permanent molar; the mucosa of the maxillary sinus; supporting soft and hard tissue structure of premolar teeth.
- *Anterosuperior alveolar nerve*: It originates from infraorbital nerve in the infraorbital canal and supplies maxillary anterior teeth and their supporting hard and soft tissue structures.
- *Anastomoses of infraorbital nerve*: Anastomoses of infraorbital nerve supplies mucosa of the upper lip; mucosa of the lower eyelid; mucosa of side of the neck.

Zygomatic Nerve

Zygomatic nerve enters orbit via the inferior orbital fissure and then divides into zygomatic temporal and zygomaticofacial nerves. This nerve supplies the bone and temporal region and the orbit.

Mandibular Nerve (Flow chart 19.7)

Mandibular divisions of trigeminal nerve exit from skull through the foramen ovale. This nerve is a mixed nerve; it has motor as well as sensory fibers. The motor fibers supplies muscles and sensory fibers to the teeth, soft and hard tissues.

Motor Fibers

The motor fibers of mandibular division of trigeminal nerve has following nerves:

- Temporal nerve supplies to temporalis muscle
- Medial pterygoid nerve supplies to medial pterygoid muscle
- Lateral pterygoid nerve supplies to lateral pterygoid muscle
- Masseter nerve supplies to masseter muscle.

Sensory Fibers

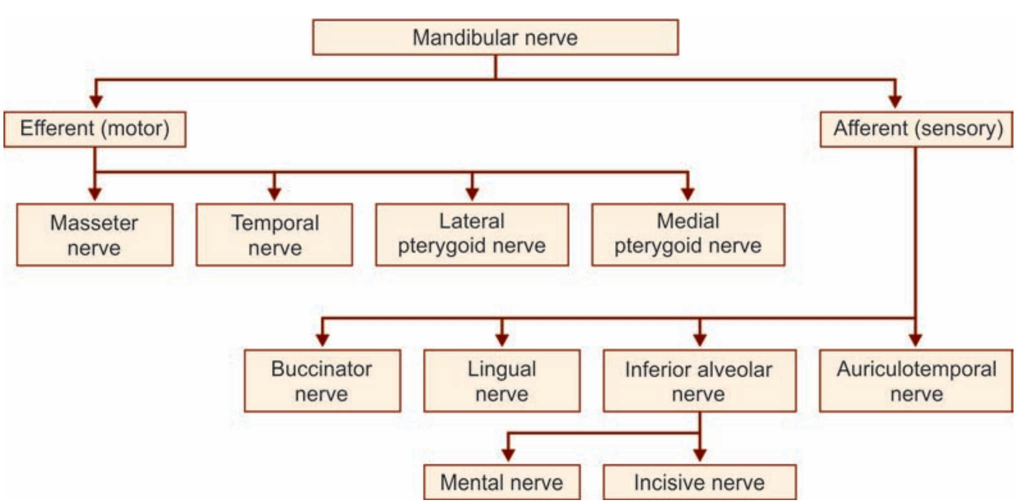
Sensory fibers of mandibular division of trigeminal nerve have following nerve.

- *Long buccal nerve*: It supplies to buccinators muscle hence this nerve is also called as buccinators nerve.
- *Lingual nerve*: The lingual nerve lies roughly about 2 mm below the foramen ovale and runs downward between the medial pterygoid muscle and ramus to the posterior part of the mylohyoid line resting closely beneath the mucous membrane of 3rd molar.

The following structures derive its nerve supply from the lingual nerve.

- The lingual gingival of the entire mandibular arch
- The dorsum and ventral surface of two-thirds of the tongue
- The mucosa of the inner surface of the mandible in the sublingual region.

Flow chart 19.7 Divisions of mandibular nerve



Inferior Alveolar Nerve

Inferior alveolar nerve is the largest nerve of the mandibular nerve and exits from mandibular foramen. This nerve runs downwards between sphenomandibular ligament and ramus of the mandibular foramen where it gives off mylohyoid nerve. It enters mandibular foramen through the mandibular canal.

Mylohyoid Nerve

Mylohyoid nerve is a efferent type. It runs forward and downward in the mylohyoid groove and then into the digastrics triangle where it supplies the mylohyoid muscle and anterior belly of the digastrics muscle.

Mental Nerve

The mental nerve exit from the mandible through the mental foramen and supplies to the facial gingival of the mandibular incisors, canines and premolars and the mucosa and the skin of the lower lip.

Incisive Nerve

Incisive nerve continues forward within the body of the mandible in the mandibular canal and supplies the pulp of the mandibular incisors and canine teeth, the periodontal ligament and the alveolar process of the incisors, canines.

Auriculotemporal Nerve

This nerve originates from the main trunk of the mandibular nerve below the base of the skull turning backward beneath the lateral pterygoid muscle to supply pain and proprioception fibers to the temporomandibular joint (TMJ) also to the outer ear, the skin of the lateral aspect of the skull and cheek and the parotid gland.

INNERVATION OF MAXILLA

The maxillary nerve gives off posterosuperior alveolar nerve and infraorbital nerve. The posterosuperior alveolar nerve supplies maxillary posterior teeth, alveolar mucosa, inter-dental septa, periodontal tissues. The infraorbital nerve divides into middle superior alveolar nerve and anterosuperior alveolar nerve. Both the branches of infraorbital nerve runs downward to supply premolars and anterior teeth. Middle superior alveolar nerve supplies maxillary premolars and their supporting soft tissues (alveolar mucosa, labial gingiva, lingual gingiva and periodontal membrane). Anterosuperior alveolar nerve supplies anterior teeth (incisors and canine) and their surrounding structures.

INNERVATION OF MANDIBLE

The mandible nerve gives off inferior alveolar nerve which enters the mandibular foramen accompanying with inferior alveolar artery. Mandibular teeth and their surrounding structures including soft and hard tissues derive nerve supply from the inferior alveolar nerve, which is the branch of maxillary nerve. This inferior alveolar nerve gives off mental nerve and enters the mental foramen, while incisive branch enters the incisive foramen. These two branches collectively supply mandibular teeth and their supporting hard and soft tissue structures.

INNERVATION OF PALATE AND LIPS

Greater palatine nerve supplies the palate and superior labial nerve supplies to upper lip and inferior labial nerve supplies to lower lip.

BIBLIOGRAPHY

1. Ash MM, Nelson SJ. Wheeler's Dental Anatomy, Physiology and Occlusion, 8th edn. St Louis: Saunders; 2003.
2. Clemente CD (Ed). Gray's anatomy of the human body, 30th edn. Philadelphia: Lea and Febiger; 1985.
3. Kraus B, Jordan R, Abrams L. Dental anatomy and occlusion. Baltimore: Williams and Wilkins; 1969.
4. Osborn JW. Dental anatomy and embryology. Oxford: Blackwell; 1981.
5. Sicher H, DuBrul EL. Oral anatomy, 7th edn. St. Louis: CV Mosby; 1975.
6. Woelfel JB, Scheid RC. Dental Anatomy: Its relevance to dentistry, 5th edn. Baltimore: Williams and Wilkins; 1997.

MULTIPLE CHOICE QUESTIONS

1. The osseous structure that supports the teeth are:
   a. Maxilla
   b. Mandible
   c. Both of the above
   d. None of the above
2. The maxilla is:
   a. Dense
   b. Hollow or porous
   c. Mixed
   d. None
3. The bone which makes the major portion of the roof of the mouth is:
   a. Maxilla
   b. Mandible
   c. Soft palate only
   d. Hard palate only
4. The maxillary sinus is also called as:
   a. Antrum of maxilla
   b. Antrum of mandible

   c. Antrum of highmore
   d. Antrum of lowmore

5. Which of the following statements is incorrect regarding the zygomatic process of the maxilla?
   a. It is rough triangular eminence seen from the lateral aspect of the maxilla
   b. Its lateral border is rough
   c. Lateral border is spongelike in appearance where it has been disarticulates from the zygomatic or cheek bones
   d. It cannot be viewed from the lateral aspect of the maxilla at all
6. Which of the following is correct regarding the frontal process of the maxilla?
   a. Superiorly, it articulates with frontal bone
   b. Medially, it forms part of the lateral wall of the nasal cavity
   c. Anteriorly, it articulates with nasal bone
   d. All of the above
7. The maxilla articulates with:
   a. The nasal bone
   b. The frontal bone
   c. Lacrimal bone
   d. All of the above
8. Which of the following is correct regarding the maxillary sinus?
   a. The maxillary sinus lies within the body of the bone and is of corresponding pyramidal form, the base is directed towards the nasal cavity
   b. Sinus is closed in laterally and above by the thin walls that forms the anterolateral, posterolateral and orbital surface of the body
   c. A layer of sinus mucosa is also always between the root tips and the sinus cavity
   d. All of the above
9. The shape of the mandible is:
   a. Horseshoe shaped
   b. 'U' shaped
   c. 'V' shaped
   d. Triangular shaped
10. The only movable bone of the skull is:
   a. Maxilla
   b. Mandible
   c. Cranial bone
   d. Hyoid bone

Answers

1. c	2. b	3. a	4. c	5. d	6. d	7. d	8. d	9. a	10. b

CHAPTER 20

Temporomandibular Joint

Temporomandibular joint (TMJ) (**Fig. 20.1**) is a synovial joint of the condylar variety. This joint is between the mandible and temporal bone of the cranium. TMJ permits gliding movements as well as hinge movements. This joint is lined up with synovial membrane which secretes synovial fluid and that lines up the internal surface of the joint capsule.

The TMJ is a *ginglymoarthrodial* joint, a term that is derived from ginglymus, meaning a hinge joint, allowing motion only backward and forward in one plane, and arthrodial, meaning a joint of which permits a gliding motion of the surfaces. The right and left TMJ form a bicondylar articulation and ellipsoid variety of the synovial joints similar to knee articulation.

The features exhibited by the TMJ common to synovial joints include a disk, bone, fibrous capsule, fluid, synovial membrane, and ligaments. However, the features that differentiate and make this joint unique are its articular surface covered by fibrocartilage instead of hyaline cartilage. Movement is not only guided by the shape of the bones, muscles, and ligaments but also by the occlusion of the teeth, since both joints are joined by a single mandible bone and cannot move independently of each other.

Figure 20.1 Temporomandibular joint—relation of condyle to the glenoid fossa

The most important functions of the TMJ are mastication and speech. This chapter briefs the TMJ and its surrounding structures.

ARTICULAR SURFACES (FIGS 20.2A AND B)

The joint has superior and inferior articular surfaces. The superior or upper articular surface is formed by articular eminence and anterior part of the mandibular fossa/glenoid fossa (**Fig. 20.2A**). The inferior articular surface is formed by the head of the condyle of the mandible (**Fig. 20.2B**).

INTRA-ARTICULAR DISK (FIG. 20.3)

The articular disk is the most important anatomic structure of the TMJ. It is a biconcave fibrocartilaginous structure located between the mandibular condyle and the temporal bone component of the joint. Its functions to accommodate a hinging action as well as the gliding actions between the temporal and mandibular articular bone. The articular disk is a roughly oval, firm, fibrous plate with its long axis being traversely directed. It is shaped like a peaked cap that divides the joint into a larger upper compartment and a smaller lower compartment. Hinging movements take place in the lower compartment and gliding movements take place in the upper compartment.

The superior surface of the disk is said to be saddle-shaped to fit into the cranial contour, while the inferior surface is concave to fit against the mandibular condyle. The disk is thick, round to oval all around its rim, divided into an *anterior band* of 2 mm in thickness, a *posterior band* 3 mm thick, and thin in the center *intermediate band* of 1 mm thickness. More posteriorly there is a *bilaminar or retrodiskal region*. The disk is attached all around the joint capsule except for the strong straps that fix the disk directly to the medial and lateral condylar poles, which ensure that the disk and condyle move together in protraction and retraction.

Figures 20.2A and B Articular surfaces of TMJ: (A) Glenoid fossa (GF) and articular eminence (E); (B) Condyle

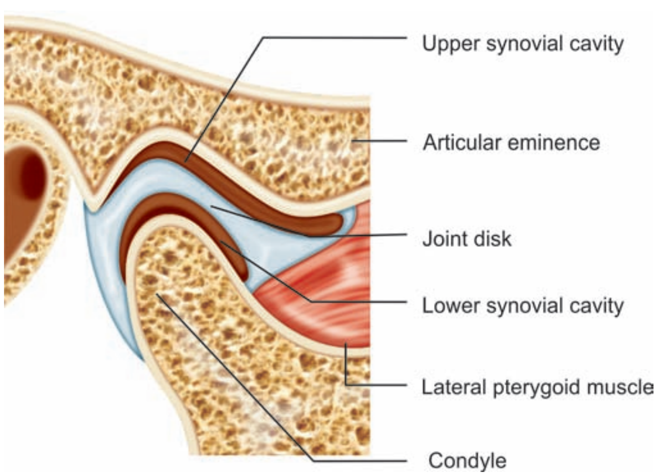


Figure 20.3 Intra-articular disk

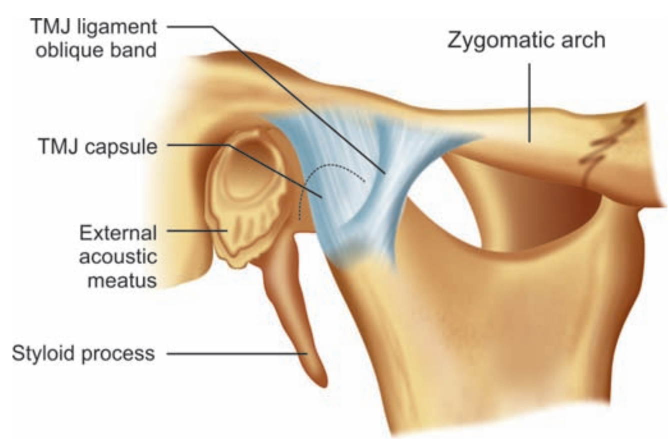


Figure 20.4 Fibrous capsule

The anterior extension of the disk is attached to a fibrous capsule superiorly and inferiorly. In between, it gives insertion to the lateral pterygoid muscle.

FIBROUS CAPSULE (FIG. 20.4)

The fibrous capsule is a thin sleeve of tissue completely surrounding the joint. It extends from the circumference of the cranial articular surface to the neck of the mandible. The synovial membrane lining the capsule covers all the intra-articular surfaces except the pressure-bearing fibrocartilage.

LIGAMENTS OF TMJ (FIG. 20.5)

The TMJ has one major and two minor ligaments. The temporomandibular ligament is the major ligament that supports the joint. The two minor ligaments, the stylomandibular and sphenomandibular ligaments are accessory and are not directly attached to any part of the joint.

Temporomandibular Ligament /Lateral Ligament

The joint capsule is strengthened by the temporomandibular ligament. It is in fact the thickened lateral portion of the capsule, and cannot be readily separated from the capsule. This ligament provides the main means of support for the joint, resists dislocation during functional movements by restricting distal and inferior movements of the mandible.

Sphenomandibular Ligament

The sphenomandibular ligament is a remnant of the dorsal part of Meckel's cartilage. It is attached superiorly to the

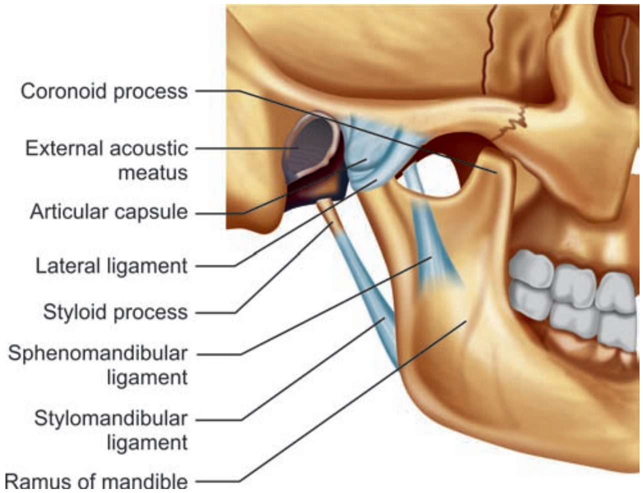


Figure 20.5 Ligaments of temporomandibular joint

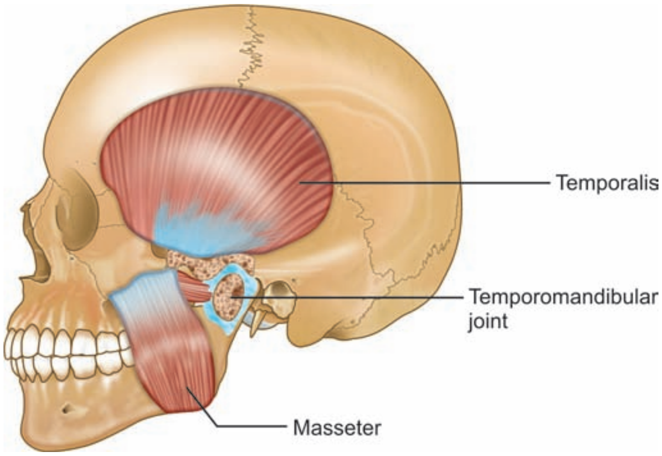


Figure 20.6 Masseter and temporalis muscles

spine of the sphenoid, and inferiorly to the lingual of the mandibular foramen.

Stylomandibular Ligament

It is a reinforced lamina of the deep cervical fascia. It is attached above to the lateral surface of styloid process and below to the angle and posterior border of the ramus of the mandible.

BLOOD AND NERVE SUPPLY TO TMJ

The temporomandibular joint derives blood supply from superficial temporal and maxillary artery. The TMJ derives nerve supply from auriculotemporal and masseter nerves.

MUSCLES OF THE JOINT

The masticatory muscles surrounding the joint are groups of muscles that contract and relax in harmony so that the jaws function properly. When the muscles are relaxed and flexible and are not under stress, they work in harmony with the other parts of the TMJ complex. The muscles of mastication produce all the movements of the jaw. They are involved in the activity of mastication and speech.

Different muscles are therefore required for the opposite movements of the mandible. The muscles of mastication are *adductors (jaw closers/elevators) and abductors (jaw openers/depressors)*. The temporalis, masseter, and medial pterygoid muscles are adductors, while the lateral pterygoids muscles are the primary abductors of the jaw. The muscles that produce forward movement (protrusive) are also used alternately to move the jaw from side to side (laterally).

Masseter Muscle (Fig. 20.6)

The principal and strongest muscle of mastication is the masseter, which stems from the temporal bone and extends down the outside of the mandible to its lower angle. It consists of two overlapping heads.

Origin

Superficial Head

- It originates from anterior 2/3rd of the lower border of the zygomatic arch and adjoining the zygomatic process of maxilla
- Fibers of this layer of muscles of mastication pass downward and backward at 45 degree.

Deep Head

It originates from deep surface of the zygomatic arch.

Insertion

- The superficial layer is inserted at lower part of the ramus of the mandible
- The middle layer of masseter muscle is inserted in the middle part of the ramus of the mandible
- The deep layer is inserted at the upper part and coronoid process of the mandible.

Nerve Supply

The masseter muscle derives nerve supply from masseter nerve which is an anterior division of mandibular nerve,which in turn is a division of trigeminal nerve.

Action

This muscle helps in closing the jaw.

Temporalis Muscle (Fig. 20. 6)

Temporalis muscle is a fan shaped muscle and the largest masticatory muscle that fills the temporal fossa.

Origin

This muscle originates from the floor of temporal fossa and from overlying temporal.

Insertion

Temporalis muscle is inserted at margins and deep surface of coronoid process and anterior border of ramus of the mandible.

Nerve Supply

The temporalis muscle derives nerve supply from temporal branch of mandibular nerve.

Action

- Its anterior fibers helps in elevation of the mandible
- Its posterior fibers retracts the protruded mandible
- It helps in lateral movement of the mandible.

Medial Pterygoid Muscle (Fig. 20.7A)

The medial pterygoid runs parallel to the masseter but on the inside of the jaw. It originates at a wing-shaped protrusion of the cranium. The medial pterygoid and the masseter muscles form a sling around the back end of the mandible and work together to pull it shut.

It is a quadrilateral muscle, has a small superficial and a large deep head.

Origin

- Its superficial head originates from the tuberosity of the maxilla and adjoining bone
- Its deep head, which is larger, originates from the medial surface of the lateral pterygoid plate and the adjoining process of the palatine bone.

Insertion

- The fibers run downwards, backwards and laterally
- It is inserted on the medial surface of the angle and the adjoining ramus of the mandible, below and behind the mandibular foramen and the mylohyoid groove.

Nerve Supply

It derives its nerve supply by the nerve to medial pterygoid, a branch of the main trunk of mandibular nerve.

Action

- It elevates the mandible
- It helps protrude the mandible
- Right medial pterygoid with the right lateral pterygoid turn the chin to sides.

Lateral Pterygoid Muscle (Fig. 20. 7B)

Lateral pterygoid muscle is short conical muscle and has upper and lower heads.

Origin

- The upper head of the lateral pterygoid muscle is small and originates from infratemporal surface of the greater wing of sphenoid bone.
- The lower head is large and originates from lateral surface of the lateral pterygoid plate of the sphenoid bone.

Insertion

- The fibers of superior head are inserted into the capsule and medial part of the intra-articular disk of TMJ.
- The fibers of inferior head insert into pterygoid fovea on the anterior surface of the neck of the mandible.

Nerve Supply

The lateral pterygoid muscle derives nerve supply from a branch from anterior division of mandibular nerve.

Action

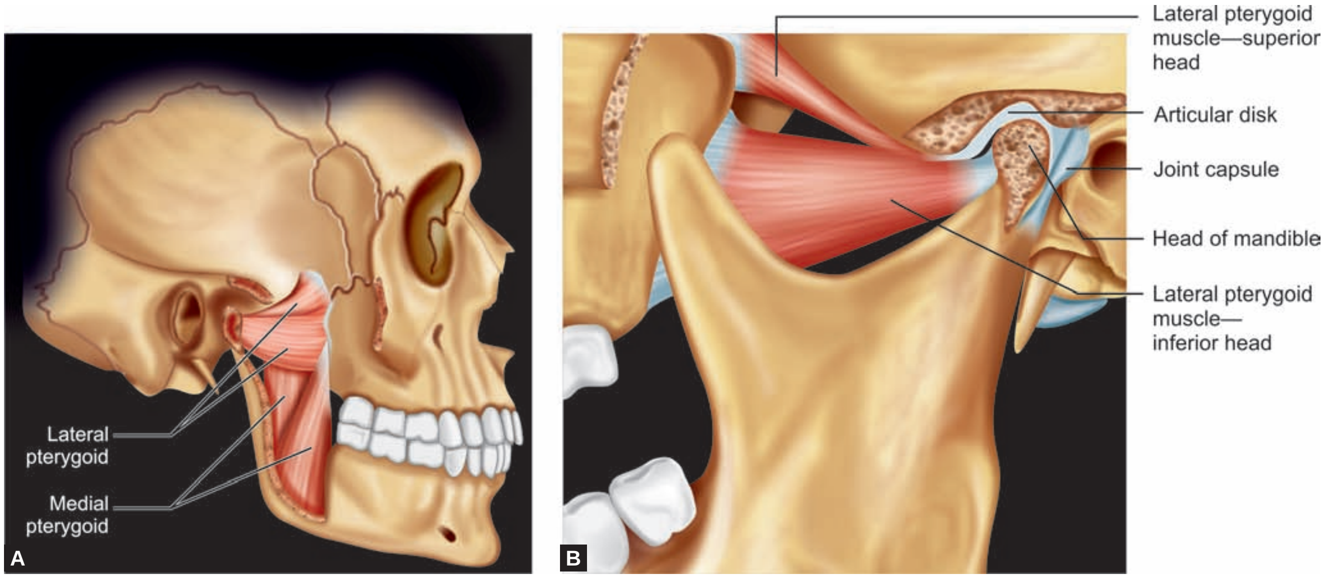
- Depress mandible to open mouth with suprahyoid muscles
- Lateral and medial pterygoid muscles protrude the mandible
- Left lateral pterygoid and right medial pterygoid turn the chin to left side as part of grinding movements.

Accessory Muscles of Mastication

Along with the four muscles of mastication, some accessory muscles are also involved in the process of mastication. They mainly include digastric, geniohyoid, tensor tympani and palatine muscles.

MANDIBULAR MOVEMENTS AND MUSCLE ACTIVITY

Mandibular movements involve complex neuromuscular patterns, originating in part in a pattern generator in the



Figures 20.7A and B Medial and lateral pterygoid muscles

brainstem and modified by influences from higher centers (cerebral cortex and basal ganglia) and from peripheral influences (the periodontium, muscles, etc.). Here, the main muscles involved in activities of jaw opening and closing, protrusion, retrusion and lateral movements.

Radiographs in **Figures 20.8A and B** show the temporomandibular joint in open and closed postions of the mandible.

Depression of Mandible

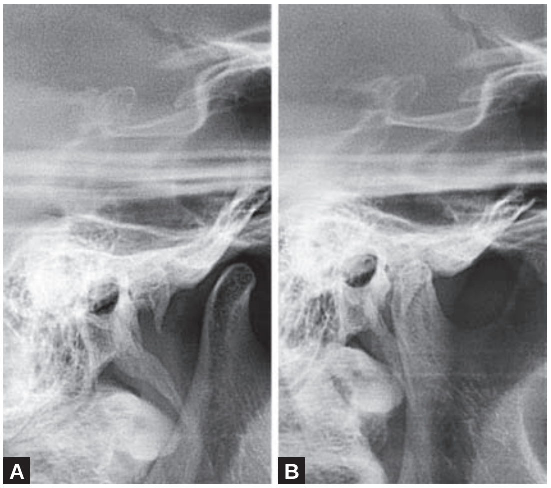
Muscles involved in mandibular opening are the lateral pterygoid, digastric, mylohyoid and geniohyoid muscles. No activity occurs in the temporalis and masseter muscles during slow mouth opening and when jaw is opened maximally, some activity may occur in the medial pterygoid muscle.

Elevation of Mandible

Elevation of mandible without contact or resistance occurs by contraction of masseter and medial pterygoid muscle. The temporalis, masseter and medial pterygoid muscle affect elevation against resistance.

Retrusion

Voluntarily, with mouth closed, it occurs due to contraction of posterior fibers of temporalis muscle. Retraction of mandible from protrusion and without occlusal contact occurs by the contraction of posterior and medial fibers of temporalis muscle.



Figures 20.8A and B Radiographs showing TMJ in open (A) and closed (B) position of mandible

Protrusion

Protrusion occurs by the lateral and medial pterygoid and masseter and suprahyoid group of muscles.

Lateral Movements

Movement to the right side (without occlusal contact) is by ipsilateral contraction of the posterior fibers of temporalis. Movement to the left side (without occlusal contact) is by contralateral contraction of the medial pterygoid and masseter. Movement to the right side, (against resistance) is by the ipsilateral contraction of temporalis. Movement to the left side (against resistance) is by contraction of medial pterygoid and masseter.

FUNCTIONS OF TMJ, TEETH AND MUSCLES

Mastication

Mastication is a complex rhythmical activity that requires coordination of the neuromusculature. It is the cutting down of the food substances into small particles and grinding them into a soft bolus.

Mastication is a repetitive sequence of jaw opening and closing with a profile in the vertical plane called the chewing cycle (**Flow chart 20.1**). Mastication consists of a number of chewing cycles.

The human chewing cycle consists of three phases:
1. *Opening phase*: The mouth is opened and the mandible is depressed.
2. *Closing phase*: The mandible is raised towards the maxilla.
3. *Occlusal or intercuspal phase*: The mandible is stationary and the teeth from both upper and lower arches approximate.

Each chewing cycle lasts approximately for 0.8 to 1.0 s. During normal function, 7 to 15 kg force occurs during swallowing and chewing.

Jaw Reflexes

The reflexes associated with mastication are:
- Jaw—closing reflex
- Jaw—opening reflex
- Tooth contact reflex
- Jaw—unloading reflex
- Horizontal jaw reflex.

Factors Affecting Mastication

- Saliva facilitates mastication, moistens the food particles, makes a bolus, and assists swallowing
- The neuromuscular control of chewing, plays an important role in the comminution of the food
- Characteristics of the food, e.g. water and fat percentage and hardness, are known to influence the masticatory process
- Food hardness is sensed during mastication and affects masticatory force, jaw muscle activity, and mandibular jaw movements
- The integrity of the occlusion surfaces of the teeth, muscles of mastication.

DEGLUTITION

Swallowing of food is known as deglutition. It occurs in three phases (**Fig. 20.9**):
1. Phase I: Oral stage.
2. Phase II: Pharyngeal stage.
3. Phase III: Esophageal stage.

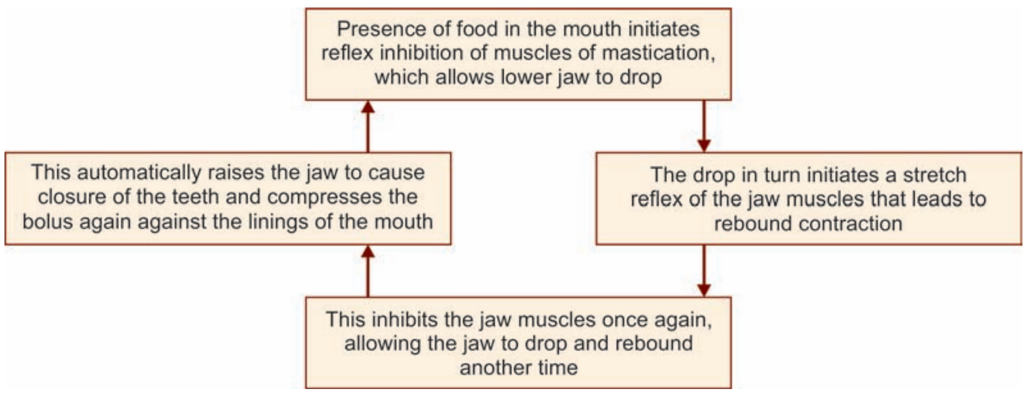
Phase I: Oral Stage

It occurs after mastication. Phase 1 is a voluntary stage. The bolus is placed over the posterodorsal surface of tongue. Soft palate is raised and seals the nasopharynx.

Phase II: Pharyngeal Stage

It is an involuntary stage. Bolus is pushed from pharynx into esophagus. Its entry back into the mouth, upwards into the nasopharynx and down into the larynx is prevented by a number of defensive mechanisms and thus the bolus enters straight into the esophagus due to:
- Stretching of the opening of the esophagus due to upward movement of the larynx

Flow chart 20.1 Masticatory cycle



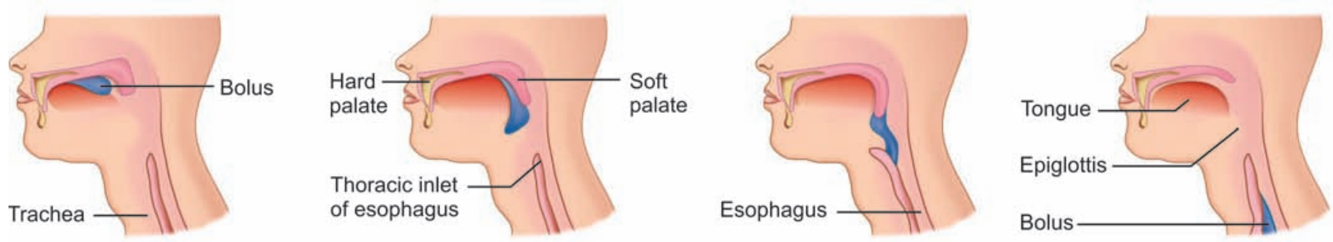


Figure 20.9 Stages of deglutition

- Simultaneous relaxation of the upper esophageal sphincter
- Peristaltic contractions in the pharynx
- Elevation of larynx.

Phase III: Esophageal Stage

It is also an involuntary stage. In this stage, the bolus is transported from pharynx to the stomach by the peristaltic movement. Peristalsis is a rhythmic movement of contraction followed by relaxation of the muscles of the gastrointestinal tract. As the bolus reaches the end of the esophagus, lower esophageal sphincter relaxes and the bolus enters the stomach.

Deglutition Reflex

Deglutition begins as a voluntary act but becomes involuntary during the pharyngeal and esophageal stages. This is because of the activation of the deglutition center.

Applied Physiology

- Due to inefficiency of the lower esophageal sphincter, there is reflux of the gastric contents into the esophagus. In healthy persons, it is called gastroesophageal reflux. If it is too frequent, it is called gastroesophageal reflux disease.
- It can also cause heart burn by reflux into the respiratory tract causing choking during sleep, mimicking angina pain.
- Persistent gastroesophageal disease may lead to Barrett's esophagitis which can eventually progress to esophageal cancer.
- If the lower esophageal sphincter fails to relax properly, the bolus of the food is held up in the esophagus, a condition known as achalasia.

SPEECH

The development of higher centers in humans is reflected in the ability to communicate with each other not seen in any other species. It is an art that requires both sensory analysis as well as motor control.

Speech is the main pillar of communication that has two aspects:

1. *Sensory aspect*: Language input involving ears and eyes.
2. *Motor aspect*: Language output involving vocalization and its control.

Sensory Aspect

Destruction of portions of auditory or visual association areas in the cortex results in inability to understand the written or spoken word and may lead to word blindness or word deafness—dyslexia.

Motor Aspect

It includes:

- Formation of thoughts in mind with choice of words to be used
- Motor control of vocalization.

The centers associated with speech are Broca's area (speech production), Wernicke's area, angular gyrus, (primary auditory area, primary visual area).

Sounds are produced in the larynx initially with the help of abdominal, thoracic and laryngeal muscles. Final meaningful speech is produced in the pharyngeal, oral and nasal cavities by the activities of organs such as the lips, tongue and soft palate.

Classification of Sounds

Sounds may be:

- Voiced (i.e. vocal folds in the larynx vibrate for sound production)
- Breathed (i.e. vocal folds do not vibrate)

Two main groups of speech sound are:

1. Vowels
2. Consonants

Vowels

All vowels are voiced, produced without interruption of air flow, are modified by resonance and are created by high amplitude waves.

Consonants

Produced when air is impeded before it is released. They may be voiced (e.g. b, d, z) or breathed (e.g. p, t, s) and are of low amplitude.

Classified based on:
1. Place of articulation
2. Manner of articulation.
   - Place of articulation
     - Bilabial (e.g. *b, p, m*) two lips are used.
     - *Labiodental*: Lower lip meets maxillary incisors (e.g. *f, v*)
     - *Linguodental*: Tip of tongue contacting incisors and hard palate (e.g. *d, t*)
     - *Linguopalatal*: Tongue meets palate away from incisor (e.g. g, k)
     - Glottal sound.
   - Manner of articulation
     - *Plosives (p, b, t, d, g, k)*: Require complete stoppage of air
     - *Fricatives (f, v, th)*: Require only partial stoppage
     - *Affricatives (c, h, j)*: Although involves partial stoppage require rapid release of air.

BIBLIOGRAPHY

1. Ahlgren J. Mechanisms of mastication. Acta Odontol Scand. 1966;24:109.
2. Beyron H. Occlusal relations and mastication in Australian aborigines. Acta Odont Scand. 1964;22:597.
3. Hickey JC. Mandibular movement in three dimension, J Prosthet Dent. 1963;13:72.
4. Hjortsjo CH. The mechanism of temporomandibular joint. Acta Odont Scand. 1953;11:5.
5. Lavelle Applied Oral Physiology, 2nd edn. London: Wright Butterworths and Copublications; 1988.
6. McNamara JA. The independent function of the heads of the lateral pterygoid muscle. Am J Anat. 1973;138:197.
7. Owall B, Moller E. Tactile sensibility during chewing and biting. Odont Revy. 1974;25:327.
8. Posselt U. The physiology of occlusion and rehabilitation. Oxford: Blackwell; 1963.

MULTIPLE CHOICE QUESTIONS

1. The stylomandibular ligament of TMJ is attached:
   a. Above to the lateral surface of the styloid process
   b. Below the angle and posterior border of the ramus of the mandible
   c. Both of the above
   d. None of the above
2. Which of the following is incorrect regarding the ligaments of the TMJ?
   a. Stylomandibular ligament is attached above to the lateral surface of the styloid process
   b. Sphenomandibular ligament is attached superiorly to the spine of mandibular foramen.
   c. Lateral ligament is attached to articular tubercle
   d. Fibrous capsule is attached below to the articular tubercle
3. The TMJ gets its blood supply from:
   a. Braches from superficial temporal and maxillary arteries
   b. Braches from mandibular arteries
   c. External carotid artery
   d. Mental artery
4. TMJ gets its innervations from:
   a. Auriculotemporal nerve
   b. Masseter nerve
   c. Both of the above
   d. None of the above
5. The muscle responsible for protrusive movement of the mandible:
   a. Lateral pterygoid muscle
   b. Medial pterygoid muscle
   c. Temporalis muscle and masseter muscle
   d. Both a and b
6. Elevation of the mandible is brought about by:
   a. Masseter muscle
   b. Temporalis muscle
   c. Medial pterygoid muscle
   d. All of the above
7. Retrusive mandibular movement is produced by:
   a. Posterior fibers of temporalis
   b. Masseter muscle
   c. Medial pterygoid muscle
   d. Lateral pterygoid muscle
8. Left lateral mandibular movement is produced by:
   a. Left lateral pterygoid and right medial pterygoid muscles
   b. Right lateral pterygoid muscle left medial pterygoid muscles
   c. Lateral pterygoid muscle only
   d. Medial pterygoid muscle only
9. Depression of the mandible is produced by:
   a. Mainly the lateral pterygoid muscle
   b. Diagastric, geniohyoid and mylohyoid muscles
   c. Both of the above
   d. None of the above
10. Which of the following muscle is not a antigravity muscle?
    a. Masseter muscle
    b. Temporalis muscle
    c. Medial pterygoid muscle
    d. Lateral pterygoid muscle

Answers

1. c	2. d	3. a	4. c	5. d	6. d	7. a	8. a	9. c	10. d

SECTION

7

Occlusion

CHAPTER

21

Occlusion

The term occlusion has both static and dynamic aspects. *Static* refers to the form, alignment and articulation of teeth within and between dental arches and the relationship of teeth to their supporting structures. *Dynamic* refers to the function of the stomatognathic system as a whole comprising-teeth, supporting structures, temporomandibular joint, neuromuscular and nutritive systems.

Several concepts of an "ideal" or optimal occlusion of the natural dentition have been suggested by Angle, Schnyler, Beyron, D'Amico, Friel, Hellman, Lucia, Stallard Stuart and Ramfjord and Ash. These concepts stress to varying degrees, the static and/or functional characteristics of an occlusion.

TERMS COMMONLY USED IN DISCUSSIONS ABOUT OCCLUSION AND MALOCCLUSION

Ideal Occlusion

It is a pre-conceived theoretical concept of occlusal structural and functional relationships that include idealized principles and characteristics that an occlusion should be.

Normal Occlusion

Normal occlusion is a class I relationship of the maxillary and mandibular 1st molars in centric occlusion. Normal occlusion is an absence of large or many facets, bone loss, closed vertical dimension, crooked teeth, bruxing habit, loose teeth and freedom from joint pain.

Physiological Occlusion

Physiologic occlusion refers to an occlusion that deviates in one or more ways from ideal yet it is well adapted to that particular environment, is esthetic and shows no pathologic manifestations or dysfunctions.

Functional Occlusion

Functional occlusion is defined as an arrangement of teeth which will provide the highest efficiency during the excursive movements of the mandible which is necessary during function.

Balanced Occlusion

An occlusion in which balanced and equal contacts are maintained throughout the entire arch during all excursions of the mandible.

Unilateral Balanced Occlusion

It is an occlusal relationship in which all posterior teeth on a side contact evenly as the jaw is moved towards that side.

Bilateral Balanced Occlusion

It is an occlusal relationship in which all of the posterior teeth contact on the working side and one or more teeth contact simultaneously on the balancing side.

Therapeutic Occlusion

It is an occlusion that has been modified by appropriate therapeutic modalities in order to change a non-physiological occlusion to one that is at least physiologic if not ideal.

Traumatic Occlusion

Traumatic occlusion is an abnormal occlusal stress which is capable of producing or has produced an injury to the periodontium.

Trauma from Occlusion

It is defined as periodontal tissue injury caused by occlusal forces through abnormal occlusal contacts.

Centric Occlusion

It is the maximum intercuspation or contact attained between maxillary and mandibular posterior teeth.

Centric Relation Occlusion

Centric relation occlusion (when centric relation and centric occlusion coincide) is the simultaneous even contact between maxillary and mandibular teeth into maximum interdigitation with the mandible in centric relation (most retruded position).

Centric Relation

Centric relation is the most posterior position of the mandible relative to the maxilla at a given vertical dimension.

Vertical Relation of Occlusion

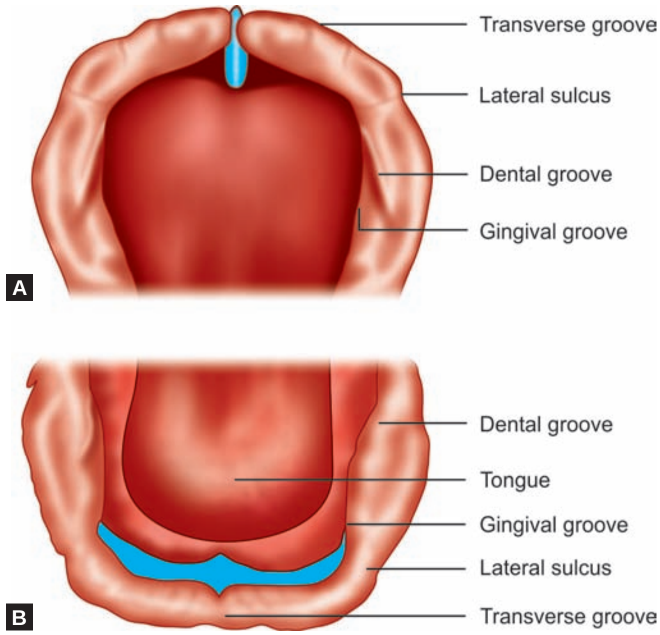
Vertical relation (or vertical dimension) of occlusion is the amount or separation between mandible and maxilla when teeth are in natural maximum contact (centric occlusion).

Deflective Malocclusion

The mandible is deflected forward and to the left in any contact of opposing teeth which guide or direct the mandible away from centric relation, either forward or to one side or both, as the teeth slide together into centric occlusion.

Canine Protected Occlusion

It is an occlusal relationship in which the vertical overlap of the maxillary and mandibular canine produces a disclusion of all the posterior teeth when the mandible moves to either side.



Figures 21.1A and B The gum pads: (A) Maxillary; (B) Mandibular

DEVELOPMENT OF OCCLUSION

Dental occlusion undergoes significant changes from birth until adulthood and beyond. This continuation of changes in the dental relationship during various stages of the dentition can be divided into four stages:

1. *Gum pads stage*: 0 to 6 months.
2. *Deciduous dentition*: 6 months to 6 years.
3. *Mixed dentition*: 6 to 12 years.
4. *Permanent dentition*: 12 years and beyond.

Gum Pad Stage (0–6 Months)

The jaws are devoid of teeth at birth. Gum pad stage extends from birth up to the eruption of first primary tooth usually the lower central incisors at around six months of age. The gum pads are pink in color and firm in consistency. The maxillary gum pad is horse shoe shaped, and the mandibular gum pad is U/square shaped (**Figs 21.1A and B**).

The gum pads develop in two portions, buccal and lingual portions which are separated by the *dental groove*. The gum pads in both the arches show certain elevations and grooves that outline the portion of the various primary teeth that are still developing in the alveolar ridges. These grooves are called as *transverse grooves*. The prominent transverse groove separating canine and first deciduous molar segments in both the arches is called the *lateral sulcus*. The lateral sulci are often used to judge the inter-arch relationship at a very early stage. The *gingival groove* separates the maxillary and mandibular gum pads from the palate and floor of the mouth respectively.

Characteristic Features of Gum Pad Stage

- *Infantile open bite*: Usually the anterior segment of the upper and lower gum pads do not approximate each other with a space created between them, while the posterior segment occlude with each other at molar region (**Fig. 21.2**). The tongue is positioned in this space between the upper and lower gum pads during suckling. This infantile open bite is transient and gets self corrected with the eruption of deciduous incisors.
- *Complete overjet*: The maxillary gum pad is usually larger, and overlaps the mandibular gum pad both horizontally and vertically with a complete overjet all around. In this way the opposing surface of the pads provide for a very efficient way of squeezing milk during breastfeeding.
- *Anteroposterior relationship*: In general, the mandibular lateral sulcii are more posterior to the maxillary lateral sulcii.
- *Precocious eruption of primary teeth*: Natal and neonatal teeth.

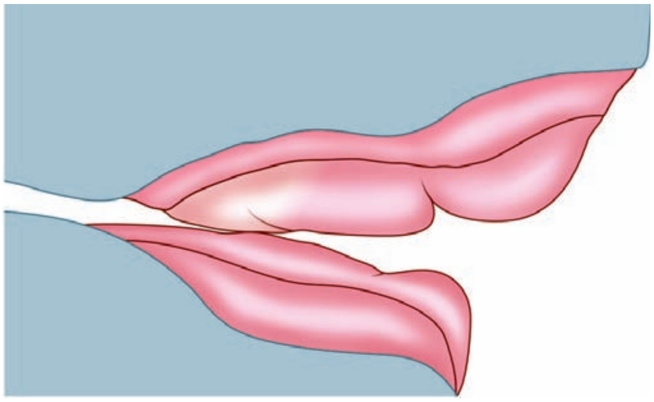


Figure 21.2 Relationship between upper and lower gum pads in infants

Figure 21.3 Natal tooth in a newborn child

Usually, jaws are devoid of teeth at birth. However, occasionally infant are born with one/two erupted teeth, usually the mandibular incisors. Such teeth present at birth are called as *natal teeth* (**Fig. 21.3**). Teeth that erupt within 30 days of life are called as the *neonatal teeth*. Familiar tendency is observed in this condition and such premature eruption of tooth may cause problems during feeding. It is advised to retain them unless they are too mobile.

Deciduous Dentition Stage (6 Months to 6 Years)

The deciduous dentition stage spans from the time of eruption of primary teeth until the eruption of the first permanent tooth around 6 years of age.

Eruption Chronology of Primary Teeth

Eruption of the primary teeth begins by 6 months of age when primary mandibular incisors erupt into oral cavity (**Fig. 21.4**). Eruption of all the primary teeth is generally complete by two and half years by which age, the deciduous dentition is in full function. Root formation of primary teeth is usually completed by three years of age.

Although considerable variation is seen in the eruption timing of deciduous teeth, there appears to be no significant gender differences. The chronology of primary teeth is presented in Table 3.1.

The sequence of eruption of primary teeth may also show some variation. However, in most of the cases, the lower central incisors are the first teeth to erupt, followed by the upper central incisors. Usually, the lateral incisor, 1st molar and canine tend to erupt earlier in maxilla than in the mandible. Deciduous dentition generally shows the following order of eruption:

	AB		D	C		E
A		B	D		CE	

Figure 21.4 Deciduous dentition stage is usually heralded by eruption of mandibular central incisors

- Central incisors
- Lateral incisors
- 1st molars
- Canines
- 2nd molars

By three years of age, the occlusion of deciduous dentition is completely established and dental arches remain relatively constant with no significant changes up to six years of age.

Characteristics of Occlusion of Deciduous Dentition

Interdental Spacing

Interdental spacing, when present in permanent dentition is considered abnormal. However, presence of interdental spacing is an important and normal feature of deciduous dentition (**Figs 21.5A to C**), which is required for the accommodation of larger permanent teeth at a later stage.

Spaces present between deciduous teeth is often referred to as *physiologic or developmental spaces*. Sufficient interdental space is needed for the permanent teeth to erupt into an uncrowded position and for establishment of their proper alignment. Malocclusion with crowding of teeth can be expected in case of unspaced primary dentition (**Figs 21.6A to C**). Leighton BC (1969) has given the probability of crowding of permanent dentition based on the amount of interdental spacing available in the primary dentition (**Table 21.1**).

Physiologic/developmental spacing in deciduous dentition include:

- Generalized spacing between teeth
- Primate spaces.

Figures 21.5A to C Presence of interdental spacing in primary dentition is physiologic and a desirable feature which aids in accommodation of larger successor teeth. Figure shows adequate physiologic spacing in a 4-year-old child

Figures 21.6A to C Insufficient interdental spacing in a 5-year-old child. Inadequate interdental spacing in primary dentition often leads to crowding in permanent dentition

Generalized spacing: According to Foster (1982), generalized spacing occurs in almost 75 percent of the individuals in the primary dentition stage. Generalized spacing between the teeth are seen in both the dental arches and helps in accommodation of larger successor teeth.

Primate spaces/anthropoid spaces/simian spaces: In addition to the generalized spacing, localized spacing are often present mesial to the upper canine and distal to the lower canine. Such spaces, originally described by Lewis and Lehman (1929), are a normal feature of the permanent dentition in the higher apes (primates) and in the human primary dentition are usually referred to as the anthropoid spaces. Anthropoid spaces appear to be a more constant feature of deciduous dentition *(***Fig. 21.7***)*.

Significance of Anthropoid Spaces

Following eruption of primary 1st molars, when canine teeth erupt and reach occlusion, the primate spaces facilitate proper interdigitation of the opposing canines into class I canine relationship.

Table 21.1 Probability of crowding of permanent teeth based on available spaces between primary teeth—Leighton BC (1969)

Space in primary teeth	*Chances of crowding of permanent teeth*
> 6 mm	None
3–5 mm	1 in 5
> 3 mm	1 in 2
No spacing	2 in 3
Crowded primary teeth	1 in 1

Incisor Relationship

Incisor relationship in deciduous dentition normally shows:
- Increased overbite (deep bite)
- Increased overjet.

Deepbite

An increased overbite is usually seen in the initial stages of development with the deciduous mandibular incisors contacting the cingulum area of the deciduous maxillary incisors in centric occlusion (**Figs 21.8A to C**). Deep bite may be due to the fact that the primary incisors are more vertically placed than the permanent incisors.

Figures 21.7 Primate/anthropoid/simian spaces: Developmental spaces present mesial to upper canines and distal to lower canines

Figures 21.8A to C Increased overbite (deep bite) is a normal feature of deciduous dentition. It may be due to the fact that the primary incisors are more vertically placed than the permanent incisors

The ideal position of the deciduous incisors has been described as being more vertical than the permanent incisors, with a deeper incisal overbite.

This deepbite later gets self-corrected by:

- Attrition of incisors
- Eruption of deciduous molars
- Differential growth of the alveolar processes of the jaws.

Increased Overjet

Excessive incisal overjet is often observed in deciduous dentition. About 72 percent of children exhibited an increased overjet in a study conducted by Foster. Excessive overjet usually gets corrected later by the forward growth of the mandible.

Molar Relationship

The anteroposterior molar relationship in deciduous dentition is described in terms of the *terminal planes*. The terminal planes are the distal surfaces of the maxillary and mandibular second primary molars.

Moyers described three possible kinds of primary molar relationships (**Figs 21.9A to C**):

1. Straight/Flush terminal plane
2. Mesial step
3. Distal step.

Flush Terminal Plane

In straight/flush terminal plane, the distal surfaces of the maxillary and mandibular deciduous molars are in same vertical plane (**Fig. 21.9A**).

It is of significance to note that, the mandibular second primary molar has a greater mesiodistal diameter than the maxillary 2nd molar. This difference in the dimensions makes the distal surfaces of both maxillary and mandibular deciduous 2nd molars to fall in same vertical plane in centric occlusion. Such an arrangement is called as *flush terminal plane*. Flush terminal plane is considered to be the ideal kind of molar relationship in the primary dentition.

Mesial step: In this terminal plane relationship, the distal surface of the mandibular deciduous 2nd molar is more mesial to the distal surface of the maxillary deciduous 2nd molar (**Fig. 21.9B**).

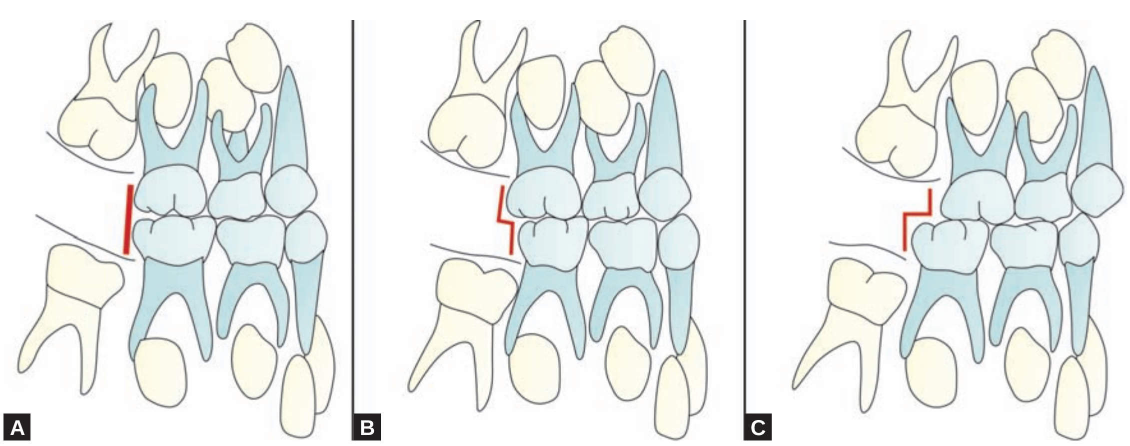
Distal step: Here, the distal surface of the mandibular deciduous 2nd molar is more distal to the distal surface of the maxillary deciduous 2nd molar. In other words, the maxillary 2nd deciduous molar is ahead of the mandibular 2nd deciduous molar (**Fig. 21.9C**).

Significance of Terminal Plane Relationship

Determining the terminal plane relationships in the primary dentition stage is of great importance, because the erupting first permanent molars are guided by the distal surfaces of the 2nd primary molars as they erupt into occlusion. Thus, the terminal plane relationship of primary dentition largely determines the type of molar relationship in the permanent dentition.

Mixed Dentition Stage (6–12 Years)

Mixed dentition stage is a transition stage when primary teeth are exfoliated in a sequential manner, followed by the eruption of their permanent successors. This stage spans from 6 to 12 years of age, beginning with the eruption of the first permanent tooth, usually a mandibular central incisor or a 1st molar. It is completed at the time the last primary



Figures 21.9A to C Terminal plane relationships: (A) Flush/straight terminal plane—the distal surfaces of maxillary and mandibular 2nd deciduous molars are in same vertical plane; (B) Mesial step—distal surface of mandibular deciduous 2nd molar is more mesial to the distal surface of the maxillary deciduous 2nd molar (mandibular primary 2nd molar is ahead of the maxillary deciduous 2nd molar); (C) Distal step—Maxillary 2nd deciduous molar is ahead of the mandibular 2nd deciduous molar

tooth is shed. Significant changes in occlusion are seen in mixed dentition period due to the loss of 20 primary teeth and eruption of their successor permanent teeth. Most malocclusions are developed at this stage.

Mixed dentition stage can be divided into the following phases:

- Early/1st transitional period
- Inter transitional period
- Late/2nd transitional period.

Early Transitional Period (6–8 Years)

Early transitional period is concerned with the replacement of the primary incisors by their successors and the addition of four permanent molars to the dentition.

This usually occurs in the age range of 6 to 8 years.

Emergence of the First Permanent Molars

The first permanent molars erupt at six years of age with mandibular molar preceding the maxillary in most cases. The 1st molars are considered to play an important role in the establishment of occlusion in the permanent dentition, and class I molar relationship is considered as the normal anteroposterior molar relationship. The location and relationship of first permanent molars is influenced by the presence of interdental spacing and the terminal plane relationship of the primary dentition.

The erupting first permanent molars are guided by the distal surfaces of the second primary molars as they erupt into occlusion. Thus, the terminal plane relationship of primary dentition largely determines the type of molar relationship in the permanent dentition, among other factors.

The possible effects of terminal plane relationship on permanent dentition are described in **Figure 21.10**.

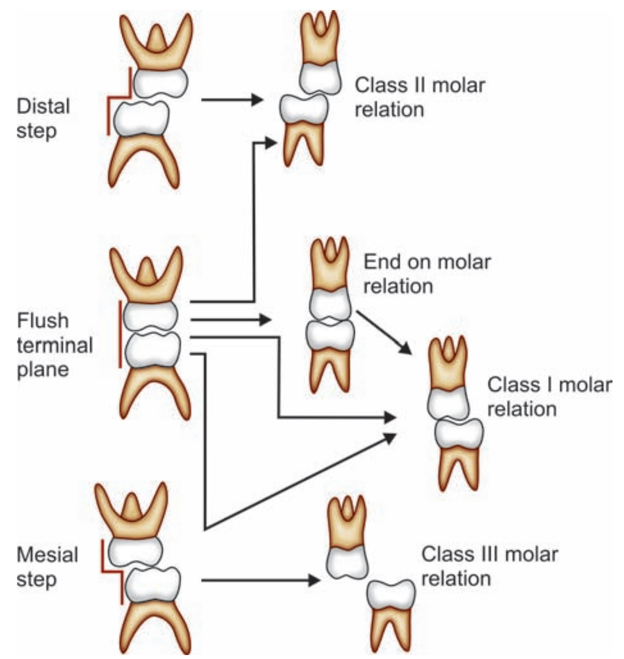


Figure 21.10 The possible effects of terminal plane relationship on permanent dentition

Effects of flush terminal plane: Flush terminal plane usually develops into class I molar relationship in the permanent dentition. Some cases of flush terminal plane may also develop into class II molar relationship when forward mandibular growth is not sufficient.

In the presence of flush terminal plane, the first permanent molars initially assume a cusp-to-cusp or end-on molar relationship as they erupt distal to the second primary molars. The lower first permanent molar has to move 2 to 3 mm anteriorly in relation to the upper first permanent molar in order to transform the end-on relation to class I molar relation. This transformation from end-on to class I molar relation occurs in two ways designated as *early and late mesial shifts*.

Early mesial shift: Early mesial shift of lower permanent molar occurs by utilization of the physiologic spaces present between primary molars and the spaces. The eruptive force of permanent molars push the deciduous molars forward into the spaces, there by establishing class I molar relationship. As this change occurs in early mixed dentition, the shift is called the 'Early mesial shift' (**Figs 21.11A and B**).

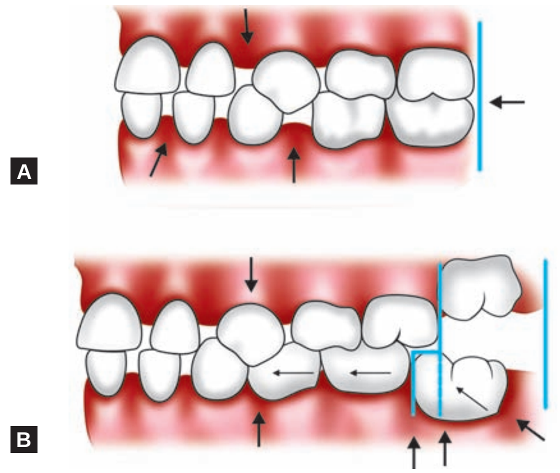
Late mesial shift: In the absence of sufficient developmental spaces in primary dentition, the erupting permanent 1st molars may not be able to establish class I relationship in early mixed dentition period. In such cases, class I molar relationship can be established following the exfoliation of primary 2nd molars; by utilizing leeway space (Leeway space is explained later in this chapter). As this occurs in late mixed dentition, it is called as the 'Late mesial shift' (**Fig. 21.12**).

Effects of mesial step: When deciduous 2nd molars are in mesial step, the first permanent molars directly erupt into class I molar relationship. Few cases may also progress to class III molar relations if forward growth of the mandible persists.

Effects of distal step: Distal step in primary dentition usually leads to Angle's class II molar relationships in the permanent dentition. A few cases may go into class I molar relationship.

Eruption of Permanent Incisors

Permanent incisors erupt lingual to the primary incisors and mandibular central are often the first to erupt. How the larger permanent incisor teeth are accommodated is described here.



Figures 21.11A and B Early mesial shift: Erupting lower permanent 1st molars shift mesially utilizing the primate spaces in early mixed dentition period to establish class I molar relationship

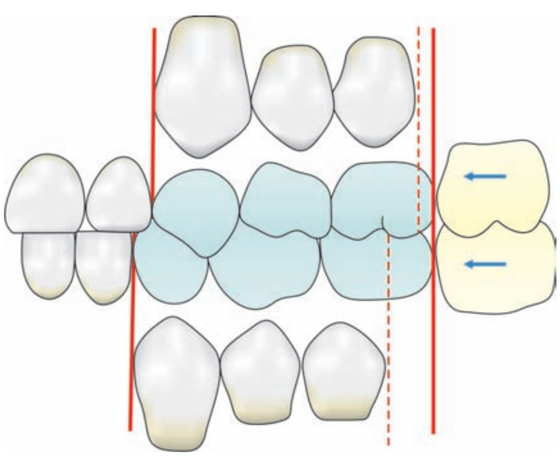


Figure 21.12 Late mesial shift: In case of primate space deficiency, class I molar relationship can be achieved in late mixed dentition period following exfoliation of primary 2nd molars, utilizing the leeway space

INCISAL LIABILITY

It can be readily appreciated that, the mesiodistal crown dimensions of permanent incisors is considerably greater than that of the primary incisors. This difference in the mesiodistal crown dimension between the primary and permanent incisors is termed as *incisal liability* by Warren Mayne.

According to the average tooth size given by Black:

- Incisal liability in maxillary arch is about 7.6 mm, i.e. the maxillary permanent incisors are larger than their predecessors by 7.6 mm.
- Incisal liability in mandibular arch is about 6.0 mm, i.e. mandibular permanent incisors are 6.0 mm larger than their predecessors.

Thus, the amount of space available in the arch following exfoliation of the primary incisors is for less than the amount of space needed for accommodation of their permanent successors. Some degree of transient crowding may occur due to incisal liability at about 8 to 9 years of age, and persist until the emergence of canines when the space for teeth may again adequate.

During the course of mixed dentition period, nature makes some adjustments to achieve the fit and maintain the dynamic balance. The incisal liability is overcome the following factors:

- *Utilization of interdental spacing between primary anteriors:* Incisal liability is partly compensated by the developmental spaces that exist in the primary dentition. Anterior crowding of permanent dentition may develop in the absence of interdental spacing.
- *Increase in the inter-canine arch width:* Continuing growth of the jaws often results in an increase in the inter-canine arch width during the mixed dentition period. This may significantly contribute to accommodation of the bigger permanent incisors in the arches.
- *Change in incisor inclination:* As stated previously, the deciduous incisors are more vertically positioned than the permanent incisors. Permanent incisors exhibit a more labial inclination which tends to increase the dental arch perimeter. The change in the labiolingual inclination of incisors also contributes to overcome the incisal liability by adding 2 to 3 mm to the arch (**Fig. 21.13**).

Intertransitional Period

After permanent 1st molars and incisors establish occlusion, there is an interim period of 1 to 2 years before the commencement of 2nd transitional period in which little changes in the occlusion is seen. This phase of mixed dentition stage is relatively stable with only minor changes taking place and is referred to as inter-transitional period.

Second Transitional Period (10–13 Years)

The second transitional period involves replacement of molars and canines by the premolars and permanent canines respectively, and the emergence of permanent 2nd molars. Exfoliation of mandibular primary canine at around 10 years of age usually makes the beginning of second transitional period.

Eruption of Permanent Canines

Mandibular canine erupts following the eruption of the incisors at around one year, while the maxillary canine usually erupts after the eruption of one or both the premolars, around 12 to 13 years.

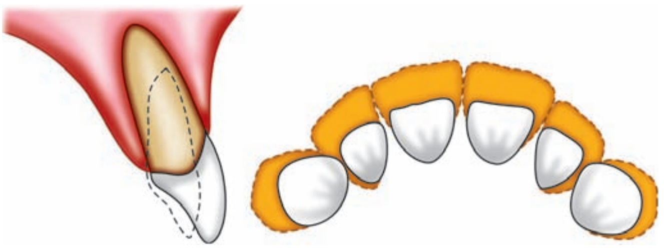


Figure 21.13 Relationship of primary and permanent incisors over basal plane: Deciduous incisors are vertically placed over basal bone while permanent incisors exhibit more labial inclination that tends to increase the dental arch perimeter

UGLY DUCKLING STAGE

A transient malocclusion is often observed to develop in the maxillary anterior region during 8 to 12 years of age. This corresponds to the eruption of permanent maxillary canines. Clinicians need to recognize it as a self-correcting malocclusion and the anxious parents and children may have to be reassured. The courses of events in the development of ugly duckling stage are as follows (**Figs 21.14A to C**):

The upper canines develop palatally, but migrate labially to come to lie slightly labial and distal to the root apex of the lateral incisors

↓

Thus erupting canines apply pressure on the apices of lateral incisors

↓

Roots of lateral incisors get displaced mesially with resultant distal tilting their crowns

↓

Mesially displaced roots of lateral incisors then apply pressure on the roots of maxillary central incisors

↓

Roots of maxillary central incisors also get displaced mesially with the resultant divergence of their crowns

↓

Creation of midline diastema

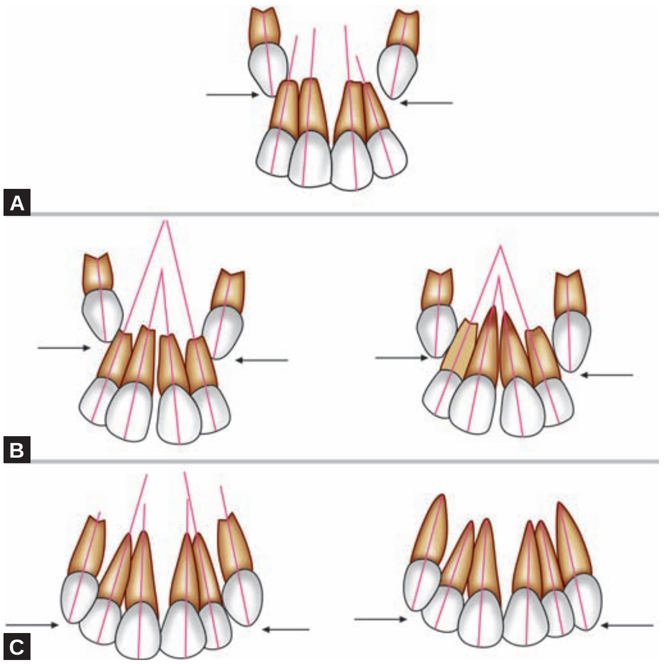
↓

Ugly duckling stage

Broadbent described this stage of development as the ugly duckling stage as the children appears ugly with crooked teeth during this phase of development. The condition resolves by itself as the continuously erupting canines shift the pressure from roots of lateral incisors to their crowns. By the time canines are fully erupted the midline diastema is closed and laterals are realigned along the arch.

Eruption of the Premolars

The important portion of the dental arch in the development of occlusion is the premolar segment. This is because the erupting premolars are significantly smaller in mesiodistal dimension than the primary molars which they replace. Thus, major changes in occlusion are observed during the premolar emergence.



Figures 21.14A to C Ugly duckling stage: A transient malocclusion observed during 8 to 12 years corresponds to eruption of permanent maxillary canines and resolves after their complete eruption. It requires no treatment

LEEWAY SPACE OF NANCE

In general, the combined mesiodistal crown dimension of the primary canine and primary 1st and 2nd molars are larger than the combined mesiodistal crown dimension of their successor namely, permanent canine and 1st and 2nd premolars. The amount of space gained by their difference in the posterior segments is termed as the leeway space of *Nance* and is present in both the arches (**Fig. 21.15**).

Measurement of leeway space for maxillary and mandibular arches is given here.

In maxilla

- Leeway space in maxilla in each quadrant is about 0.9 mm
- The total leeway space in maxilla is 1.8 mm.

In mandible

- Leeway space in each quadrant of the mandible is about 1.7 mm
- The total leeway space in the mandible is 3.4 mm.

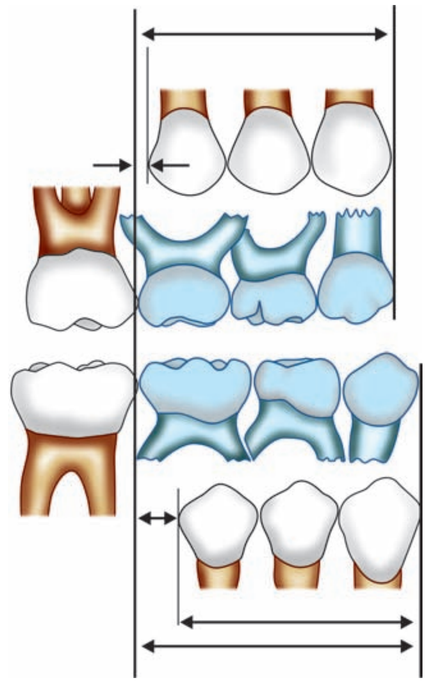


Figure 21.15 Leeway space of Nance: Space gained by the difference between the mesiodistal widths of primary canine, molars and permanent canine and premolars. Relatively greater space gained in the mandibular arch helps in establishment of class I permanent molar relationship

Significance of Leeway Space of Nance

- Presence of excessive leeway space is a favorable feature, which provides for the mesial movement of the permanent molars.
- Leeway space in the mandibular arch is more than that of the maxillary arch. This is because the primary mandibular molars are wider than the primary maxillary molars. The leeway space differential between the two arches cause the mandibular 1st premolar to move mesially relatively more than the maxillary 1st premolar. Such an arrangement causes a change in the molar relationship from end—on in the early mixed dentition period to class I relation at the late mixed dentition period (late mesial shift).
- Leeway space deficiency may be seen in some individuals when size of unerupted premolars and permanent canine are larger than the space available.

Eruption of Permanent 2nd molars

Emergence of 2nd permanent molars ideally should follow the eruption of the premolars. If the 2nd molars erupt before the premolars erupt fully, a significant shortening of the arch perimeter occurs and malocclusion may be more likely to occur.

Change in the Anteroposterior Molar Relationship in Mixed Dentition

To begin with newly erupted permanent 1st molar occlude in a cusp-to-cusp relation especially when deciduous dentition exhibit flush terminal plane. End-on molar relationship is considered normal in early mixed dentition stage, changes to class I molar relationship which is considered normal in permanent dentition stage by the following factors:

- Leeway space of *Nance*
- Differential mandibular growth.

Differential Mandibular Growth

During growing period both the maxilla and the mandible grow downward and forward.

However, the mandible grows relatively more forward than the maxilla during this developmental stage. Such differential mandibular growth is thought to contribute to the transition from end-to-end to class I molar relationship.

Permanent Dentition Stage

Permanent dentition stage is pretty well established by about 13 years of age, with the eruption of all permanent teeth except the 3rd molars. Permanent successors develop from lingual extension of the dental lamina (successional lamina) and the permanent molar develop from the posterior extension of the dental lamina. The permanent incisors develop lingual to the primary incisors and move labially as they erupt. The premolars develop below the divergent roots of the primary molars.

Permanent dentition begins to form at birth, at which time, calcification of the 1st permanent molars becomes evident. Chronology of permanent dentition is depicted in Table 3.2.

Sequence of eruption of permanent dentition is more variable than that of the primary dentition. In addition, there are significant differences in the eruption sequences between the maxillary and the mandibular arch.

- Most common eruption sequence in maxilla:
  - 6-1-2-4-3-5-7-8
  - 6-1-2-4-5-3-7-8.
- Most common eruption sequence for mandibular arch:
  - (6-1)-2-3-4-5-7-8
  - (6-1)-2-4-3-5-7-8.

These are also the most favorable sequences for the prevention of malocclusion. It must be noted that, there is a difference in eruption timing of the canines in the two arches. In the mandibular arch, the canine erupts before the premolars, whereas in the maxillary arch the canine generally erupts after the premolars.

When 2nd molars erupt before the premolars are fully erupted significant shortening of the arch perimeter occurs, increasing the likelihood of malocclusion.

CHARACTERISTICS OF OCCLUSION IN PERMANENT DENTITION

Some of the characteristics of the normal occlusion in the permanent dentition stage are listed below:

- *Overlap*: The maxillary teeth overlap the mandibular teeth both in labial and buccal segments in centric occlusion (**Fig. 21.16**).
- *Intra-arch tooth contacts*: With the exception of the maxillary 3rd molars and mandibular central incisors, each permanent tooth occludes with two teeth from the opposite arch. In other words, each permanent tooth has two antagonistic teeth.
- *Angulations*: Permanent teeth have buccolingual and mesiodistal angulations, whereas the primary teeth are generally vertically positioned in the alveolar bone.

Figure 21.16 Maxillary teeth overlap mandibular teeth in labial as well as buccal segments in centric occlusion

- *Arch curvatures*: The anteroposterior curvature exhibited by the mandibular arch is called the curve of Spee. The corresponding curve in the maxillary arch is called the compensating curve. The buccolingual curvature from one side of the arch to the others is called the Monson curve or the Wilson curve.
- *Incisor relationship*: The vertical overlap between maxillary and mandibular incisors called *overbite* is about 1 to 2 mm, and the horizontal overlap called the *overjet* is generally between 1 and 3 mm (**Figs 21.17A and B**).

Molar Relationship

In permanent dentition stage the class I molar relationship is the ideal relationship. In class I molar relationship the mesiobuccal cusp of the maxillary 1st molar is in the buccal groove of the mandibular 1st molar (**Figs 21.18A and B**).

TYPES OF CUSPS

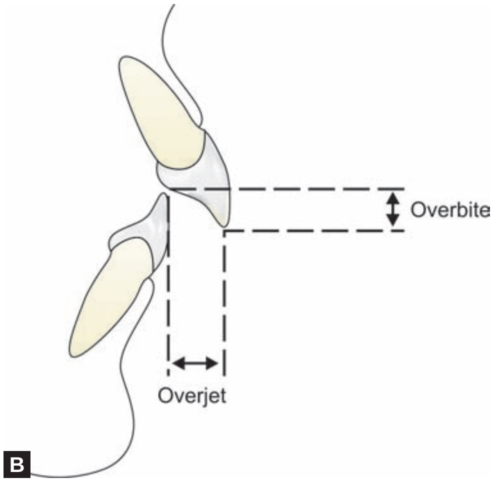
The human dentitions present two types of cusps and are as follows:

Centric Holding Cusp/Stamp Cusp/Supporting Cusp

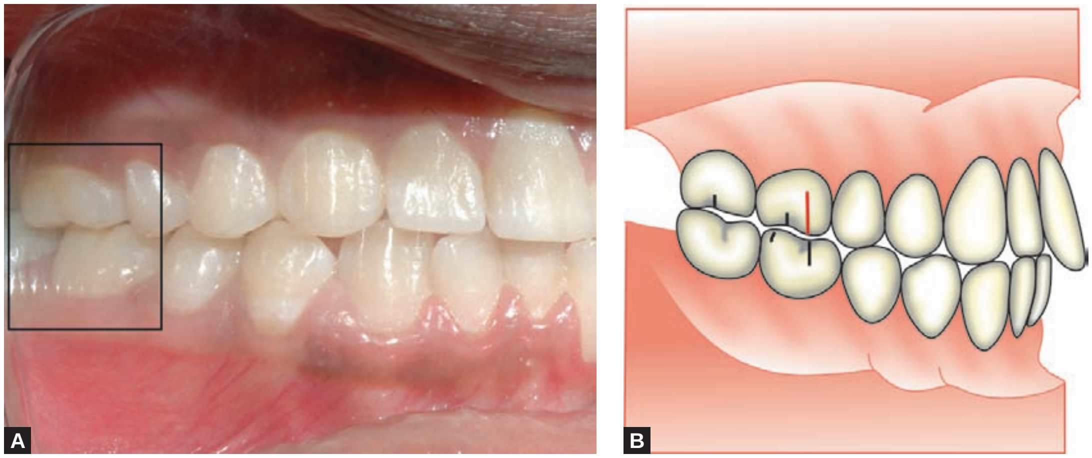
The lingual cusps of the maxillary posterior teeth and the buccal cusps of the mandibular posterior teeth are referred to as supporting cusps. Supporting cusps are also called as centric holding cusps or stamps cusps and they occlude into the central fossa and marginal ridges of opposing teeth (**Fig. 21.19**).

Guiding Cusp/Shear Cusp/Non-supporting Cusps

The buccal cusps of the maxillary posterior teeth and the lingual cusps of the mandibular posterior teeth are called non-supporting cusps. Non-supporting cusps are also called centric as guiding or shear cusps and they guide the mandible



Figures 21.17A and B Normal incisal relationship: (A) Overbite; (B) Overjet



Figures 21.18A and B Normal molar relationship

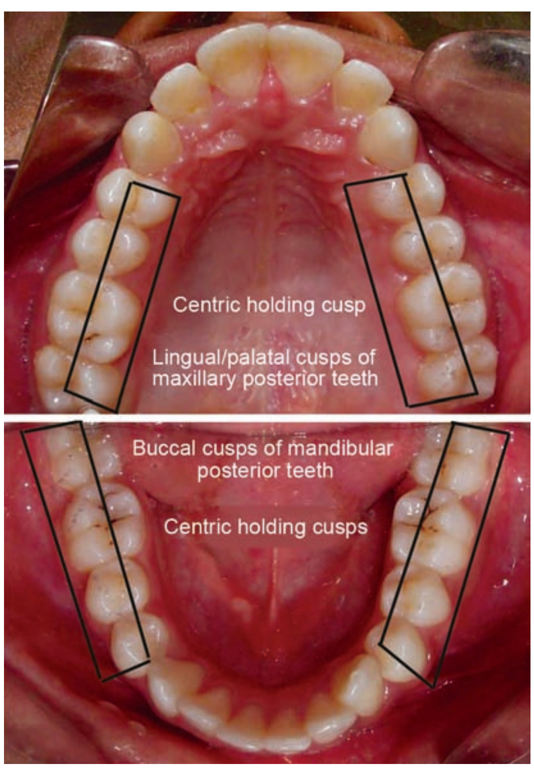


Figure 21.19 Supporting cusp/centric holding cusp /stamp cusp

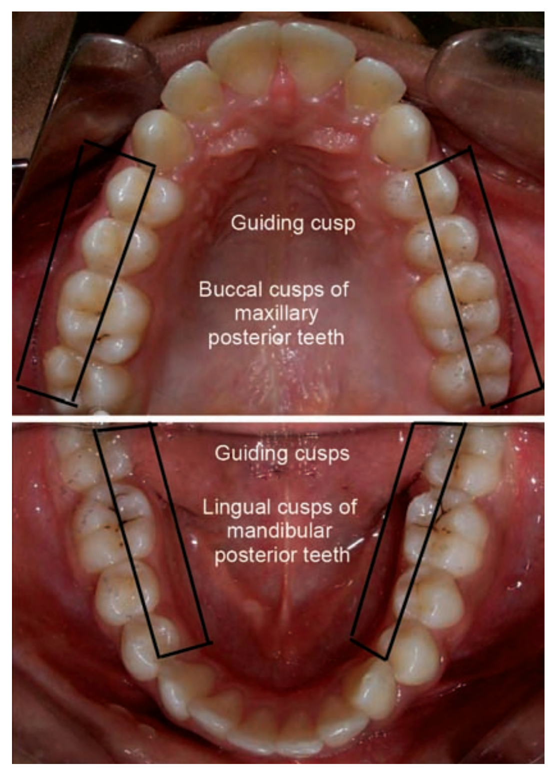


Figure 21.20 Non-supporting cusp /guiding cusp/shear cusp

during lateral excursions and shear food during mastication (**Fig. 21.20**).

CENTRIC OCCLUSAL CONTACTS

One scheme of occlusal contacts presented by Hellman included 138 points of possible occlusal contacts for 32 teeth (**Figs 21.21A and B**). Concepts of ideal occlusion are used primarily in orthodontics and even in restorative dentistry. Centric occlusal contacts are classified into anterior centric occlusal contacts and posterior centric occlusal contacts points.

Anterior Centric Occlusal Contacts

Anterior centric occlusal contacts consist the labial and lingual range of contacts of maxillary and mandibular

Figures 21.21A and B Occlusal contacts: (A) Maxillary arch; (B) Mandibular arch

anteriors and are in line with the buccal range of posterior centric contacts.

Anterior centric occlusal contacts are listed below:
- Lingual surfaces of maxillary incisors and canines; 6
- Labial surfaces of mandibular incisors and canines; 6.

Posterior Centric Occlusal Contacts

Posterior centric occlusal contacts consist of the buccal range of contacts and the lingual range of contacts of maxillary and mandibular posteriors.

Posterior centric occlusal contacts are listed below:
- Triangular ridges of lingual cusps of mandibular premolars and molars; 16
- Triangular ridges of buccal cusps of premolars and molars;16
- Buccal embrasure of mandibular premolar and molars; 8
- Lingual embrasure of maxillary premolars and molars (including the canine and 1st premolar embrasure accommodating the mandibular premolar); 10
- Lingual cusp points of maxillary premolars and molars; 16
- Buccal cusp points of mandibular premolars and molars; 16
- Distal fossae of premolars; 8
- Central fossae of the molars; 12
- Mesial fossae of the mandibular molars; 6
- Distal fossae of the maxillary molars; 6
- Lingual grooves of the maxillary molars; 6
- Buccal grooves of the mandibular molars; 6.

Cusp-fossa Occlusion

The supporting cusp of one tooth occludes in a single fossa of a single opposing tooth are referred to as cusp-fossa occlusion or tooth-to-tooth arrangement (**Fig. 21.22**).

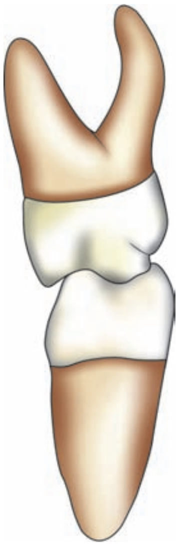


Figure 21.22 Cusp-fossa occlusion (Tooth to Tooth)

Cusp-embrasure Occlusion

When a tooth occludes with two opposing teeth are called cusp-embrasure occlusion or tooth to two teeth occlusion (**Fig. 21.23**).

TOOTH GUIDANCE

Concepts of occlusion often describe "idealized" contact relations in lateral movements. However, in the natural dentition, a variety of contact relations may be found, including group function, cuspid disocclusion only, or some combination of canine, premolar and molar contacts in lateral movements.

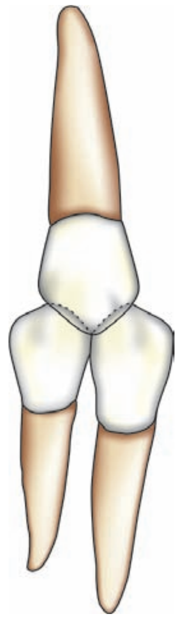


Figure 21.23 Cusp-embrasure occlusion (Tooth to Teeth)

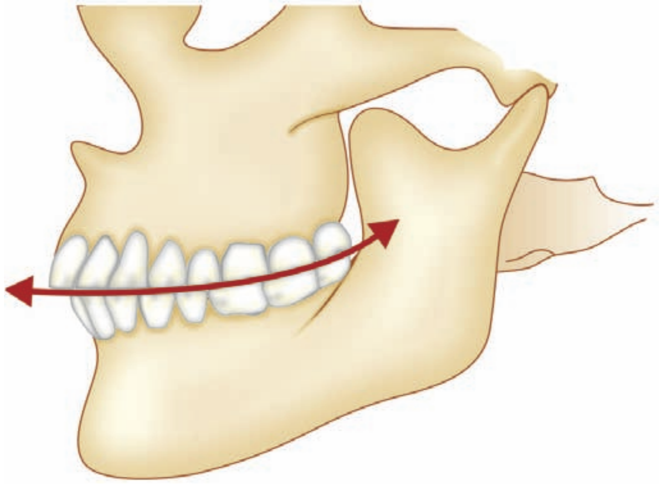


Figure 21.24 Curve of Spee

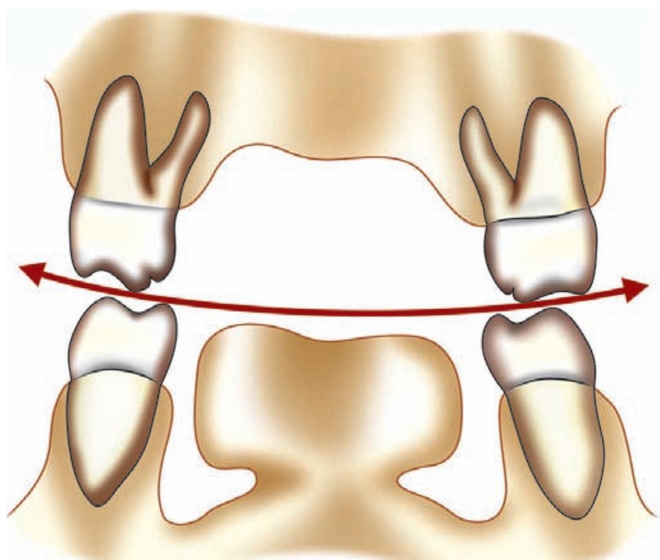


Figure 21.25 Curve of Wilson

Group Functions

Multiple contacts in lateral or eccentric mandibular movements are referred to as group functions.

Canine Guidance

Canine guidance is also called as cuspid guidance. Only maxillary and mandibular canines are in contact during lateral/eccentric mandibular movements.

Incisal Guidance

Incisal guidance refers to contact of the anterior teeth during protrusive movements of the mandible.

Condylar Guidance

Condylar guidance refers to the downward movement of both the condyles along the slopes of the articular eminence during protrusive movements leading to separation of the posteriors.

IMAGINARY OCCLUSAL PLANES AND CURVES

Curve of Spee (Anteroposterior Curve/The Curve Occlusal Plane)

When viewed from the buccal aspect, the cusp tips of posterior teeth follow a gradual concave curve anteroposteriorly (**Fig. 21.24**). The curve of the maxillary arch is convex; that of the mandibular arch is concave.

Curve of Wilson (Side-to-Side Curve)

When viewed from anterior aspect with the mouth slightly open, the cusp tips of the posterior teeth follow a gradual curve from the left side to the right side (**Fig. 21.25**). The curve of the maxillary arch is convex; that of the mandibular arch is concave. Thus, the lingual cusps of the posterior teeth are aligned at a lower level then the buccal cusps on both sides and in both arches.

BIBLIOGRAPHY

1. Bishara SE, Hoppens BJ, Jakobsen JR, Kohout FJ. Changes in molar relationship between the deciduous and permanent dentition: a longitudinal study. Am J Orthod Dentofac Orthoped. 1988;93:19.
2. Friel S. The development of ideal occlusion of the gum pads and teeth. Am J Orthodont. 1954;40:1963.
3. Howe RP, McNamara JA Jr, O'Conner KA. An examination of dental crowding and its relationship to tooth size and arch dimension. Am J Orthod. 1989;83:363.
4. McNamara JA Jr, Brudon WL. Orthodontics and dentofacial orthopedics. Ann Arbor. 2001, Needham press; 2001.
5. Morrees C, Chadha JM. Available space for the incisors during dental development-a growth study based on physiologic age. Angle Orthod. 1965;35:12.
6. Moyers RE. Handbook of Orthodontics, 3rd edn. Chicago: Yearbook; 1973.
7. Ramfjord SP, Ash MM. Occlusion. Philadelphia: WB Saunders; 1966.

MULTIPLE CHOICE QUESTIONS

1. Physiological spaces seen mesial to maxillary canine and distal to mandibular canines is:
   a. Primate space
   b. Simian space
   c. Anthropoid space
   d. All of the above
2. Mesiodistal relation between the distal surfaces of upper and lower second deciduous molars is:
   a. Flush terminal plane
   b. Mesial step
   c. Distal step
   d. Terminal plane
3. Flush terminal plane is:
   a. Normal feature of deciduous dentition
   b. Plane where distal surface of upper and lower second deciduous molar are in same plane
   c. Maxillary deciduous molar is ahead of mandibular
   d. Both a and b
4. First transition period in mixed dentition is:
   a. Characterized by emergence of first permanent molar
   b. Eruption of permanent canines
   c. None of the above
   d. All of the above
5. Shift in molars from a flush terminal plane to a Class I relation occurs by:
   a. Early shift
   b. Late shift
   c. Mesial shift
   d. Early and late shift
6. Leeway space is utilized by:
   a. Early shift
   b. Late mesial shift
   c. Mesial shift
   d. Distal shift
7. Incisal liability is:
   a. Difference in space between maxillary and mandibular incisors
   b. Difference in space between primary and permanent incisors
   c. Both a and b
   d. None of the above
8. Incisal liability is corrected by:
   a. Utilization of interdental spaces
   b. Increase in inter-canine width
   c. Change in incisor inclination
   d. All of the above
9. Incisor liability is:
   a. 7 mm in maxillary arch and 5 mm in mandibular arch
   b. 5 mm in mandibular arch and 7 mm in maxillary arch
   c. 5–7 mm in maxillary arch
   d. 5–7 mm in mandibular arch
10. Ugly duckling stage is corrected by:
    a. Eruption of permanent lateral incisors
    b. Eruption of permanent maxillary canines
    c. Eruption of permanent mandibular canines
    d. Eruption of 2nd molar

Answers

1. d	2. d	3. d	4. a	5. d	6. b	7. b	8. d	9. a	10. b

SECTION

8

Evolution of Teeth, Comparative Dental Anatomy, Forensics and Dental Anthropology

CHAPTER

22

Evolution of Teeth, Comparative Dental Anatomy and Forensic Odontology

Teeth are highly mineralized appendages found in the entrance and the alimentary canal of both invertebrates and vertebrates. The teeth are mainly associated with prehension and processing of food. However, they frequently serve other functions such as defense, display of dominance and phonetics as in humans.

This chapter gives an overview and evolution of teeth, comparative dental anatomy and forensic application of dental anatomy.

EVOLUTION OF TEETH

A huge amount of literature is devoted to the origin, evolution and organogenesis of teeth, knowledge of which help better understand the regulation of tooth development and associated pathogenesis.

Teeth can be classified into 3 types, based on where they are formed: jaw, mouth and pharyngeal. The close relationship between past and present teeth can be demonstrated by a phylogenetic analysis. Using this type of analysis, amelogenesis appears to have been duplicated from SPARC (SPARC, secreted protein, acidic, rich in cysteine), some 630,000,000 years ago.

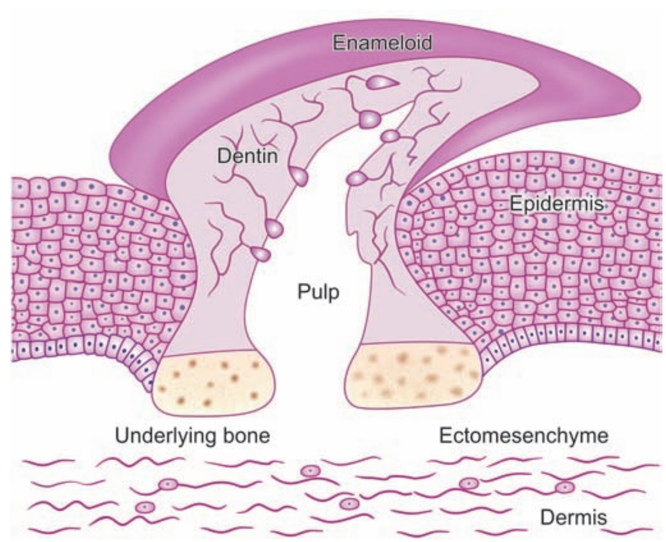


Figure 22.1 Odontodes, the ancestors of teeth, looked like placoid scales of recent sharks

There is substantial evidence to suggest that teeth evolved from scale-like epidermal structures, the *odontodes* which "migrated" into the month after enough mutations. This process is visible in modern sharks, which have *placoid scales* on the skin that grade into the teeth on the jaws.

Teeth with the basic microscopic anatomy similar to that of recent vertebrates first appeared at ordovicium, approximately 460 million years ago. Some jawless fishes developed superficial dermal structures known as *odontodes* (**Fig. 22.1**). These small tooth-like structures were located outside the mouth and served various functions, including protection, sensation and hydrodynamic advantage. Over the evolution, encroachment of odontodes into the oropharyngeal cavity created the buccal teeth, which covered the entire surface and later were localized to the jaw margins.

To begin with, teeth were of uniform conical shape (*homodont*). Over the period, dietary habits and ecological adaptations have driven the teeth of higher vertebrates to acquire numerous anatomical forms and shapes, as represented by incisors, canines, premolars and molars (*heterodont*).

It is interesting to note that there is close similarities in structure and development between the *dermal denticles/ placoid scales* and the teeth of higher vertebrates.

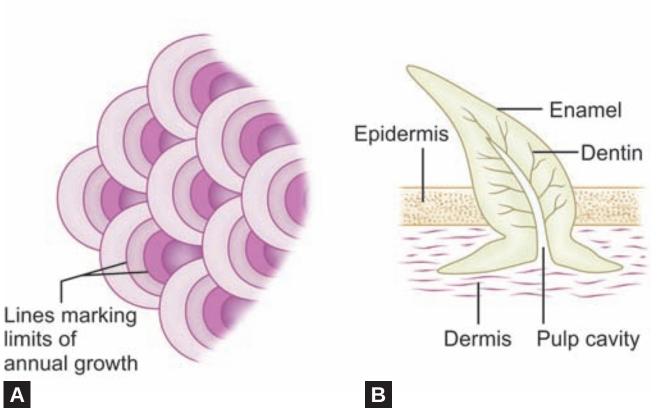
Each placoid scale when seen in vertical section consists of a base of bone like substance which is embedded in the dermis and the spine projects through the epidermis beyond the surface (**Figs 22.2A and B**). Each spine is covered on the outside with a hard transparent, shiny layer—*The enamel/ enameloid* within which is the dentin. Numerous fine canals (canaliculi) ramify through the dentin. The center of the spine is occupied by a cavity—*The pulp cavity*, in which lie blood vessels, nerves and the dentin forming cells (*odontoblasts*), the protoplasmic extensions of which are continued into the fine canals of the dentin. The pulp cavity is continued into the base and had small aperture to admit the blood vessels and nerves.

The development of placoid scale is much similar to that of teeth (**Fig. 22.3**).

The first sign of a developing scale is a condensation of mesenchymal cells in the dermis to form *dental/dermal papilla*. This becomes capped by a cone-like down growth of the epidermis. The layer next to the papilla forms a single layer of columnar cells called the *enamel organ*. The outermost cells of the papilla form collagen fibers are the organic basis of the scale. Then the organic matter between the enamel organ and the outermost layers of the dental papilla get calcified to form the *enamel/enameloid*.

The scale is then thickened by further calcification on the outside of the cone to form the *dentin*, the cells secreting it are called *odontoblasts*. But the central cavity the *pulp cavity* is left within the scale which communicates with the dermis through a small opening.

As the scale grows in size, its spine pushes up through the epidermis. As the scales get constantly worn away the new scales form, so that in a vertical section. In the skin, denticals on various stages of development can be seen.



Figures 22.2A and B (A) Dermal scales of bony fish; (B) Placoid scale of a cartilaginous fish. (e.g. Dogfish in section)

Important Changes in the Course of Evolution of Teeth

The evolutionary pathway from fish to reptiles to mammals is characterized by:

- Reduction in number of teeth (from polydonty to oligodonty)
- Reduction on generations of teeth (from polyphyodonty to di- and/or monophyodonty)
- Increase in morphological complexity of the teeth (from homodonty to heterodonty).

Evolution Favored an Increase in Teeth Complexity

Diet and mastication are regarded as central factors in teeth evolution. There is a strong correlation between teeth form and feeding habits.

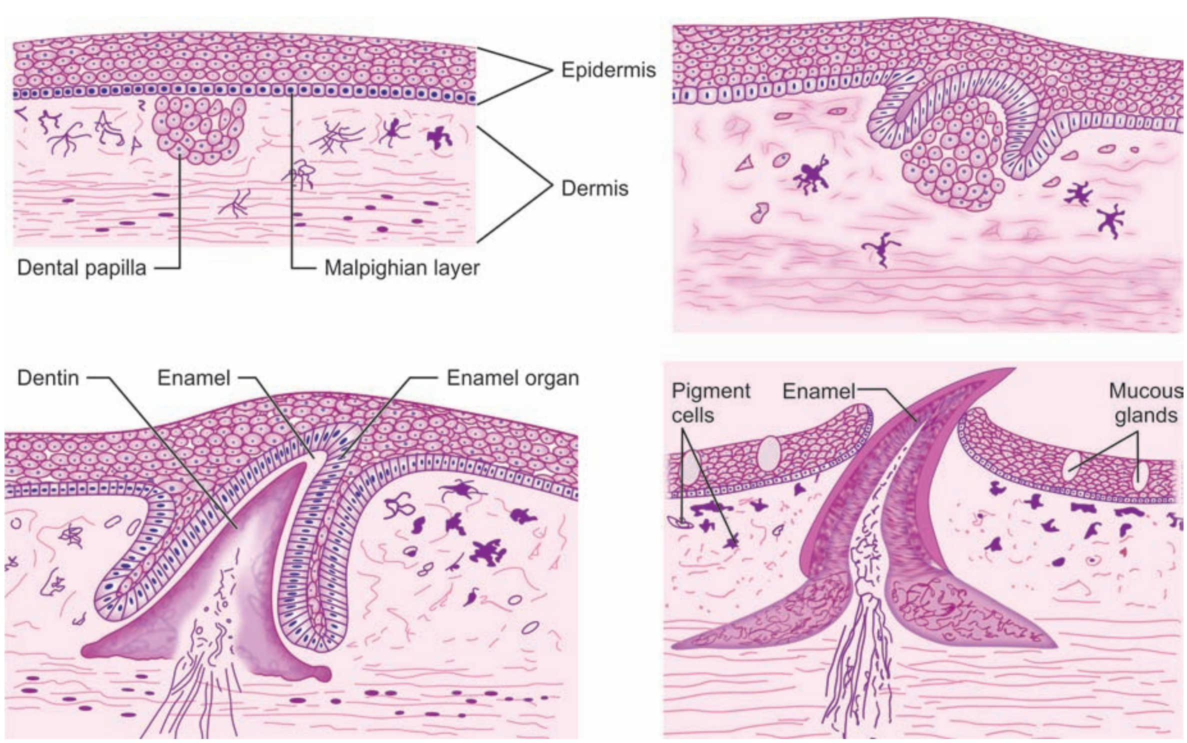


Figure 22.3 Development of placoid scales is similar to that of teeth

The most important anatomic and functional feature of the masticatory surface of an erupted tooth is the cusps. Cusp number, morphology, topology and orientation are species specific; these features also differ between teeth of the same mammal. The evolution of the mammalian jaw and teeth created occlusal surfaces that are adequate for a great variety of food.

Figures 22.4A to D gives four phylogenetic classes of tooth forms:

1. Single cone (*Haplodont*)
2. Three cusps in line (*Triconodont*)
3. Three cusps in a triangle (*Tritubercular molar*)
4. Four cusps in a quadrangle (*Quadritubercular molar*).

The *haplodont class* have simplest form of tooth, single cone (**Fig. 22.4A**). In haplodont animals (e.g. crocodiles, alligator), the jaws have many teeth and jaw movements are limited to simple open and close (hinge) movements. No occlusion of teeth occurs and teeth are mainly used for prehension of prey and defense (**Fig. 22.5**).

The *triconodont class* have three cusps in line in posterior teeth (**Fig. 22.4B**). The largest cusp is in center with smaller cusps located anteriorly and posteriorly. Purely triconodont dentitions are not seen, but the design can be appreciated in some teeth of carnivores.

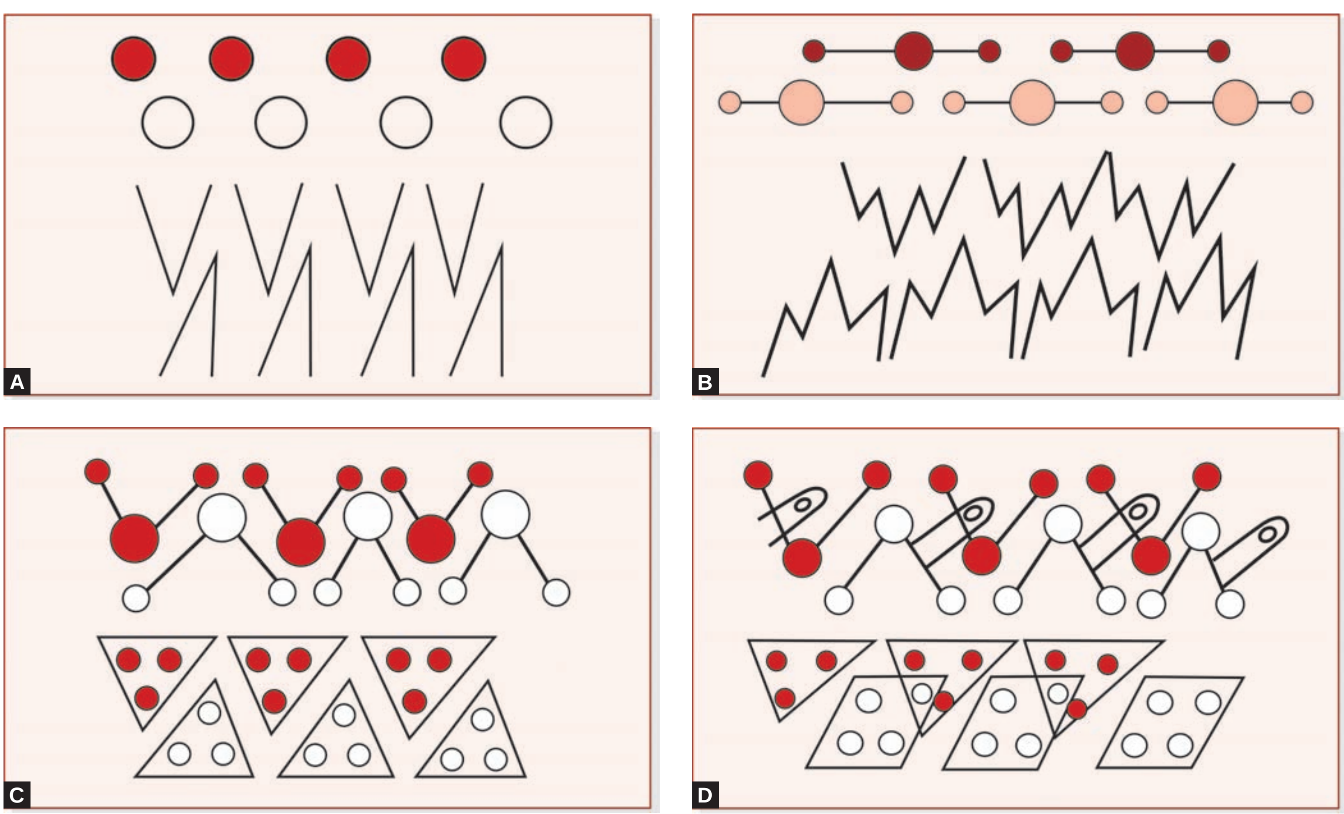
The *tritubercular molar* evolved from the triconodont. The central cusp was separated from the other two outer cusps so that a triangle was formed on the occlusal surface of upper molars (**Fig. 22.6**). The carnivores, like dogs are considered to be in tritubercular class (**Fig. 22.7**).

The *quadritubercular class* reflects an occlusal contact relationship between the teeth of the upper and lower jaw. There is dramatic increase in the masticatory efficiency of the molars. The humans have quadritubercular molars.

COMPARATIVE DENTAL ANATOMY

To understand the human dentition, it is helpful to compare the dentitions and other vertebrates. Although human dentition is different in form and function from the dentitions of other vertebrates, it becomes obvious that overall plan is common to all.

The fishes, amphibians, reptiles, birds and mammals together make up the vertebrate group of animals. They are similar to one another in that they all possess a vertebral



Figures 22.4A to D Phylogenetic classes of tooth forms: (A) Single cone (*haplodont*); (B) Three cusps in a line (*triconodont*); (C) Three cusps in a triangle (*tritubercular molar*); (D) Four cusps in a quadrangle (*quadritubercular molar*)

Figure 22.5 Haplodont dentition in crocodile (*Courtesy*: Crocodile park, La Vanille, Mauritius)

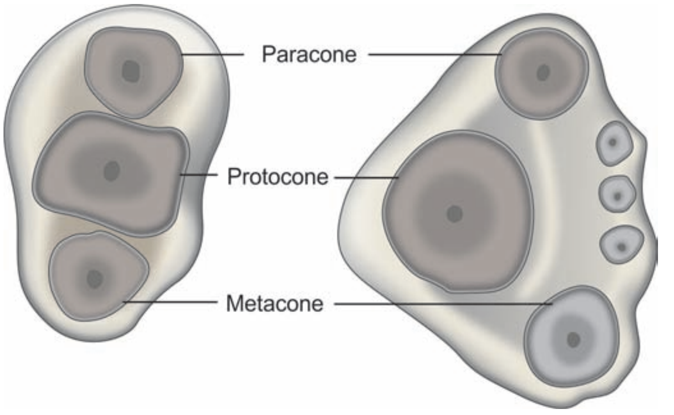


Figure 22.6 Evolution of tritubercular molars from triconodont tooth

column and teeth, unless the teeth have been lost as a secondary process of degeneration or specialization.

Fishes

Most fishes have teeth, but in few teeth are absent. The primary function of teeth in them is to hold their prey. Teeth of the fishes usually exhibit continuous succession (*Polyphyodonty*). The fishes are of two types—bony fishes and cartilaginous fishes.

Examples of *bony fishes* include herring and tront. Bony fishes have a wide variety of teeth. Some even appear on the tongue, plate in extreme cases—the throat. Most fishes have homodont (of similar form) dentitions (**Fig. 22.8**) but few exhibit heterodont teeth (teeth of different classes). In bony fishes teeth are attached to jaws by ankylosis.

Examples of *cartilaginous fishes* include sharks, rays and dogfish. They have many successions of similar shaped teeth. The successional teeth are developed from a persistent dental lamina on the lingual side of the upper and lower jaws. The succeeding teeth lie behind and beneath each functional tooth in rows, with the cutting margins turned upwards or downwards so that the soft tissue are not damaged (**Fig. 22.9**). Sharks have haplodont teeth (single cone), but the shape of teeth vary in different types of sharks (**Figs 22.10A to D**). The teeth are attached to the jaws by fibrous tissues.

Amphibians

Teeth are absent in some amphibians (e.g. toad). In others, they are present in one jaw only. In these, the teeth are usually small conical structures attached by bony ankylosis and undergo continuous replacement.

Figure 22.7 Transition from triconodont to tritubercular molar in carnivores like dog

The frog has a row of small teeth along the edges of the upper jaw only, and two small patches of teeth—vomer teeth on the roof of the mouth.

Figure 22.8 Radiograph showing homodont (Similar form of teeth) dentition in fish

Figure 22.9 Successional teeth in the jaw of a shark with cutting margins turned downwards to avoid soft tissue injury

Reptiles

The typical reptilian dentition consists of a row of conical teeth of varying sizes in each jaw, attached by bony ankylosis and undergoing a process of continuous succession. In some reptiles like crocodiles, the teeth are attached by a periodontal membrane to bony sockets.

Crocodiles and alligators have conical shaped, teeth of varying sizes that interlock when jaws are closed **(Fig. 22.11)**. Only opening and closing jaw movements are possible in them and the upper jaw is movable. All teeth have single roots.

Teeth are absent in turtles and are replaced by horny plates **(Fig. 22.12)**.

In some snakes **(Fig. 22.13)**, certain teeth are modified to form poison fangs. These contain a canal or a groove which conducts the venom from the base of the tooth to just below the tip in a manner similar to a hypodermic needle.

MODERN MAMMALS

The characteristic dentition of modern mammals is heterodont, i.e. the teeth vary in form in different parts of the mouth. The typical mammalian dentition is generally considered to have the following dental formula:

$$I\frac{3}{3}, C\frac{1}{1}, P\frac{4}{4}, M\frac{3}{3}$$

There are, however a great number of variation from this formula. The teeth are attached by a periodontal membrane to the walls of a bony socket in the jaws. There are usually two dentitions: the deciduous and the permanent.

Rodents (Guinea Pig, Rat and Hamster)

Rodents have most constant type of dentitions. At the front of the mouth are the specialized chisel shaped, continuously erupting, incisor teeth. At the back of the mouth is a series of check teeth that are usually similar in form **(Fig. 22.14)**.

The dental formula for rat is:

$$I\frac{1}{1}, C\frac{0}{0}, P\frac{0}{0}, M\frac{3}{3}$$

There is only one dentition.

Herbivorous Mammals (Sheep, Cow, Horse)

The herbivorous animals have back teeth adapted for grinding up vegetation. The jaws from side to side while chewing.

Dental formula for horse is:

$$I\frac{3}{3}, C\frac{1}{1}, P\frac{4}{4}, M\frac{3}{3}$$

Dental formula for sheep and cow:

$$I\frac{0}{3}, C\frac{0}{1}, P\frac{3}{3}, M\frac{3}{3}$$

Interestingly, the herbivores like sheep, cow do not have upper anteriors. Instead, they have a horny pad against which the front teeth of lower jaw bite (**Figs 22.15A and B**).

Carnivorous Mammals (Dog, Cat, Seal)

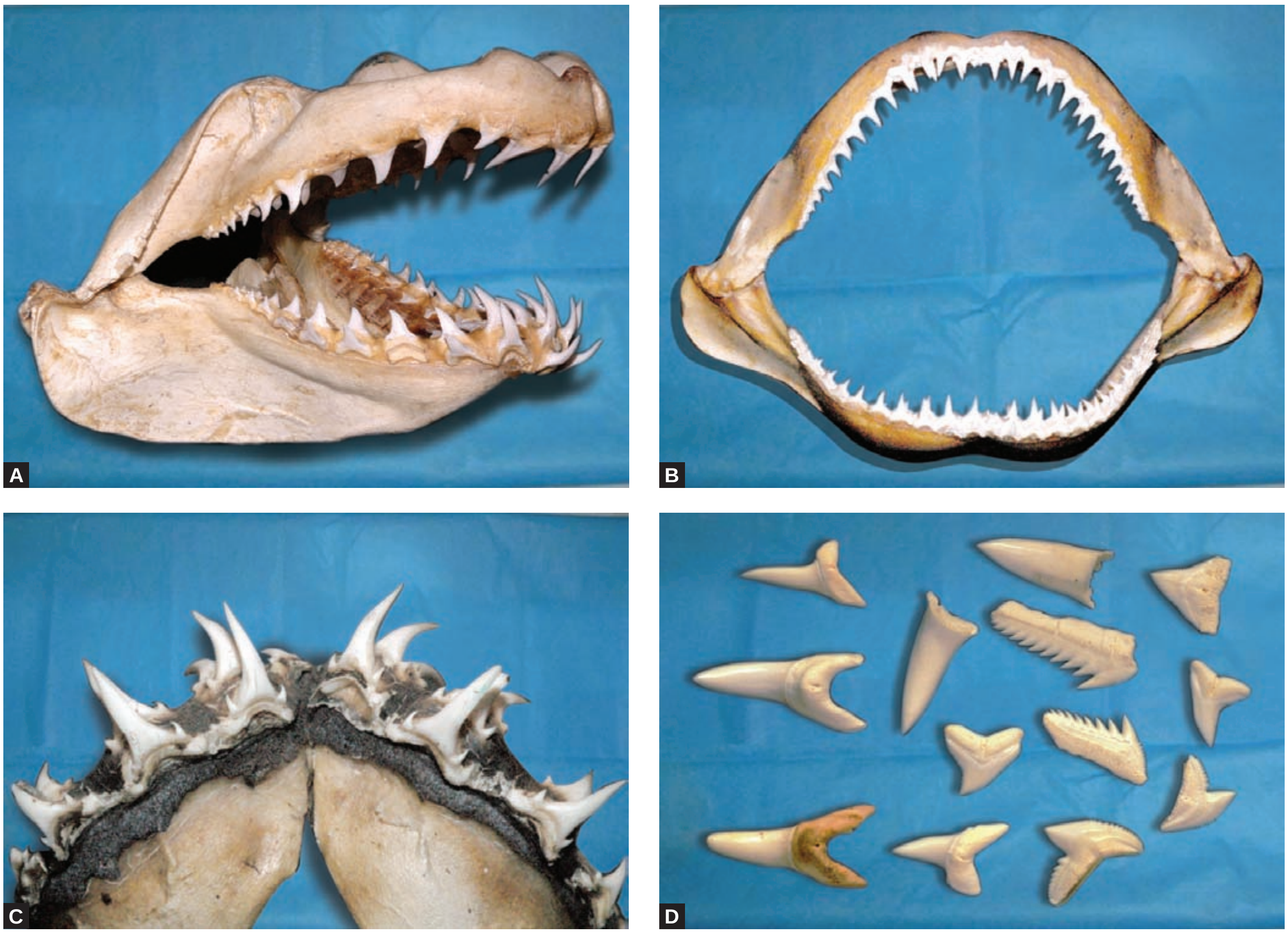
Teeth in carnivores are adapted for catching, killing their prey. They have powerful blade like cheek teeth called *carnassials.*

Dog

The dental formula for dog is:

$$I\frac{3}{3}, C\frac{1}{1}, P\frac{4}{4}, M\frac{2}{3}$$

They have three incisors and four premolars. The canines are the strongest and longest teeth in the jaws (**Fig. 22.16**).



Figures 22.10A to D Sharks have haplodont (single coned) teeth, but shape vary in different types of sharks

Figure 22.11 Alligator has interlocking conical shaped teeth (*Courtesy*: Crocodile park, La Vanille, Mauritius)

Figure 22.12 In turtles, teeth are replaced by horny plates (*Courtesy*: Crocodile park, La Vanille, Mauritius)

Figure 22.13 Small conical teeth in a snake (*Courtesy*: Dr DC Master, Professor and Head, Department of Anatomy, Medical Hospital, Vadodara, Gujarat, India)

Figure 22.14 Mandibular jaw of a rodent with continuously erupting incisors (*Courtesy*: Dr DC Master, Professor and Head, Department of Anatomy, Medical Hospital, Vadodara, Gujarat, India)

Figures 22.15A and B Dentition in a cattle does not have upper anteriors

Cat

The dental formula for cat is:

$$I\frac{3}{3}, C\frac{1}{1}, P\frac{3}{2}, M\frac{1}{1}$$

Cat has 3 incisors lined in astraight line but only one molar. Canine is large and sharp (**Fig. 22.17**).

New World Monkey

Monkey's dentition is most similar to that of man, only difference being is an extra set of premolars. They have larger primate spaces (**Fig. 22.18**).
The dental formula is:

$$I\frac{2}{2}, C\frac{1}{1}, P\frac{3}{3}, M\frac{3}{3}$$

Figure 22.16 Dentition of a dog (*Courtesy*: Dr DC Master, Professor and Head, Department of Anatomy, Medical Hospital, Vadodara, Gujarat, India)

Figure 22.18 Dentition of a monkey

Figure 22.17 Dentition of a cat (*Courtesy*: Dr DC Master, Professor and Head, Department of Anatomy, Medical Hospital, Vadodara, Gujarat, India)

FORENSIC ODONTOLOGY

Forensic odontology/forensic dentistry is a branch of forensic medicine that, in the interest of justice, deals with the proper examination, handling and presentation of dental evidence in a court of law. The dental anatomy is the basis for any forensic dentistry investigation. The main responsibilities of a forensic dentist include the following:

- Identification of human remains, and identification in mass disasters
- Bite mark registration and analysis
- Age estimation
- Assessment of cases of abuse (child, spousal, elder).

Identification of Human Remains

Dentistry has much to offer in identification as the teeth are the most durable parts of human body and dentitions are unique due to custom dental restorations and developmental characteristics. The most common role of a forensic dentist is to identify the deceased individuals in whom other means of identification (e.g. finger prints, facial features) are not available. This is true in situations involving burns, decomposition such as air crashes, incineration, floods and other similar disasters.

The *postmortem* (after death) teeth, jaw, prostheses and appliances can yield a positive identification, when compared with the *antemortem* (before death) records. Even when antemortem records are not available, useful information can be drawn by *postmortem dental profiling* which provides information on deceased individual's age, ancestry, sex and socioeconomic status.

Postmortem and antemortem dental charts are prepared by carefully recording various features such as—number and identity of teeth, tooth rotation, spacing and malposition, anomalies, restorations, prosthesis or appliances, caries, endodontic treatment, implants and surgical repairs, pathology, bone patterns, occlusion, erosion and attrition.

The postmortem and antemortem dental charts are then compared to arrive at conclusion. Presence of unique and rare anatomical variations such as bifurcated mandibular canine, peg shaped maxillary laterals, etc. may aid early positive identification.

Bite Marks

Human and animal teeth both leave conspicuous marks. Teeth leave behind noticeable bruises/ punctuate marks in the flesh and the marks may also be left on other substances such as food stuffs (apple, cheese, chocolate, and chewing gum), leather and wood. Bite marks are frequently seen on victims of attack and in cases of child abuse. The distinctiveness of the bite mark where sufficient detail is available, may lead to identification of the person who caused the mark or exclusion of other suspects.

The physical characteristics of both the bite mark wound and the suspect's teeth that can be compared include—canine to canine distance, shape of dental arch, tooth out of alignment, teeth width, spacing between teeth, missing teeth, curves of biting edges, any unique anatomy or variations and wear patterns such as chipping of teeth or grinding.

The bite marks are recorded and documented using photographs with measurement scales. Positive replicas can be poured using dental impression material. Corresponding morphological featured found on the bite mark pattern and the suspect's teeth on a dental cast are then compared to arrive at a conclusion weather the bite mark is caused by the suspect or not.

Age Estimation

Estimation of chronological age is an important aspect of forming the dental profile of an unknown individual. The age of children can be accurately determined by the analysis of tooth development and subsequent comparison with standard developmental charts to the accuracy of ± 1.5 years. However, adult age estimation after all the teeth are completely formed is difficult and less accurate. Features such as attrition, secondary dentin formation, root dentin translucency and periodontal status, etc. are used to determine adult age to the accuracy of ± 10 to 12 years. Certain techniques such as aspartic acid racemization may give accuracy of ± 4 years.

Dental Deoxyribonucleic Acid

Teeth represent an excellent source of deoxyribonucleic acid (DNA) material since they are resistant to most environmental assaults. DNA extracted from dental tissues (pulp, dentin) can prove identity when conventional dental identification methods fail. DNA from dental tissues can be both genomic and mitochondrial DNA (mtDNA). Comparison of DNA from the teeth of an unknown individual can be matched to a known antemortem sample (stored blood, hair brush, biopsy, etc.) or to a parent or sibling.

BIBLIOGRAPHY

1. Acharya AB, Sivapathasundharam B. Forensics odontology. In: Rajendran R, Sivapathasundharam B, (Eds). Shafer's Textbook of Oral Pathology, 6th edn. Elsevier; 2009.
2. Anderson BL, Thompson GW, Popovich F. Evolutionary dental changes. Am J Phys Anthropol. 1975;43(1):95-102.
3. Ferreira da Silva R, et al. Anatomical variations in the permanent mandibular canine: forensic importance RSBO. 2012;9(4):468-73.
4. Grove AJ, Newell GE, Carthy JD. Animal biology, 6th edn. University tutorial press Ltd; 1961.
5. Koussoulakou DS, Margaritis LH, Koussoulakos SL. Curriculum Vitae of teeth: Evolution, Generation, Regeneration. Int J Biol Sci. 2009;5:226-43.
6. Pretty IA, Sweet D. A look at forensic dentistry. Part 1: The role of teeth in the determination of human identity BDJ. 2001;190(7):359-66.

MULTIPLE CHOICE QUESTIONS

1. Forensic odontology deals with:
   a. Victim identification
   b. Bite mark analysis
   c. Age estimation
   d. All of the above
2. Upto adolescence, age estimation can be done by:
   a. Eruption stage of teeth
   b. Examining stage of root formation radiographically
   c. Examining stage of crown formation radiographically
   d. All of the above
3. Age estimation after adulthood can be done by:
   a. Eruption stage of teeth
   b. Examining stage of root formation radiographically
   c. Examining stage of crown formation radiographically
   d. Studying the regressive changes of teeth
4. The regressive changes of teeth include:
   a. Attrition
   b. Secondary dentin formation and apical cementum deposition
   c. Transparency and resorption of roots
   d. All of the above
5. Deoxyribonucleic acid (DNA) in humans is:
   a. Same for all the individuals
   b. Same for only identical twins
   c. Different for different individuals
   d. Both b and c

Answers

1. d 2. d 3. d 4. d 5. d

CHAPTER

23 Dental Anthropology

Anthropology is the study of humans in all places and at all times. The term anthropology comes from Greek, anthropos = man, logos = the study. The study of Anthropology is an investigation into what we are now, from whence we came and how we got to be the way we are today.

Anthropologists study modern humans and their direct ancestors generally referred to as hominids.

Anthropology is a recent discipline originating a little more than a hundred years ago. The first course in the field was offered in 1879 at University of Rochester (New York).

Dental anthropology has evolved more recently as a distinct subfield of physical anthropology, one of the major branches of anthropology.

BRANCHES/SUBFIELDS OF ANTHROPOLOGY

There are four distinct branches of anthropology in current literature.

Physical Anthropology

It is the study of people from a biological perspective. It utilizes both biological and physical sciences for the study of humans.

The following are some of the area of interest to physical anthropologists:

Evolution

Paleontology is the study of fossils. It is especially useful in study of evolution and human origins. The study of the fossils of modern humans and human ancestors is called paleoanthropology.

The term *Hominids* refers to modern humans (Homo sapiens), the *Neanderthals*, Homo erectus and the many Australopithecines. The term *Hominids* is a more inclusive term for all the hominids and their closest primate relations, i.e. apes (*Gorilla*, Chimpanzee, Orangutan and Gibbon).

Human Variation

How and why physical traits vary around the world is studied. *Anthropometry* is the measuring of human physical characteristics; variations in skeletal shape and bone structure provide useful clues on the search for the origins of human species.

Primatology is the study of primates. Primates are our closest relations and are studied for their implications as evolutions and the insights they provide into human behavior.

Forensic anthropology is a specialized area of physical anthropology, which deals with identification of human remains for legal purposes.

Dental anthropology is the study of teeth as recorded in casts of living mouths or as seen in the skulls of archeological and fossil collections.

Archeology

It is the study of human cultures and behavior through material remains such as caves, temples, mummies, etc. It mainly focuses on prehistoric cultures.

Linguistics

It is the discipline that studies speech and language. According to anthropologists, language is conservative. When people move to new areas, they adapt new foods, and lifestyles, but their language is retained. Linguistics has been valuable in tracing the migrations of prehistoric human populations/communities such as that of Native American Indians.

Ethnology

Ethnology is the study of the cultures of the present. Ethnography is the intensive study of a single culture. Ethnography studies human behavior as it can be experienced a particular culture and compares it with that of many cultures of today.

DENTAL ANTHROPOLOGY

Terms used in Dental Anthropology

Many of the terms used in anthropology are derived from Greek or Latin and are explained for ease in learning.

Categories of Teeth by Shape

'Homodont' Dentition (Homo = Similar)

Dentition on which all the teeth are uniformly of similar shape, e.g. teeth in reptiles such as crocodiles—all teeth are conical in shape (**Fig. 23.1**).

'Heterodont' Dentition (Hetero = Different)

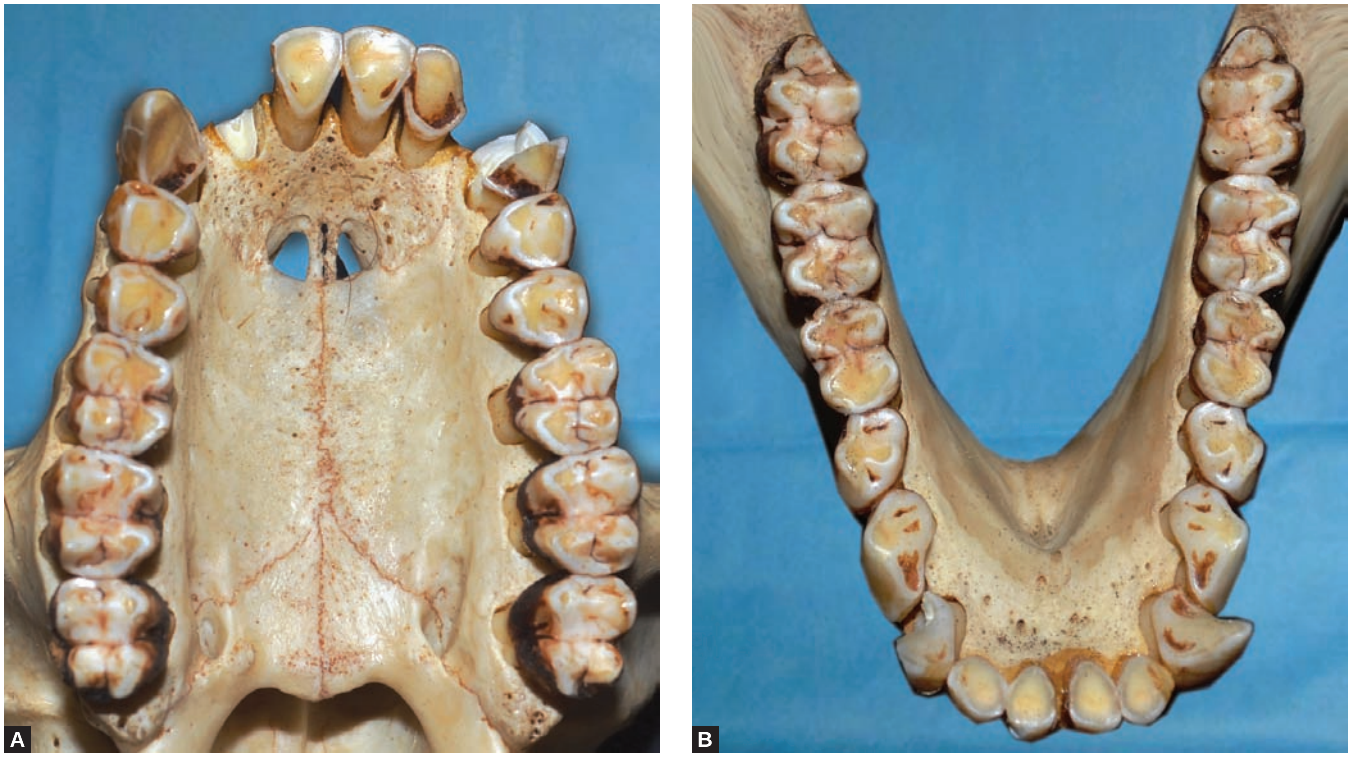
Dentition in which teeth are regionally specialized into classes, e.g. majority of mammals have heterodont dentitions including humans and higher vertebrates such as dog, cat, sheep, etc.

In heterodont dentition, generally there are four classes of teeth, i.e. incisors, canines, premolars and molars (**Figs 23.2A and B**).

Categories of Teeth by Generation

- *Monophyodont dentition (Mono = single)*: A monophyodont dentition has a single generation of teeth in lifetime
- *Diphyodont dentition (Di = double)*: If the condition of having two generations of teeth in lifetime, e.g. Humans are diphyodonts with two generations of teeth, i.e. deciduous and permanent dentitions.

Figure 23.1 Homodont dentition in crocodile



Figures 23.2A and B Heterodont dentition in monkey

- *Polyphyodont dentition (Poly = many)*: It refers to many generations of teeth in a lifetime, e.g. many reptiles including crocodiles are polyphyodonts. Fishes such as sharks are also polyphyodonts.

Crown

- Bunodont (Gr = *Mound or hell*) teeth have cone-shaped tubercles or cones. They are low crowned with well-developed roots, e.g. posterior teeth in pig.
- *Selenodont (Gr = the moon)*: Selenodont teeth have cusps transformed into half-moon shapes, e.g. posterior teeth of sheep.
- *Sectorial (L = Secare/to cut) teeth*: Sectorial teeth are blade-like teeth adapted to cutting the diet into pieces and swallowing them whole. A specialized variant in carnivores are the carnassials teeth, which consist of the last premolar in the upper jaw and the 1st molar of the lower jaw.
- *Lophodont (Gr = Crest)*: Lophodont molars are ridged teeth that have transverse ridges as in the tapir. Lophs are sharp crests that join the cusps in multicusped teeth, i.e. transverse ridges.

Bilophodont molars have two sets of transverse ridges. Polyphodont molars have many ridges, e.g. molar teeth of elephants.

- *Brachydont (Gr = Short)*: Brachydont teeth have low crowns and well-developed roots, e.g. humans have brachydont teeth.
- *Hypsodont (Gr = Height)*: Hypsodont teeth have long crown and short roots, e.g. this condition is seen in horse. It is a functional adaptation in these animals for continuous wear sustained by chewing grass with high abrasive silica content.
- *Haplodont (Gr = Simple)*: Haplodont teeth have simple conical crowns and roots, e.g. teeth in dolphin and crocodiles.
- *Tusks*: Tusks are incisors or canines of continuous growth that protrude beyond the lips when mouth is closed.

The following are some of the examples of tusks:

- The incisors of the elephant and hippopotamus
- The left incisors of narwhal
- Canines of the wild board, wart hog and the walrus.

Teeth in the Study of Human Variation

Physical traits of humans vary around the world, e.g. skin color, body size, eye color and size and shape of teeth. Human variation is the combined result of genetic influences, as well as environmental factors such as climate and geographic location.

Teeth provide unique advantage in the study of human variations since tooth crowns are fully formed in childhood before eruption into oral cavity.

Teeth have been used intensively in the study of human variation since tooth crowns are fully formed in childhood before eruption, permitting study of tooth morphology in mixed samples of teeth from ranging ages. This is not possible with skeletal material since only full grown adults show developed skeletons. Furthermore, tooth morphology can also be studied in living subjects by simply taking dental impressions. Scott and Turner II have divided humans into several population groups based on their geographic origin feature, e.g. presence/absence/Carabelli's cusp.

Dental features used to describe population differences are broadly classified as metric (tooth size) and nonmetric (tooth shapes).

METRIC VARIATION IN TEETH

Metric variations are features that are directly measured. Generally, the maximum dimensions of the teeth are considered.

Three basic dimensions are usually used:

1. Mesiodistal diameter of the crown
2. Buccolingual diameter of the crown
3. Crown height.

NON-METRIC VARIATIONS IN TEETH

Several non-metric features of the tooth crown and root have been described. Some of the commonly recorded features are discussed below. Non-metric variation has been used to study migration patterns of human populations in various regions of the world.

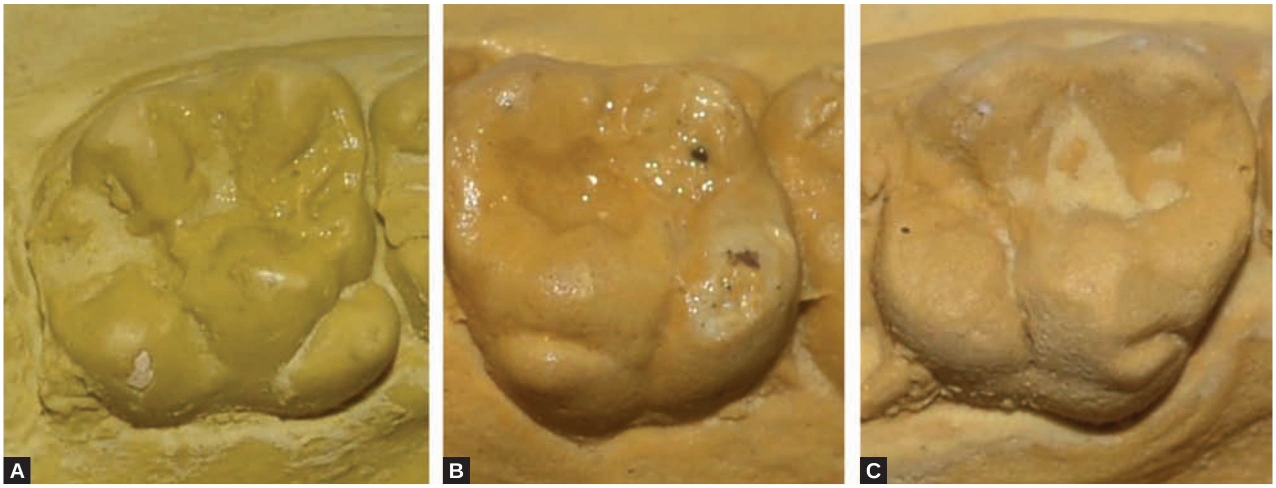
Carabelli Trait (Cusp of Carabelli)

The Carabelli trait was first described in 1811 by George Carabelli, who was Court dentist to the Austrian Emperor Franz. The trait when present is located on the mesiolingual corner of upper first permanent molar and second deciduous molar. The trait shows varied expression. It can express itself as a pit, a groove, ridge and tubercle or as a well-formed cusp (**Figs 23.3A to C**). When present as a cusp version, it can be larger than the main cusp.

The Carabelli trait is most frequently seen in Caucasoid populations and has a low incidence of expression in Mongoloid population. Sometimes the trait expresses as a lingual cingulum; a similar feature is found amongst primates—gibbon, chimpanzee, gorilla and orangutan.

Shovel-shaped Incisors

- Shoveling is a feature seen in incisors, where the marginal ridges are especially prominent and enclose a deep fossa in the lingual surface (**Fig. 23.4**)



Figures 23.3A to C Varied expression of cusp of Carabelli

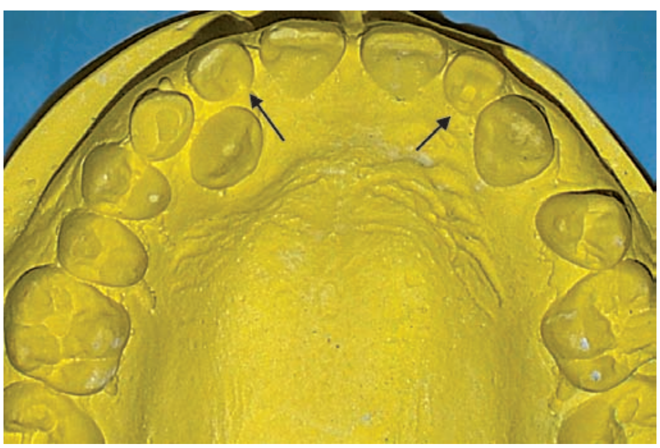


Figure 23.4 Shoveling in maxillary lateral incisors

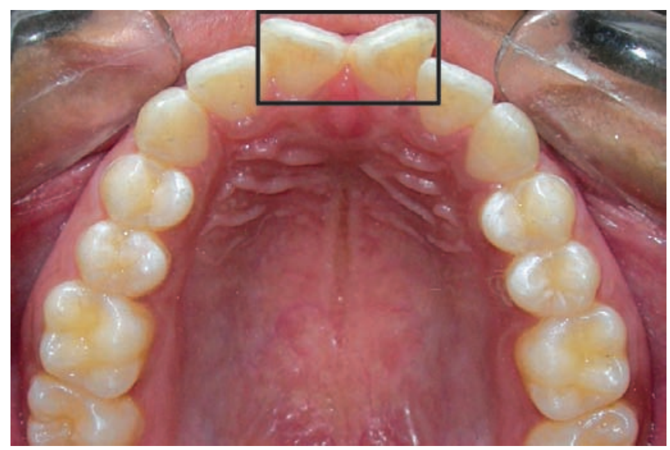


Figure 23.5 Winged incisors

- Shoveling is commonly seen on permanent and deciduous upper incisors but can sometimes appear in lower incisors also
- Shoveling can also create a pit on the lingual surface of central incisors
- Shovel-shaped incisors show highest frequency of occurrence in Asians and Native Americans and lowest occurrence in Europeans
- Shovel-shaped incisors are found in Homo erectus, suggesting that this is a very ancient trait.

Winged Incisors

Winging is an indirect crown trait. In this condition, distal margins of both the upper central incisors are rotated labially creating a "V" shaped pattern of incisal edges when view occlusally (**Fig. 23.5**).

Protostylid of Molars

- The protostylid is a feature on the buccal side of the lower molar crown characterized by a tubercle on the mesiobuccal cusp, ranging from a spot in the buccal groove, through a furrow to a prominent cusp (**Fig. 23.6**)
- The feature is seen especially on 1st or 3rd permanent lower molars or in deciduous lower 2nd molar
- Population identification is based on protostylid on lower 1st molar.

Lower Molar Groove Pattern

Occlusal groove configuration (X,Y and "+") on the lower 1st and 2nd molars are also used for population identification (**Fig. 23.7**).

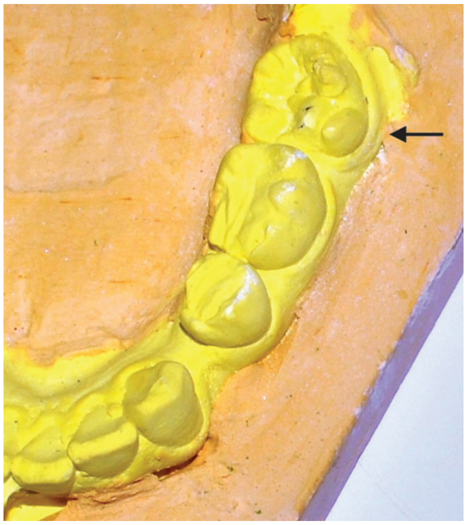


Figure 23.6 Protostylid in a mandibular 2nd molar

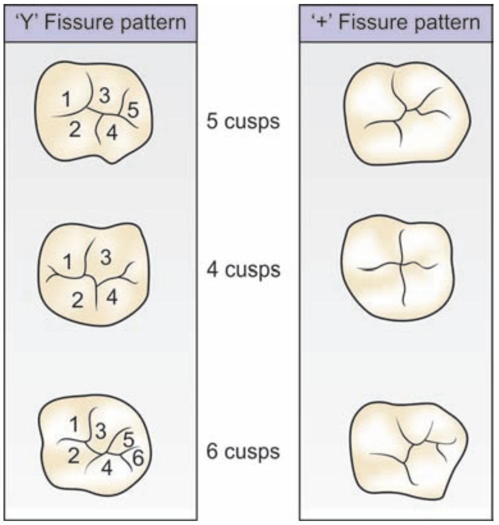


Figure 23.7 Developmental grooves pattern in lower molars

6th Cusp on Lower Molar

Lower 1st molar may have a supernumerary cusp on the distal aspect between the distolingual and the distal cusp (**Fig. 23.8**).

Taurodontism (Taurus = Bull)

The term taurodontism is used to describe the bull-like condition on the multirooted posterior teeth in which, the teeth have long root trunks with wide pulp chamber. Some consider this feature to be an atavistic tendency. Taudodontism is found prominently on Krapina Neandthal specimens.

Variation in Root Morphology

Single Rooted Upper 1st Premolar

Upper 1st premolar with single root is used for population identification (**Fig. 23.9A**).

Two Rooted Lower Canine

Presence of double rooted lower canine is rare in humans, but is a typical feature in primate dentition (**Fig. 23.9B**).

Three Rooted Lower 1st Molar

Presence of a third root on lower 2nd molar also helps in population identification (**Fig. 23.9C**).

Sexual Dimorphism and Teeth

The sexual dimorphism of teeth is a well-known feature of higher animals and primates where size and shapes of teeth especially that of canine teeth, differ significantly among males and females. In many animals, large canines are

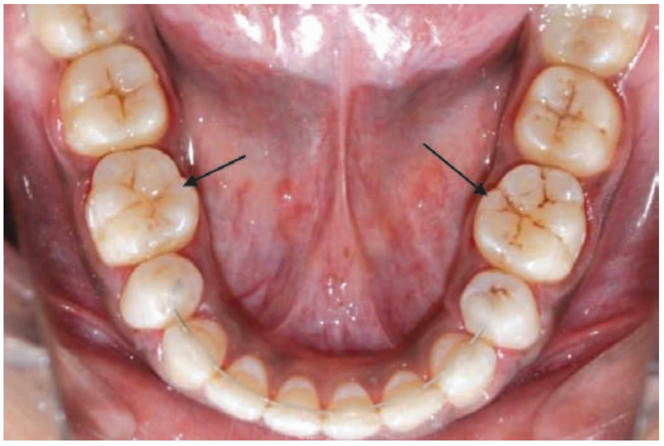


Figure 23.8 Sixth cusp on lower molar

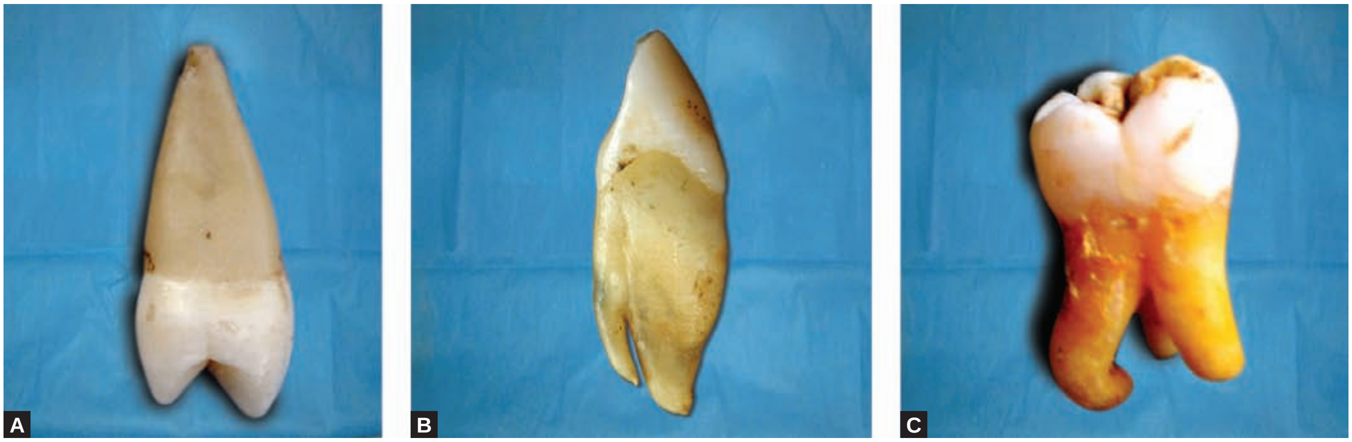
considered to be a visual sexual signs of dominance and rank. Due to evolutionary changes, there has been a reduction in sexual dimorphism of teeth in humans.

However, studies have shown significant differences in males and females on metric and certain nonmetric features of teeth. In general, mesiodistal and buccolingual diameters of crowns is greater in males than in females.

Human dental dimorphism is centered on canines, with lower canines showing the greatest dimorphism followed by the upper canines.

Nonmetric Features

Sexual difference in females have a higher frequency of missing teeth and a lesser frequency of supernumerary teeth than in males.



Figures 23.9A to C (A) Single rooted upper 1st premolar; (B) Two rooted lower canine; (C) Three rooted lower 1st molar

A nonmetric feature of canine "distal accessory ridge", is the most sexually dimorphic (feature) trait in human dentition, with males showing higher frequencies than females.

Presence of only four cusps in mandibular 1st molar (absence of 5th cusp) is more commonly seen in females than in males. In addition to tooth size, certain tooth proportions show sexual dimorphism.

Incisor Index (Aitchison)

The index is higher in males than in females.

BIBLIOGRAPHY

1. Chandra SS, Chandra S, Shankar P, et al. Oral Prevalence of radix entomolaris in mandibular permanent 1st molars: a study in a South Indian population. Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;112(3):77-82.
2. Hillsons. Dental Anthropology. New York: Cambridge University Press; 1996.
3. Hrdlička A. Shovel-shaped teeth. Am J Phy Anthro. 1920;3:429-65.
4. Khraisat A, Taha ST, Jung RE, Hattar S, et al. Prevalence, association and sexual dimorphism of Carabelli's molar and shovel incisor traits amongst Jordanian population. Odontostomatol Trop. 2007; 30(119):17-21.
5. Krogman Marion W. The role of genetic factors in the human face, jaws and teeth: a review. The Eugenics Review. 1967;59(3):165-92.
6. Portin P, Alvesalo L. The inheritance of shovel shape in maxillary central incisors. Am J Phy Anthro. 1974;41:59-62.

MULTIPLE CHOICE QUESTIONS

1. Homodont dentition refers to:
   a. Dentition in which all the teeth are uniformly of similar shape
   b. Dentition in which teeth are regionally specialized into classes
   c. Dentition has a single generation of teeth in lifetime
   d. Dentition having two generations of teeth in lifetime
2. Heterodont dentition refers to:
   a. Dentition in which all the teeth are uniformly of similar shape
   b. Dentition in which teeth are regionally specialized into classes
   c. Dentition has a single generation of teeth in lifetime
   d. Dentition having two generation of teeth in lifetime
3. The term monophyodont dentition refers to:
   a. Dentition in which all the teeth are uniformly of similar shape
   b. Dentition in which teeth are regionally specialized into classes
   c. Dentition has a single generation of teeth in lifetime
   d. Dentition having two generations of teeth in lifetime
4. The term diphyodont dentition refers to:
   a. Dentition in which all the teeth are uniformly of similar shape
   b. Dentition in which teeth are regionally specialized into classes
   c. Dentition has a single generation of teeth in lifetime
   d. Dentition having two generation of teeth in lifetime
5. An example of homodont dentition is:
   a. Reptiles
   b. Humans

c. Fish
d. Sheep

6. An example of heterodont dentition is:
   a. Reptiles
   b. Humans
   c. Fish
   d. Sheep
7. The term polyphyodont dentition refers to:
   a. Dentition in which all the teeth are uniformly of similar shape
   b. Dentition in which teeth are regionally specialized into classes
   c. Dentition has a single generation of teeth in lifetime
   d. Many generations of teeth
8. Which of the following is true regarding the selenodont teeth?
   a. Selenodont teeth have cusps transformed into half moon shaped
   b. Posterior teeth of sheep
   c. Both of the above
   d. None of the above
9. Which of the following is false statement?
   a. Sectorial teeth—blade like teeth
   b. Selenodont—half moon shaped teeth
   c. Lophodont—confined to molars
   d. Bilophodont incisors—incisors having ridges
10. Bilophodont molars are seen in:
   a. Molars teeth of humans
   b. Molars teeth of elephant
   c. Molars teeth of fish
   d. Molars teeth of sheep.

Answers

1. a	2. b	3. c	4. d	5. a	6. b	7. d	8. c	9. d	10. b

SECTION

9

Tooth Carving

CHAPTER

24

Tooth Carving

The importance of knowing tooth morphology and its application in clinical dentistry cannot be overemphasized. Tooth carving is one of the best methods for learning tooth morphology. Carving gives a 3-dimensional understanding of details of tooth form, right from the simple design of an incisor to the complex anatomy of the molar.

This chapter gives the rationale, armamentarium, general principles of carving and step by step carving procedure.

RATIONALE OF TOOTH CARVING

It is no secret that good carving skills come handy in clinical practice, especially during restoration of lost tooth structure, tooth recontouring, laboratory procedures such as fabrication of metal/ceramic crowns and veneers. Restoration of anterior teeth using tooth colored material such as composite also requires carving skills to bring about the natural contour of teeth conductive to esthetic appeal.

Accurate reproduction of the occlusal anatomy when restoring a part/whole tooth structure is very much essential in order to maintain the normal occlusal harmony. Improper finishing with under carving may lead to microleakage, while overfilled restoration may cause discomfort and pain due to high points. Overhanging proximal restoration often leads to food impaction and periodontal problems.

Though some are born with artistic hand, with practice anyone who systematically follows the steps of carving should be able to carve a reasonably good tooth form out of a wax block.

ARMAMENTARIUM (FIG. 24.1)

Wax Blocks

Wax blocks made of paraffin wax are used for carving teeth. The blocks come in various colors (e.g. white, blue, pink and yellow). They usually measure about 4.00 × 1.25 × 1.25 cm.

An ideal wax block should be:
- Tough and not very soft in room temperature
- Free of air bubbles and impurities
- Should not flake or chip off during manipulation
- Allow/amenable to polishing.

Lecron Carver (Fig. 24.2)

Lecron carver is a double ended instrument made of stainless steel.

Carvers come in various designs and dimensions, thus carry different model numbers by the manufacturer.

It has a handle/shaft and two working ends with neck/shank. The shaft is generally serrated to facilitate firm grip of the instrument. The working end of the carver should be sharp and free of any nicks/scratches on them.

Knife Shaped Working End (Fig. 24.3)

The knife shaped working end has a straight part and a curved part. The straight part is used for most steps of carving unless otherwise specified. The curved part is used for occlusal carving, and for obtaining concavity of lingual fossa.

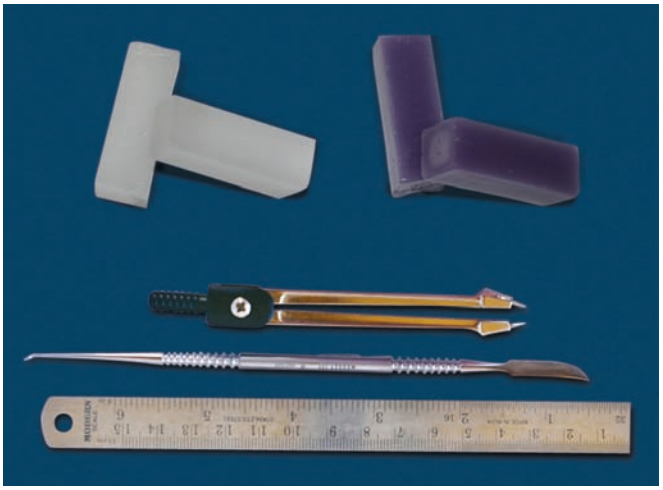


Figure 24.1 Materials required for tooth carving

Spoon Shaped Working End (Fig. 24.4)

The spoon shaped working end is generally used for carving lingual grooves of anteriors and developmental depression of roots.

Ruler with Millimeter Markings

It is used for measuring.

Boley's Gauge or Vernier Calipers

Used for measuring teeth specimen with accuracy of millimeter.

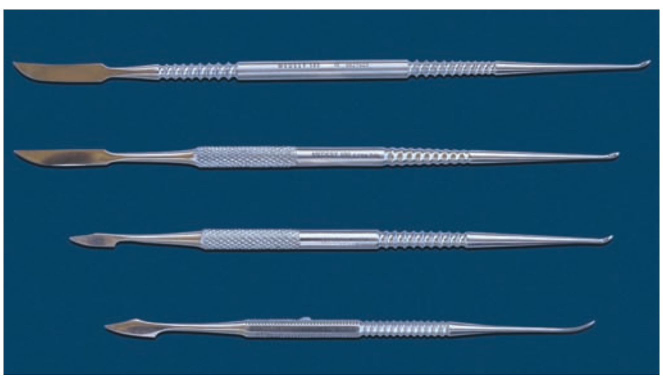


Figure 24.2 Lecron carver

Divider

Can be used for measuring the carved tooth specimen especially the curved parts.

Cotton or a Piece of Soft Silk Cloth

It is used for polishing the finished carving.

GENERAL PRINCIPLES OF CARVING

One must know the detailed anatomy of the tooth before attempting to carve. Extracted teeth specimen devoid of caries and gross attrition serve as ideal models for carving. The average measurement of the tooth (**Table 1.7**) should be used to reproduce the exact form of the tooth.

Proper method of handling the carver and the wax block is the first step in learning the skills of carving.

Instrument Grasp

The carver should be held using the *modified pen grasp*, which gives flexibility and allows for optimum force application (**Fig. 24.5**). In the modified pen grasp, the carver is held at its neck using the thumb, index finger and the middle finger. The middle finger is held more close to the working end of the carver and index finger is bent at its second joint.

Instrument Stabilization

While giving strokes, the carver is stabilized by finger rests using the ring and little fingers of operating hand.

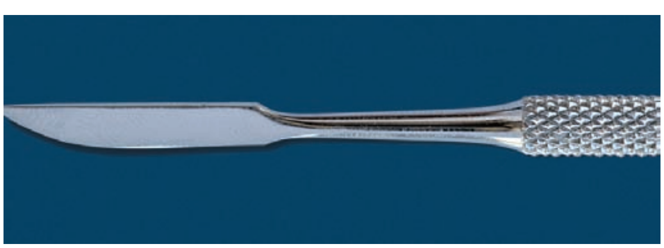


Figure 24.3 Knife-shaped working end of the carver

Figure 24.4 Spoon shaped working end of the carver

Figure 24.5 Modified pen grasp

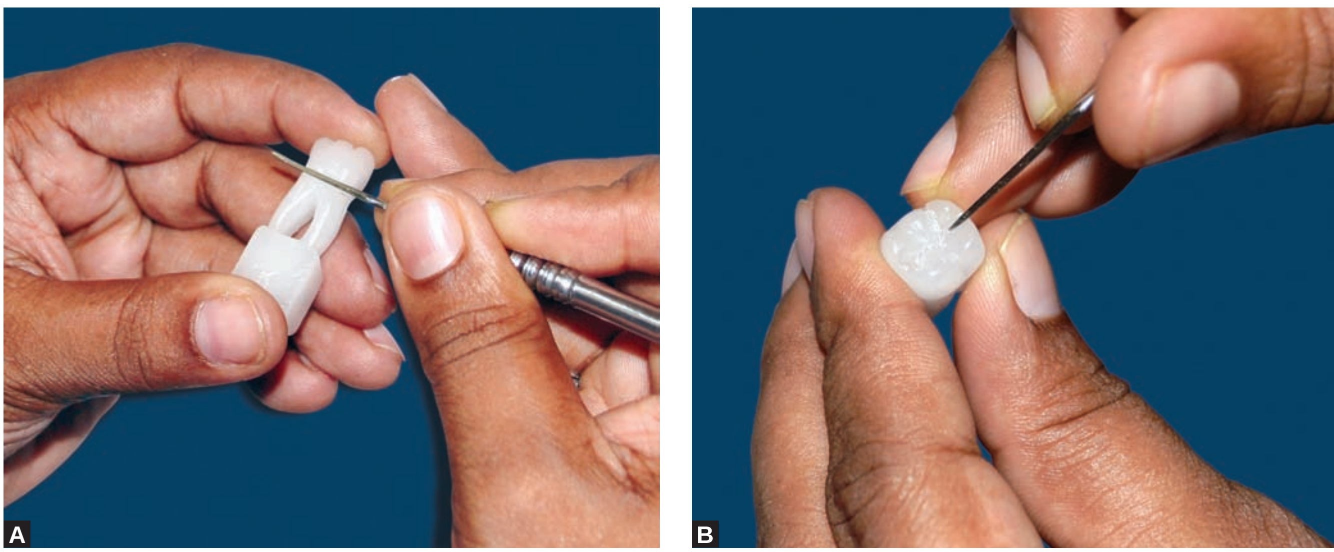
- *Finger on finger rest (Fig. 24.6A)*: Support is gained by resting the ring and little finger of the operating hand on the finger of the non-operating hand holding the block.
- *Finger on block rest (Fig. 24.6B)*: The ring and little finger of the operating hand are placed on wax block held with the non-operating hand.

Either of these finger rests are used depending on the operator's ease and situation. Carving should never be done without using finger rest.

PRELIMINARY STEPS

Before carving any tooth, some preliminary steps have to be followed.

- *Smoothening of wax block*: Before carving, wax block should be checked for any porosities/irregularities. All the surfaces of the block should be smoothened.
- *Preliminary markings (Fig. 24.7)*:
  - The block is divided into three parts crown, root and base. The length of crown and root are measured and



Figures 24.6A and B (A) Finger on finger rest; (B) Finger on block rest

Figure 24.7 Preliminary markings on the wax block

Figures 24.8A and B

marked on the block. The remaining part of the block serves as a base.
- It is a good practice to mark midline on all the surfaces of the block so that the carved tooth will be properly centered over the base.
- The crown portion is divided into 3 parts—cervical, middle and incisal/occlusal third.
- An attempt should be made to preserve the base as the carving is best displayed along with an intact base.

CARVING OF MAXILLARY CENTRAL INCISOR

The procedure of carving a permanent maxillary central incisor is described below. The basic steps of carving remain same for all other incisor with only minor changes required.

Note: The longer, straight part of working end is used for most steps in carving unless otherwise specified.

Crown Carving

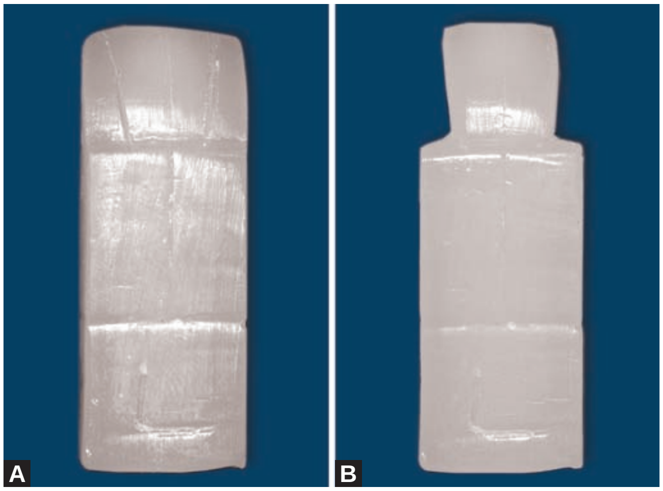
- *Step 1*: Obtaining triangular proximal form of incisor (**Figs 24.8A and B**).
  - *1A*: Marking triangle with conserving wax at cervical third—crest of labial and lingual contour at cervical third (**Fig. 24.8A**)
  - *1B*: Removal of excess wax outside the triangular marking (**Fig. 24.8B**)
- *Step 2*: Obtaining convex labial surface—both cervicoincisally and mesiodistally (**Fig. 24.9**)
- *Step 3*: Obtaining concavoconvex lingual surface (**Fig. 24.10**).
  - Obtaining concave lingual fossa
  - Obtaining convex cingulum
- *Step 4*: Obtaining trapezoid facial form (**Figs 24.11A and B**)
  - *4A*: Marking trapezium on the labial surface (**Fig. 24.11A**)
  - *4B*: Reduction of wax outside trapezoid marking (**Fig. 24.11B**)
- *Step 5*: Obtaining lingual convergence of crown (**Fig. 24.12**)
- *Step 6*: Carving developmental grooves in lingual fossa (**Fig. 24.13**)
  - Spoon shaped working end is used.
- *Step 7*: Giving finishing touches to crown (**Fig. 24.14**)
  - Rounding the distoincisal angle
  - All line angles are rounded.

Root Carving

- *Step 8*: Obtaining conical root form from labial and lingual aspects (**Figs 24.15A to C**)
- *Step 9*: Obtaining conical root form from proximal aspects (**Figs 24.16A and B**)
- *Step 10*: Cervical line carving and finishing.
  - Finished carving from all aspects is shown in (**Figs 24.17A to E**).

Figure 24.9

Figure 24.10

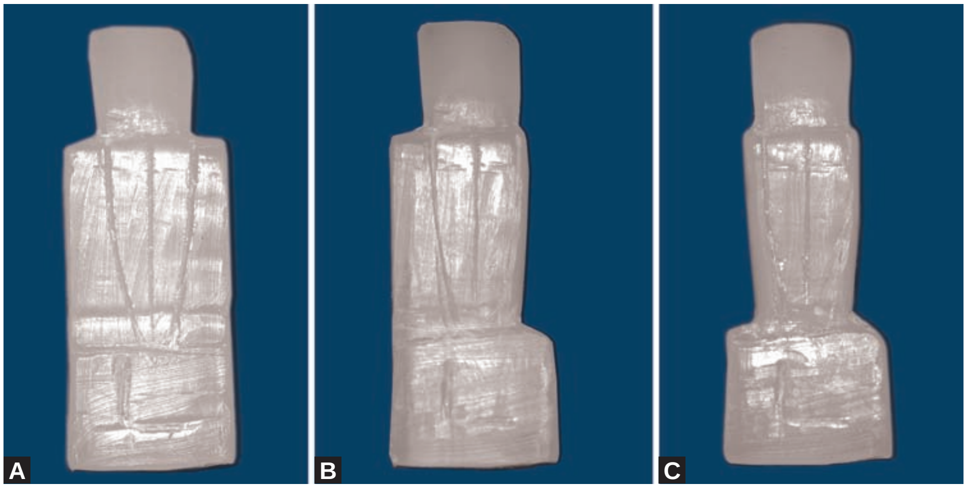


Figures 24.11A and B

Figure 24.12

Figure 24.13

Figure 24.14



Figures 24.15A to C

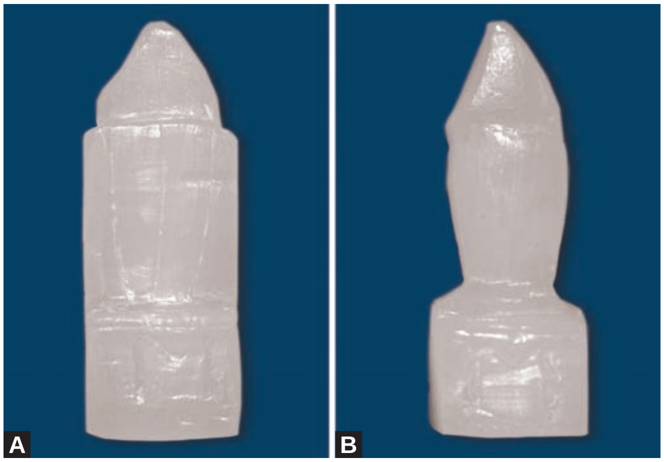
CARVING OF MAXILLARY LATERAL INCISOR (FIGS 24.18A TO E)

The procedure of maxillary lateral incisor carving is essentially similar to that of maxillary central incisors except following feature:

- Tooth dimension smaller
- Both mesioincisal and distoincisal angles of the crown are rounded with the latter being more so
- Root is slender and has distal curvature at apical third.

CARVING OF MANDIBULAR CENTRAL INCISOR (FIGS 24.19A TO E)

The basic steps remain same as that of the maxillary central incisor.



Figures 24.16A and B

Facts to keep in mind:

- Crown is smaller mesiodistally and bilaterally symmetrical
- Both incisal angles are sharp
- From incisal view, the labial ridge is perpendicular to the labiolingual bisecting line.

CARVING OF MANDIBULAR LATERAL INCISOR (FIGS 24.20A TO E)

All steps similar to that of the mandibular central incisor except that:

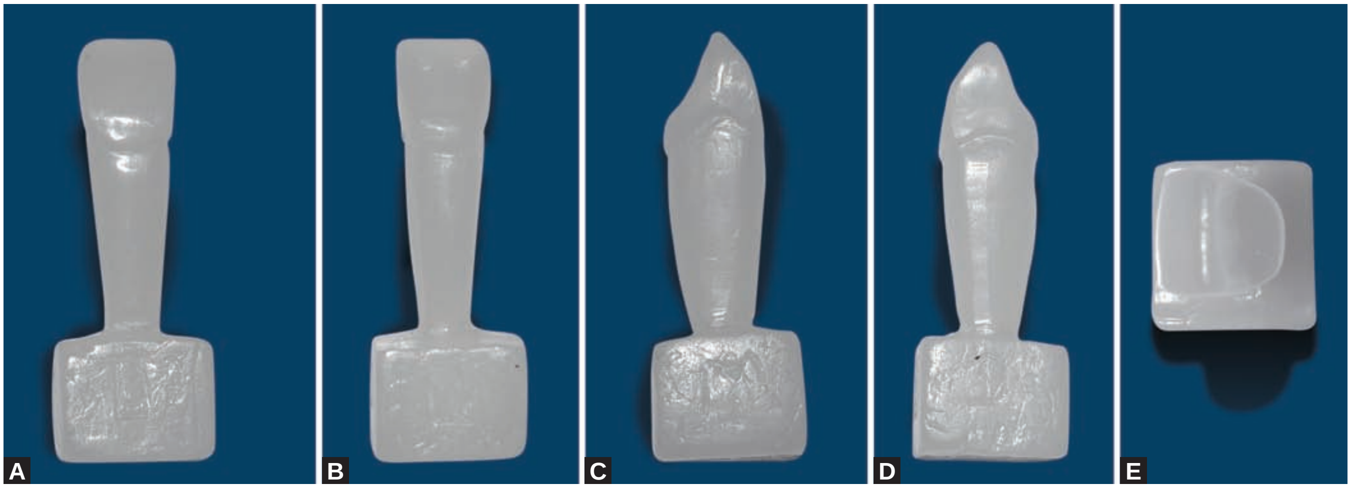
- Crown dimension is more
- Crown is bilaterally asymmetrical
- From incisal view, incisal ridge is at an angle to the labio-lingual bisecting line and curved distally.

CARVING OF MAXILLARY CANINE

All the anteriors including canine essentially have a triangular/wedge-shaped proximal form. Thus the initial step of canine carving aimed at obtaining the proximal form are similar to the technique employed for maxillary central incisor carving.

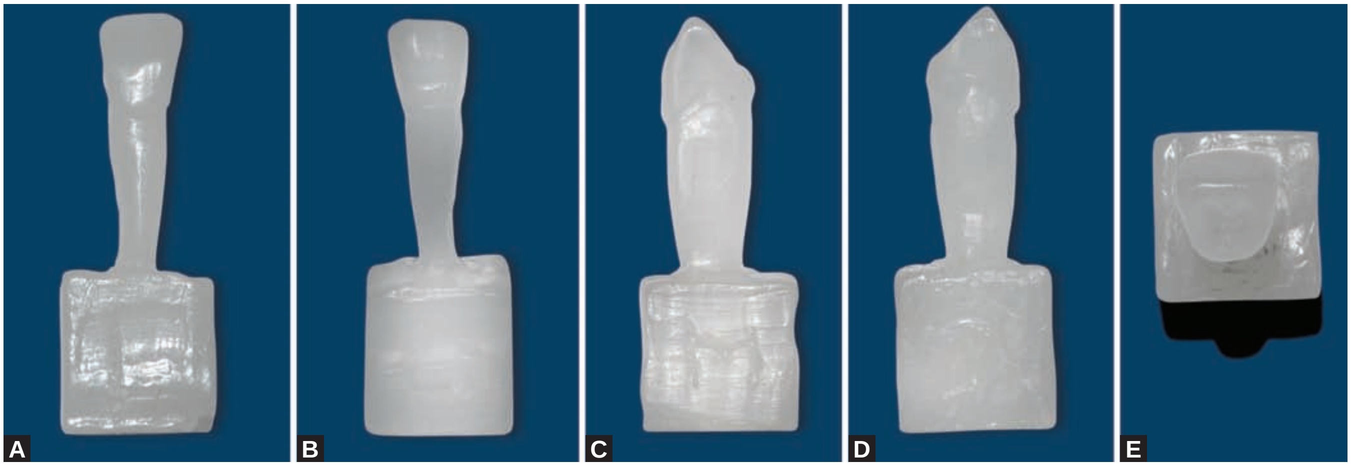
Crown Carving

- *Step1*: Obtaining triangular proximal form
  - *1A*: Marking triangular outline with conserving maximum at the cervical third for prominent cingulum (**Fig. 24.21A**)
  - *1B*: Reduction of excess wax outside the marking (**Fig. 24.21B**)
- *Step 2*: Obtaining convex labial surface (**Fig. 24.22**)

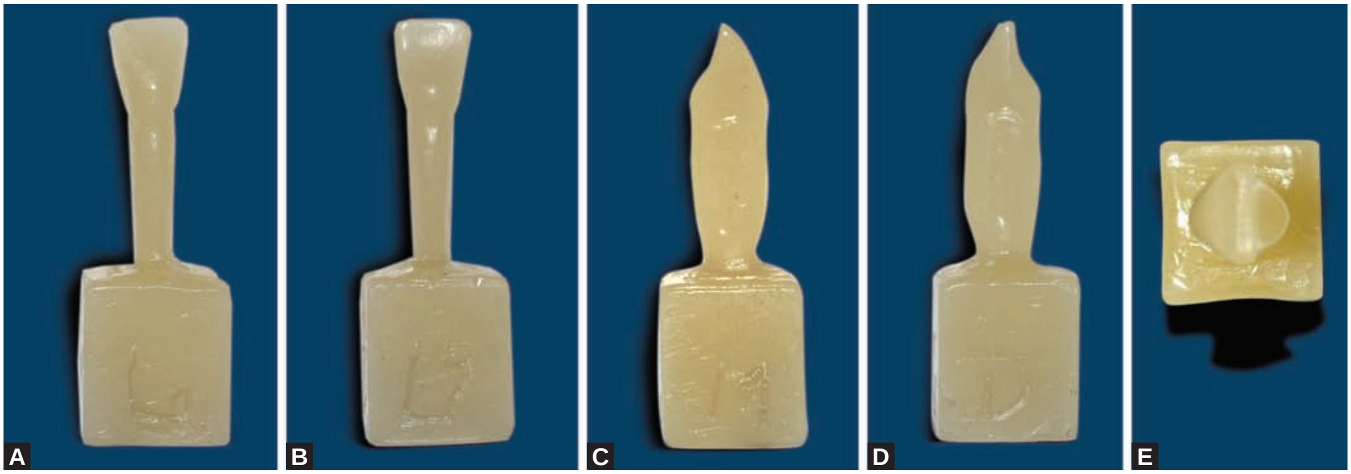


Figures 24.17A to E

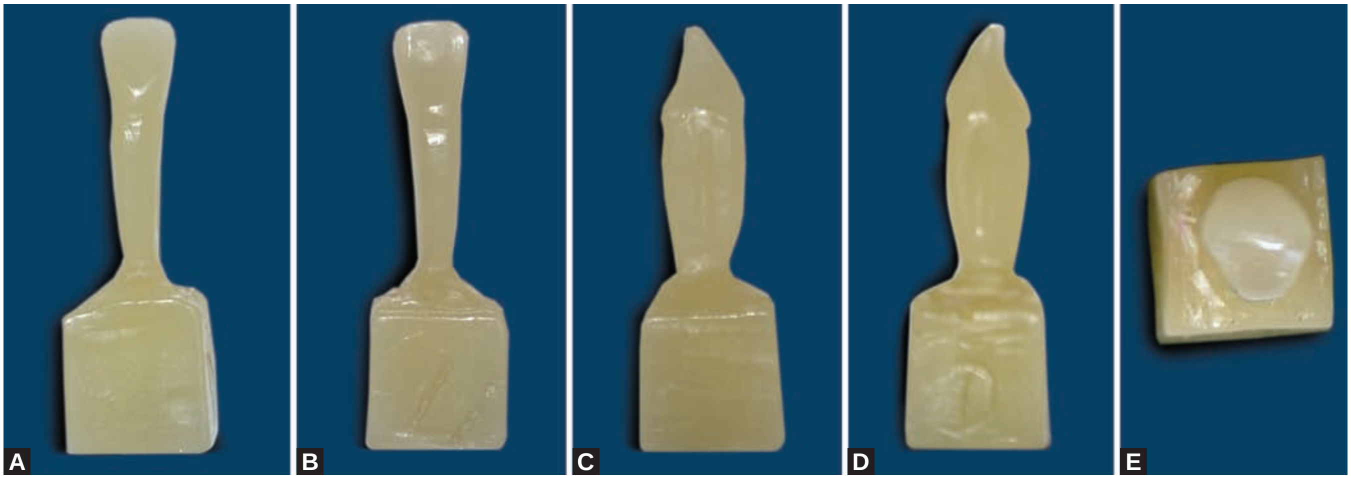
Figures 24.8 to 24.17 Stepwise procedure for carving a maxillary central incisor (See text for details of the procedure)



Figures 24.18A to E A specimen carving of maxillary lateral incisor



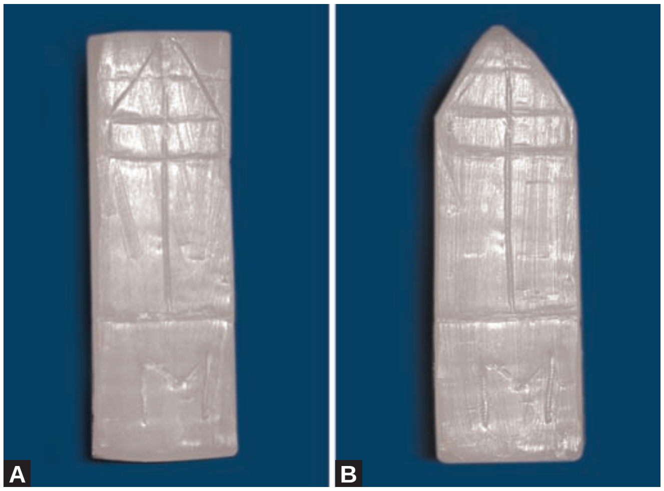
Figures 24.19A to E A specimen carving of mandibular central incisor



Figures 24.20A to E A specimen carving of mandibular lateral incisor

- *Step 3*: Obtaining concavoconvex lingual surface (**Fig. 24.23**)
  - Concave lingual foss
  - Convex and prominent cingulum
- *Step 4*: Obtaining pentagonal facial form (**Fig. 24.24**)
  - Marking pentagon on labial surface with distal cusp slope longer
  - Wax reduction outside the marking
- *Step 5*: Obtaining lingual convergence of crown (**Fig. 24.25**)
- *Step 6*: Lingual fossae carving (**Fig. 24.26**)
  - Lingual ridge divides lingual fossa into mesial and distal lingual fossae
  - Spoon shaped working end used
- *Step 7*: Finishing touches the crown (**Fig. 24.27**)
  - Rounding the line angles
  - Mesial cusp slope made concave.

Figure 24.23



Figures 24.21A and B

Figure 24.24

Figure 24.22

Figure 24.25

Figure 24.26

Figure 24.27

Root Carving

- *Step 8*: Obtaining long conical root form from labial and lingual aspects (**Figs 24.28A and B**)
- *Step 9*: Obtaining broad conical root form from proximal aspects (**Figs 24.29A and B**)
- *Step 10*: Cervical line carving and finishing (**Figs 24.30A to E**)
  - Lingual convergence of root
  - Developmental depression on mesial and distal root surface
  - Distal root curvature.

CARVING OF MANDIBULAR CANINE

The basic steps are same as that of maxillary canine, except the following:

- The labial and lingual ridges are not so prominent
- The crown is narrow but long.

Figures 24.31A to E show a specimen of mandibular canine carving.

CARVING OF MAXILLARY 1ST PREMOLAR

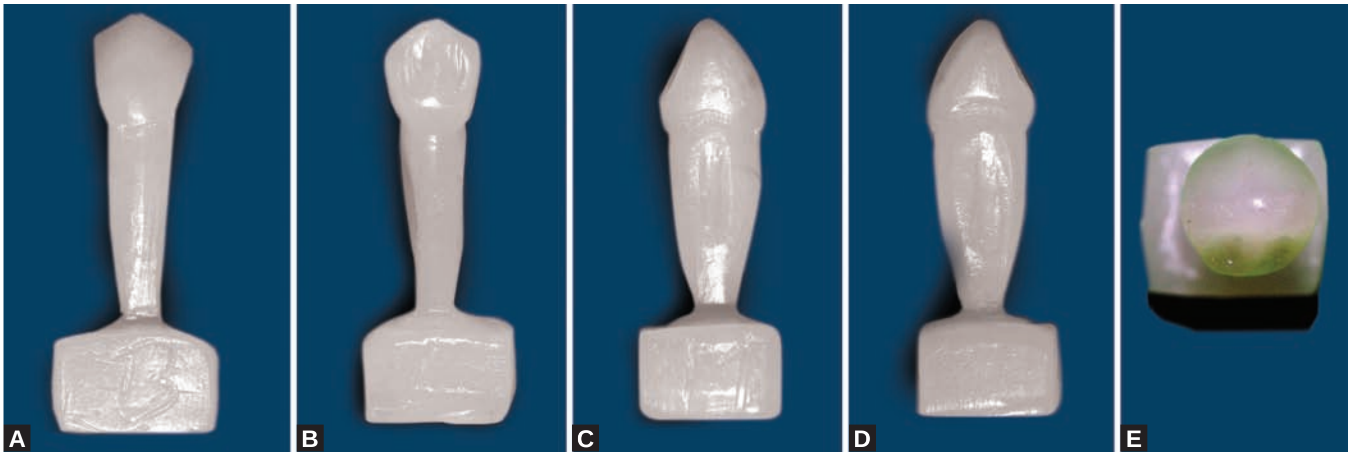
Carving procedure of posterior teeth differs from that of the anteriors in that, the occlusal surface has to be carved with all the details including the cusps, cusp ridges, triangular fossa, etc.

Premolars appear pentagonal from buccal aspect and their buccal and lingual surfaces have ridges analogous to the labial ridge found on canines. Thus, the steps used for obtaining pentagonal form; buccal and lingual ridges bear resemblance to canine carving technique.

The maxillary 1st premolar has two roots. The crown is hexagonal from the occlusal view. It has two cusps; lingual cusp being smaller.

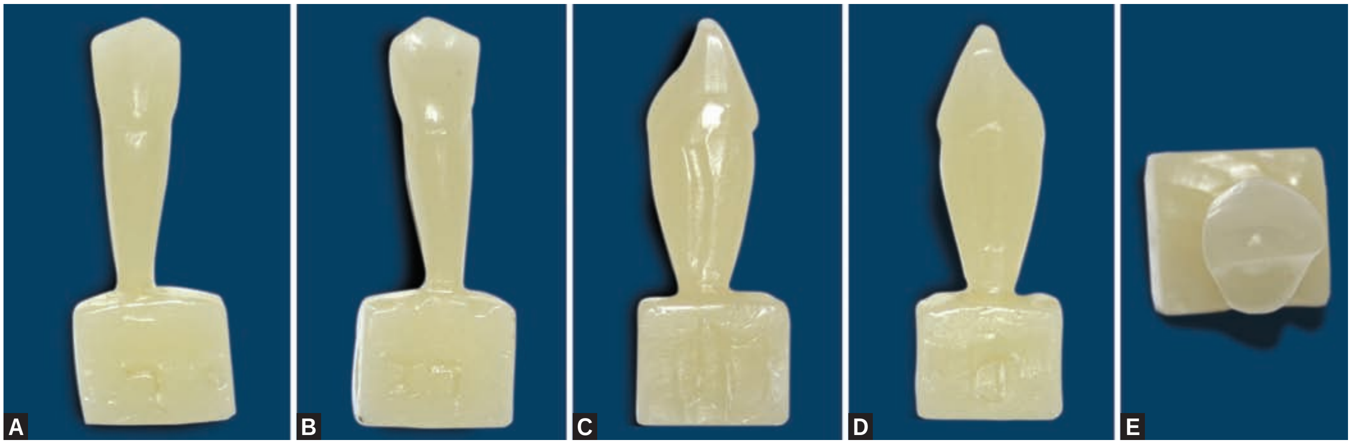
Figure 24.28A and B

Figures 24.29A and B



Figures 24.30A to E

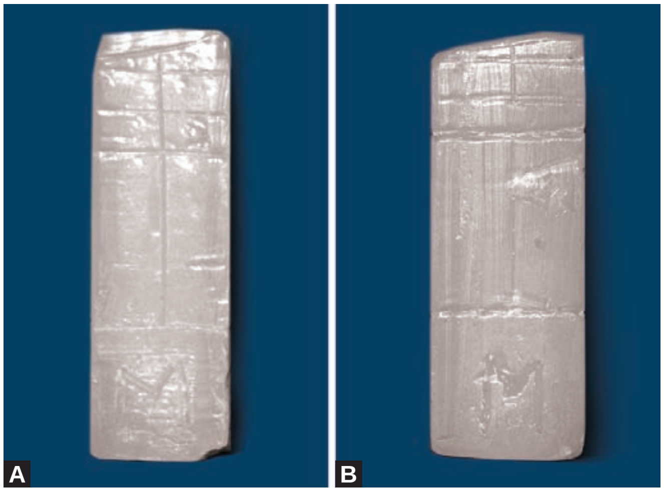
Figures 24.21 to 24.30 Stepwise procedure for carving a maxillary canine



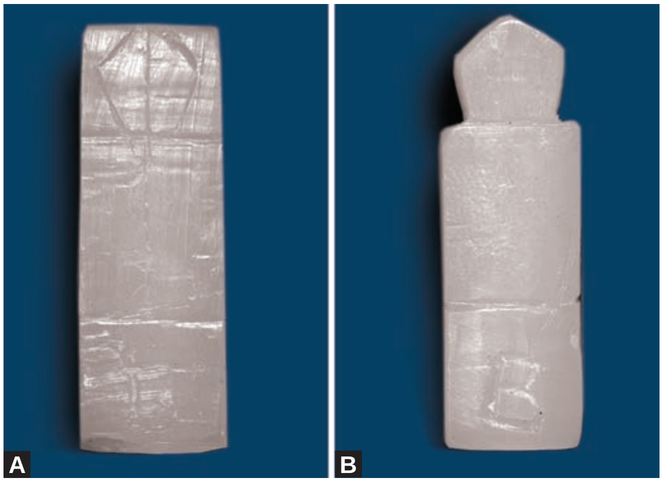
Figures 24.31A to E A specimen carving of mandibular canine

Crown Carving

- *Step 1*: Reduction of crown height lingually towards smaller lingual cusp (**Figs 24.32A and B**)
- *Step 2*: Obtaining pentagonal buccal and lingual crown form (**Figs 24.33A and B**)
  - *2A*: Marking a pentagon on labial surface with mesial cusp slope longer (**Fig. 24.33A**)
  - *2B*: Reduction of excess wax outside the marking (**Fig. 24.33B**)
- *Step 3*: Obtaining lingual convergence of crown (**Fig. 24.34** occlusal view)
- *Step 4*: Obtaining buccal and lingual contours of crown with crests of contour at cervical and middle thirds respectively (**Fig. 24.35**)
- *Step 5*: Obtaining buccal and lingual ridges by removing the wax on either side of the midline on each surface (**Figs 24.36A and B**)



Figures 24.32A and B



Figures 24.33A and B

- *Step 6*: Occlusal carving
  - *6A*: Making a 'V' shaped notch on occlusal surface with larger area for buccal cusp (**Fig. 24.37A**)
  - *6B*: Carving the cusp slopes and triangular ridges of the cusps (**Fig. 24.37B**)

Using the distal end of the knife shaped working end, strokes are given in an oblique direction from the buccal cusp towards the mesial and distal margins alternatively. This will form the inclined slopes and triangular ridge of the buccal cusp simultaneously. Same is repeated to form the lingual cusp.

Mesial and distal triangular fossae are carved, their base towards marginal ridges.

Root Carving

- *Step 7*: Obtaining conical root form from the buccal and lingual aspects (**Figs 24.38A and B**)

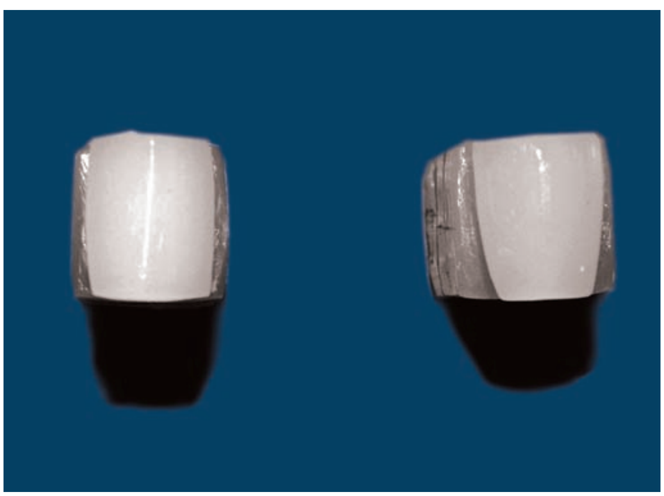
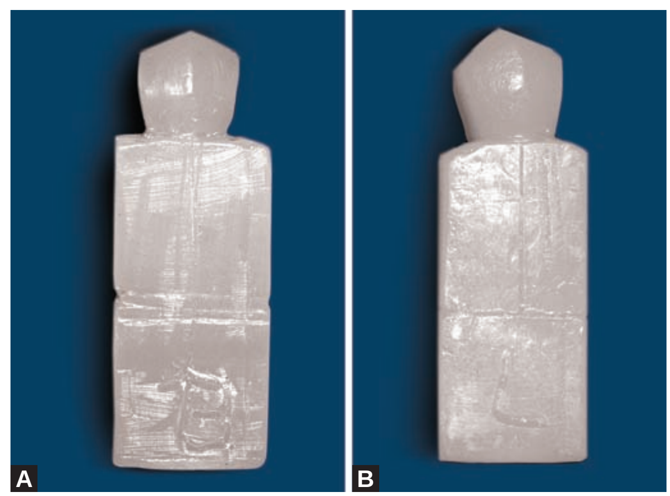
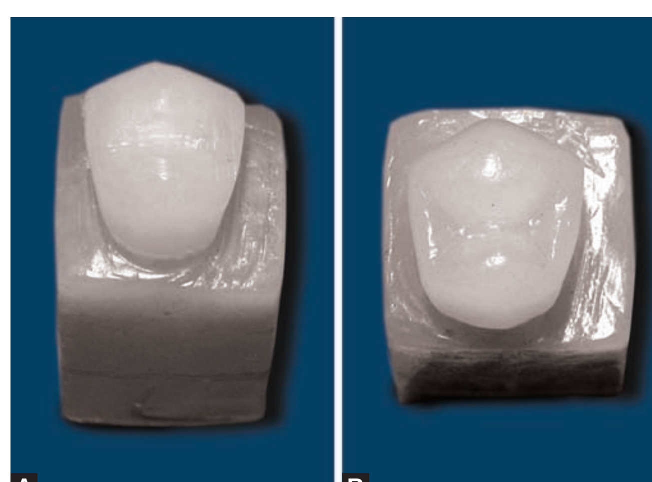


Figure 24.34



Figures 24.36A and B

Figure 24.35



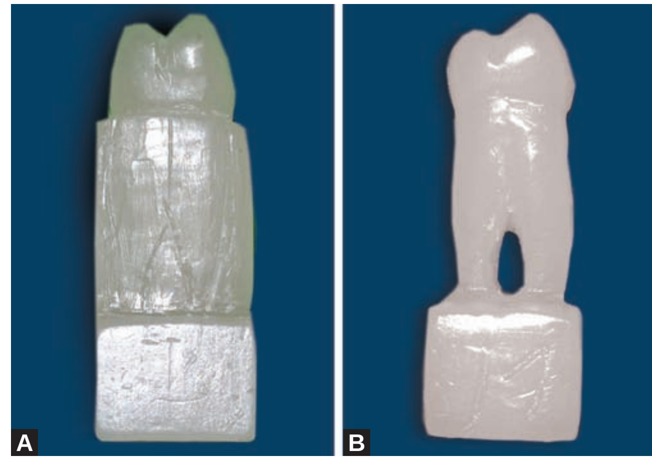
Figures 24.37A and B

- *Step 8*: Obtaining bifurcated root from the proximal aspects (**Figs 24.39A and B**)
- *Step 9*: Mesial marginal developmental groove carving (**Fig. 24.40**)
- *Step 10*: Cervical line carving and finishing (**Figs 24.41A to E**).

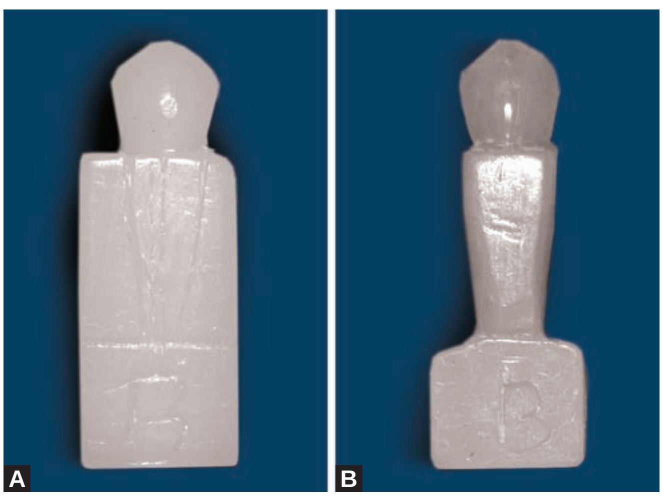
MAXILLARY 2ND PREMOLAR CARVING

Carving technique for maxillary 2nd premolar is similar to that of maxillary 1st premolar with following changes:

- Both the cusps are same in height, so the occlusal slope is carved
- Single root
- Crown oval and not angular, and has many supplemental grooves giving a wrinkled appearance.



Figures 24.39A and B



Figures 24.38A and B

Figure 24.40

Figures 24. 41A to E

Figures 24.32 to 24.41 Stepwise procedure for carving a maxillary 1st premolar

Figures 24.42A to E show a specimen of carving of maxillary 2nd premolar.

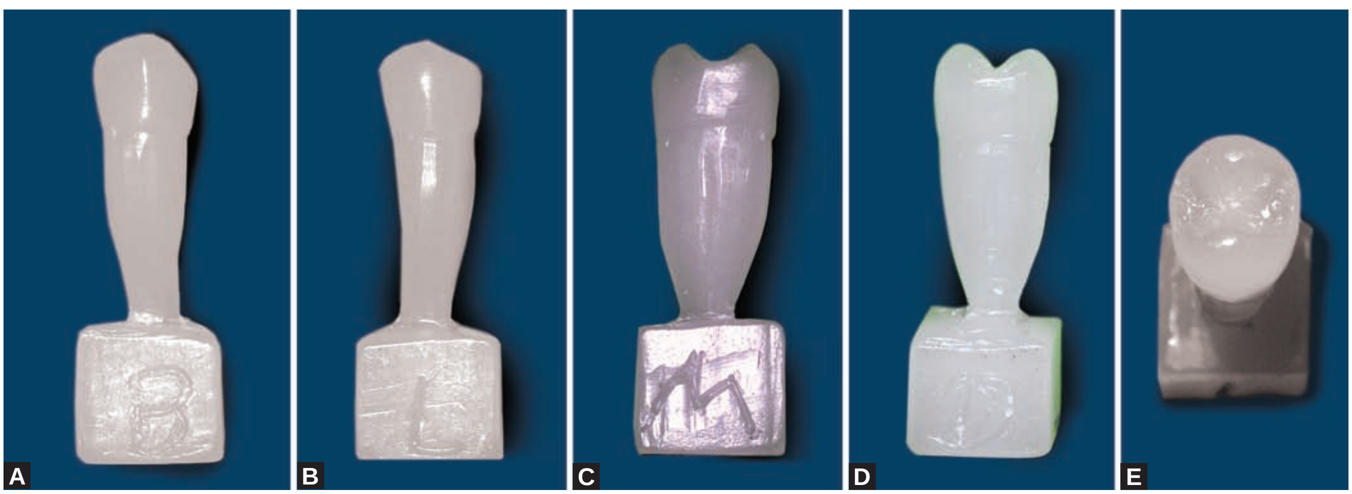
CARVING A MANDIBULAR 1ST PREMOLAR

Carving technique for mandibular premolars differs from that of maxillary premolars in that, the mandibular premolars have their crowns lingually inclined over the root base.

The mandibular premolar has a small lingual cusp and its buccal cusp tip is in line with the vertical root axis.

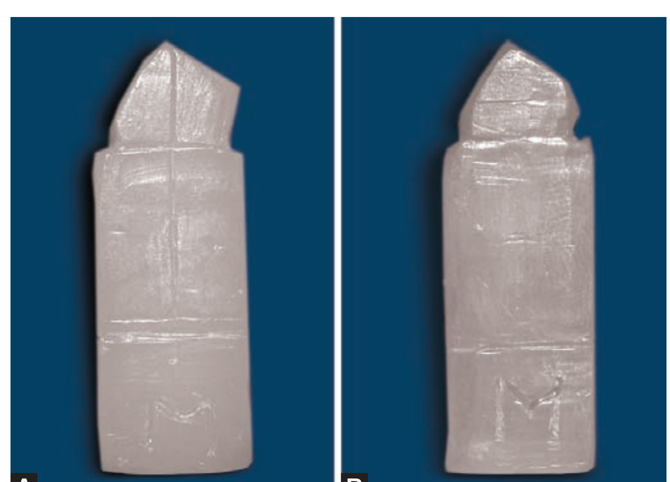
Crown Carving

- *Step 1*: Obtaining rhomboidal proximal form (**Figs 24.43A and B**)
  - *1A*: Marking a rhombus on the mesial surface with lingually slanting occlusal table. Buccal cusp tip should come at midline
  - *1B*: Removal of excess wax outside the margin
- *Step 2*: Obtaining crests of buccal and lingual contours at cervical and middle thirds respectively (**Figs 24.44A and B**)
- *Step 3*: Obtaining pentagonal crown from buccal and lingual aspects (**Figs 24.45A and B**)
  - *3A*: Marking a pentagon on buccal surface of the crown
  - *3B*: Reduction of excess wax outside the marking
- *Step 4*: Obtaining buccal and lingual ridges **(Fig. 24.46)**
- *Step 5*: Obtaining lingual convergence of crown (**Fig. 24.47**)

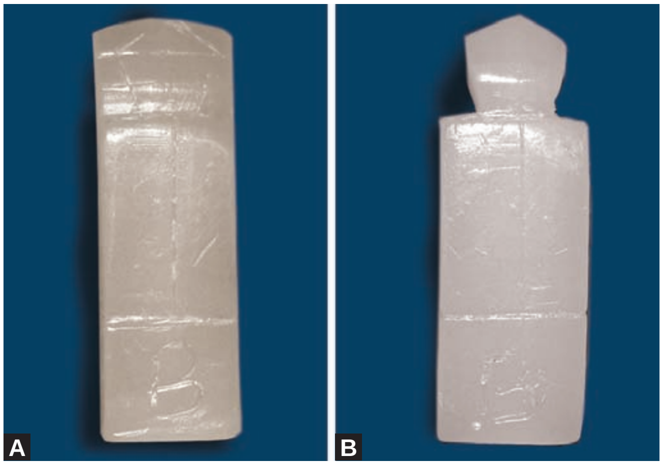


Figures 24.42A to E A specimen carving of maxillary 2nd premolar

Figures 24.43A and B



Figures 24.44A and B



Figures 24.45A and B

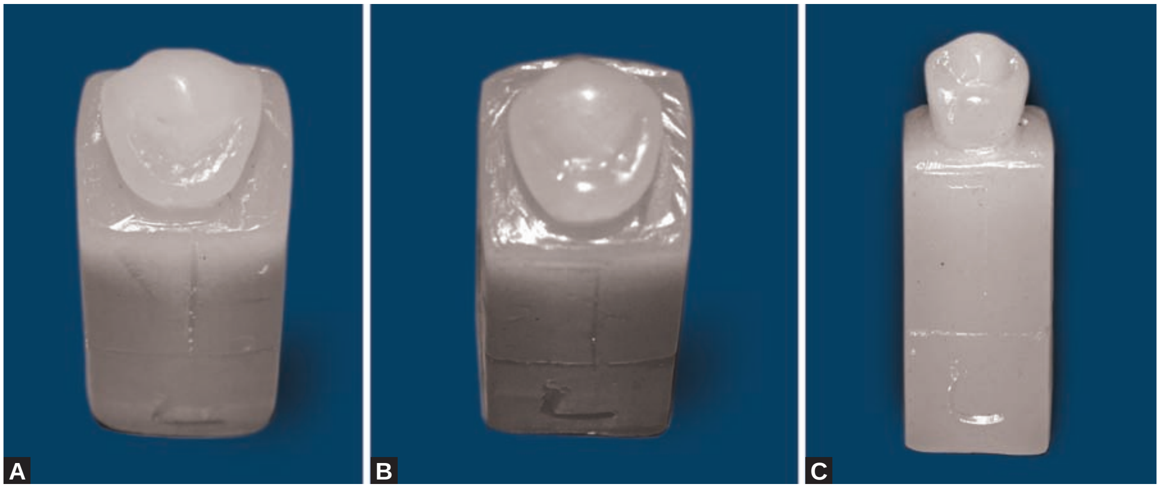
- *Step 6*: Occlusal carving (**Figs 24.48A to C**)
  - *6A*: Marking 'V' shaped notch on the occlusal surface with three-fourth area towards the buccal cusp portion (**Fig. 24.48A**)
  - *6B*: Carving the cusp slopes, inclined planes and the triangular ridges of cusps. Triangular ridge of the lingual cusp is not prominent (**Fig. 24.48B**)
  - *6C*: Carving the mesiolingual developmental groove (**Fig. 24.48C**)

Root Carving

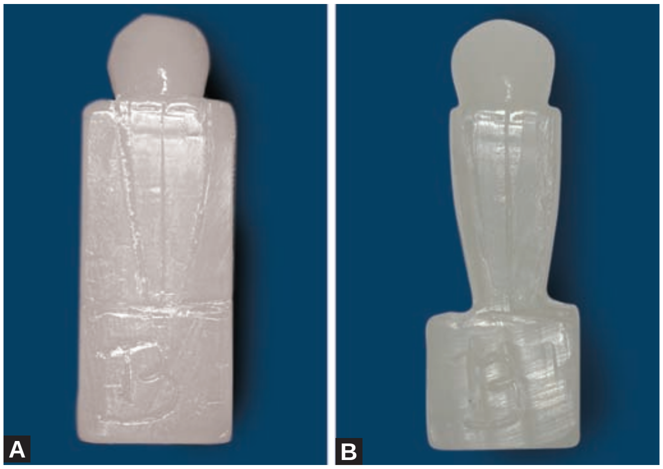
- *Step 7*: Obtaining conical root form from buccal and lingual aspects (**Figs 24.49A and B**)
- *Step 8*: Obtaining broad conical root form from proximal aspects (**Figs 24.50A and B**)
- *Step 9*: Cervical line carving and finishing (**Figs 24.51A to E**).

Figure 24.46

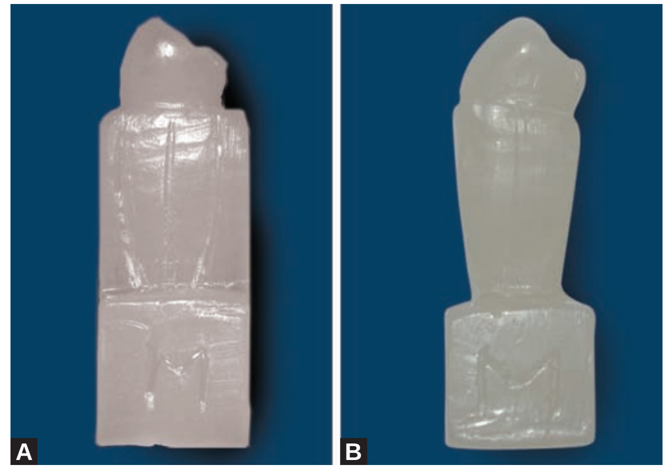
Figure 24.47



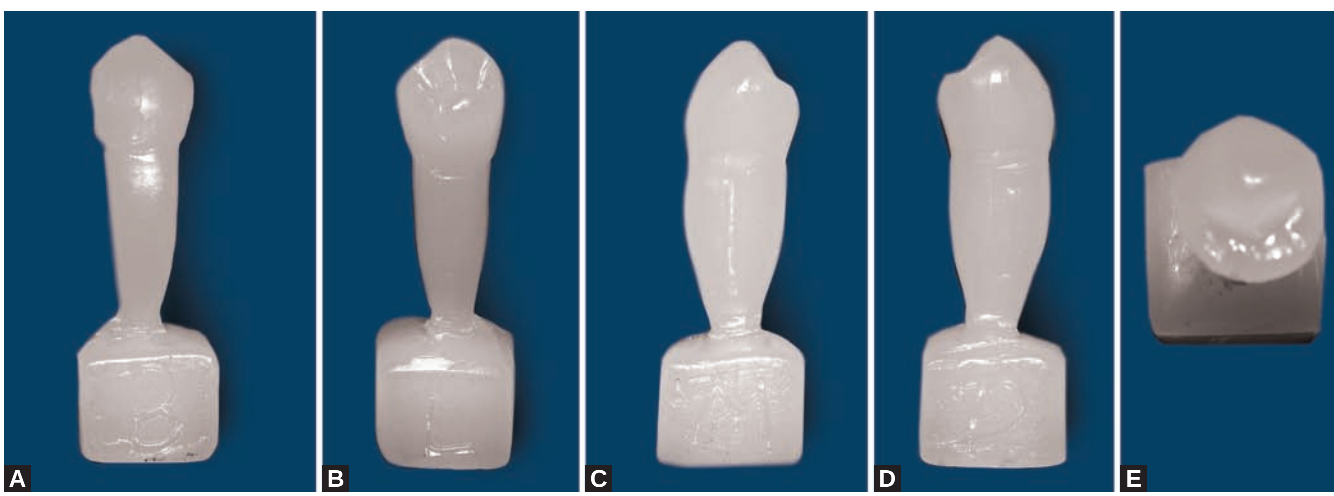
Figures 24.48A to C



Figures 24.49A and B



Figures 24.50A and B



Figures 24.51A to E

Figures 24.43 to 24.51 Stepwise procedure for carving a mandibular 1st premolar

CARVING OF MANDIBULAR 2ND PREMOLAR

Mandibular 2nd premolar has a slight lingual crown tilt over the root base. The crown may have three cusps or two cusps. Lingual cusp is sharp, well developed and lingual crown convergence is not marked.

Basic procedure is similar to that of mandibular 1st premolar carving, with some differences in the occlusal carving.

Crown Carving

- *Step 1*: Obtaining rhomboid proximal crown form with slight lingual crown tilt over the root base (**Figs 24.52A and B**)

Figures 24.52A and B

- *Step 2*: Obtaining crest of the buccal and lingual contours at the cervical third and middle third respectively (**Fig. 24.53**)
- *Step 3*: Obtaining pentagonal crown form from the facial aspect (**Figs 24.54A and B**)
- *Step 4*: Obtaining the buccal and lingual ridges (**Fig. 24.55**)
- *Step 5*: Occlusal carving (**Figs 24.56A and B**)
  - *5A*: Marking a 'Y' shaped notch on the occlusal surface dividing the lingual portion into two parts for mesiolingual and distolingual cusps.
  - *5B*: Carving cusp slopes, inclined planes and the lingual ridges of each cusp.

Root Carving

Root carving is similar to that of the mandibular 1st premolar:

- *Step 6*: Obtaining conical root form from buccal and the lingual aspects (**Figs 24.57A and B**)
- *Step 7*: Obtaining conical root form from the proximal aspects (**Figs 24.58A and B**)
- *Step 8*: Cervical line carving and finishing (**Figs 24.59A to E (i)**)

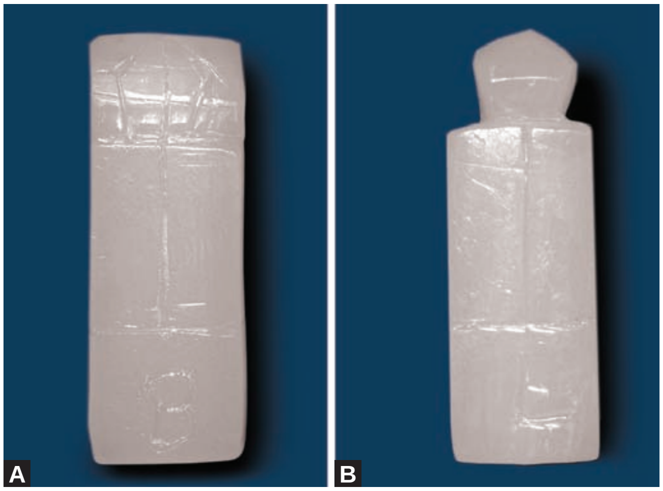
Figure 24.59E (ii) shows occlusal view of two cusp type of the mandibular 2nd premolar with 'U' and 'H' shaped occlusal groove pattern; and three cusp type with 'Y' shaped groove pattern.

CARVING A MAXILLARY 1ST MOLAR

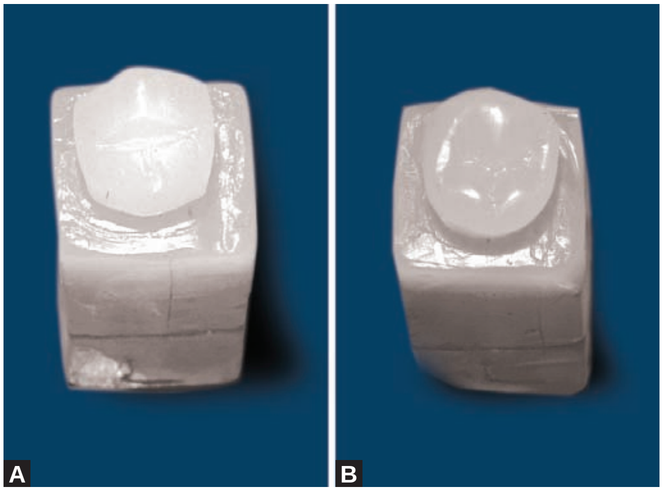
Molars have broad occlusal table with four to five cusp. Maxillary 1st molar has five cusps and three roots.

Figure 24.53

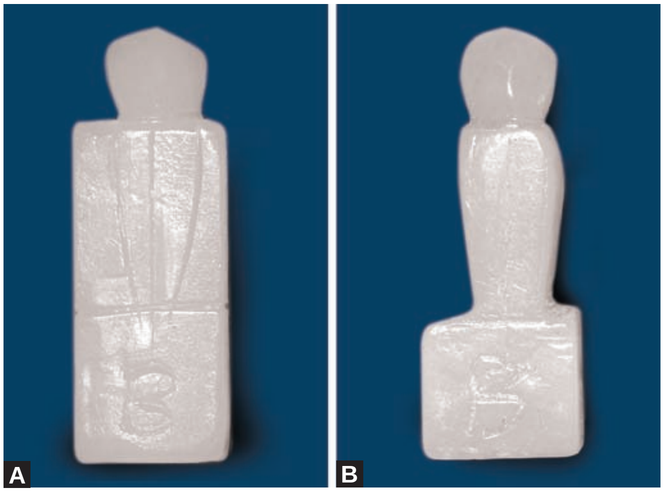
Figure 24.55



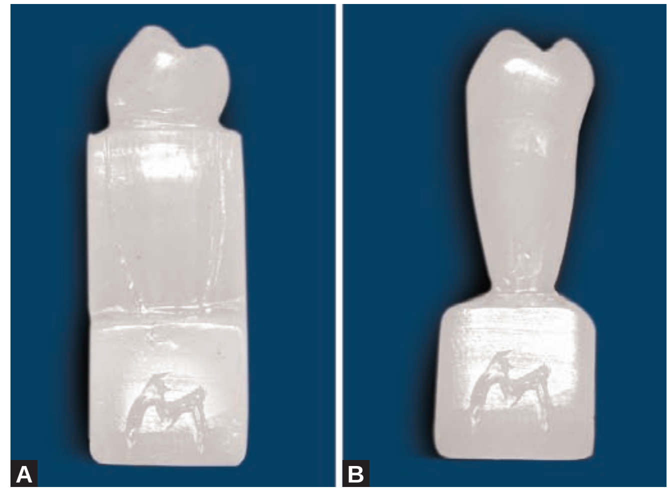
Figures 24.54A and B



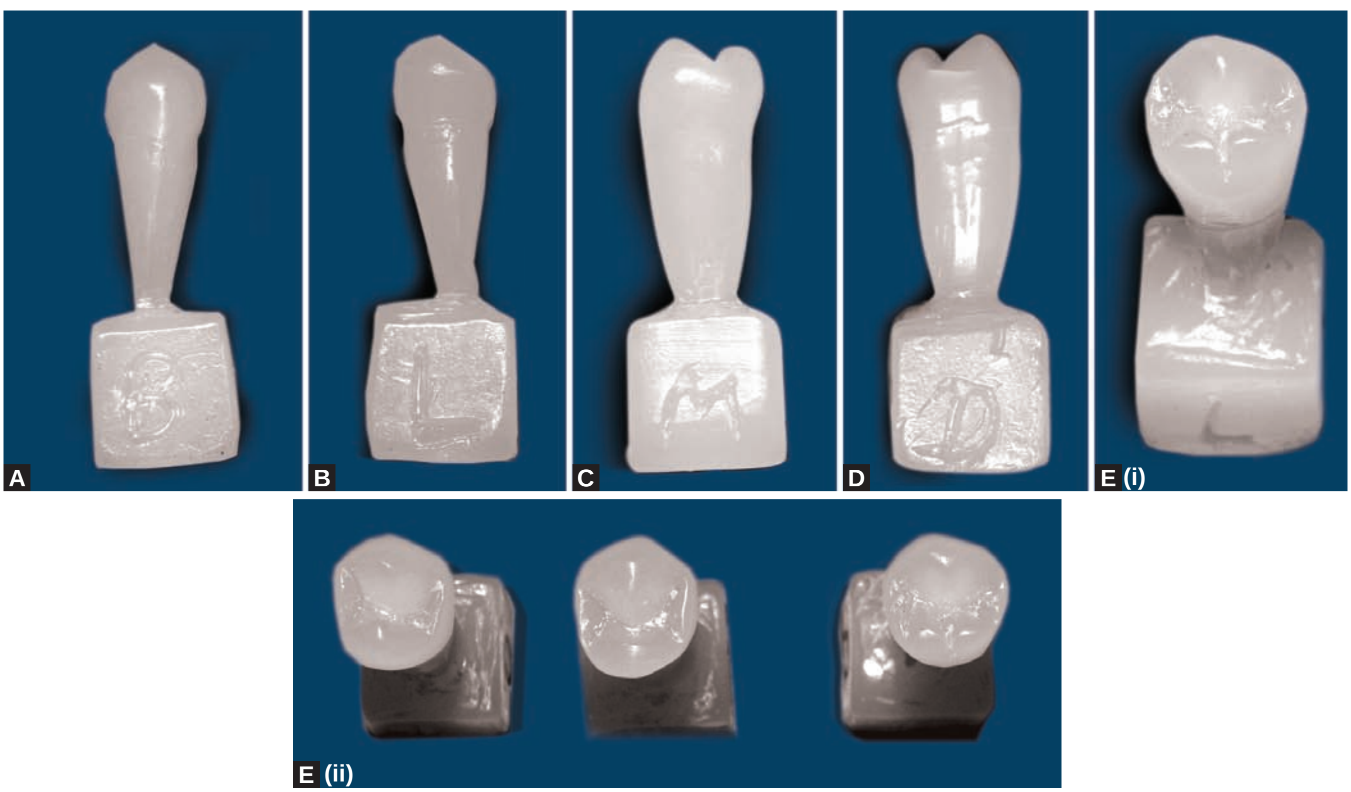
Figures 24.56A and B



Figures 24.57A and B



Figures 24.58A and B



Figures 24.59A to E

Figures 24.52 to 24.59 Stepwise procedure for carving a mandibular 2nd premolar

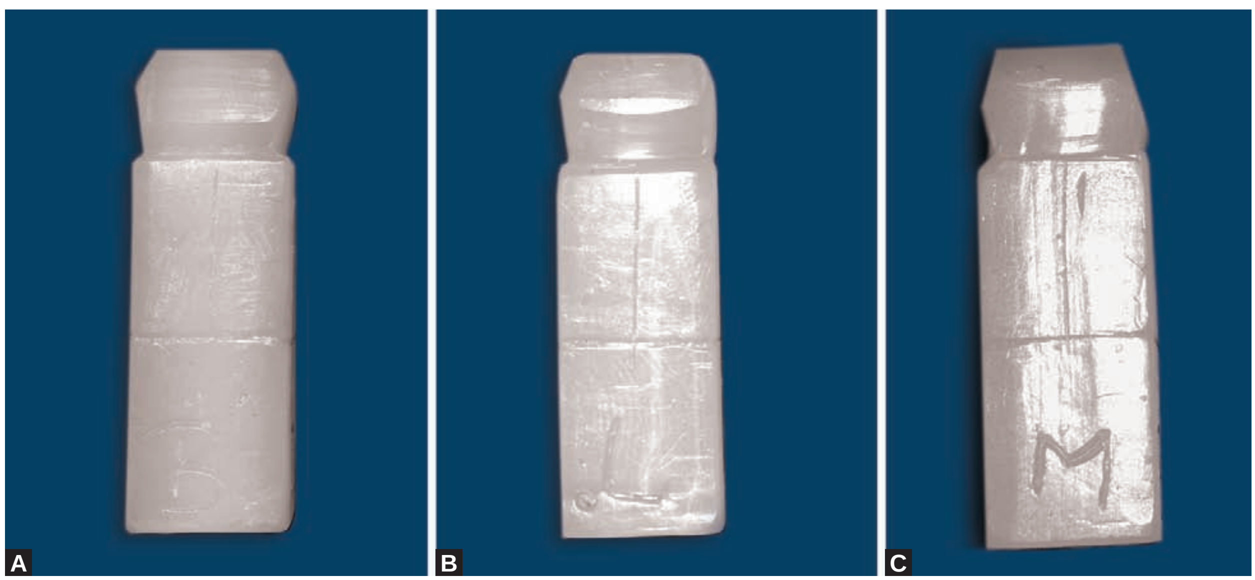
Crown Carving

- *Step 1*: Obtaining crest of curvature on buccal (at cervical third), lingual (at middle third) and proximal (at occlusal third) surfaces (**Figs 24.60A to C**)
  - At the end of this step we get a proximal trapezoidal form
- *Step 2*: Obtaining rhomboidal occlusal form with two acute and two obtuse angles (**Figs 24.61A and B**)
- *Step 2A*: Rounding off mesiolingual and distobuccal line angles to make them obtuse
- *Step 2B*: Tapering the buccal surface towards distal.

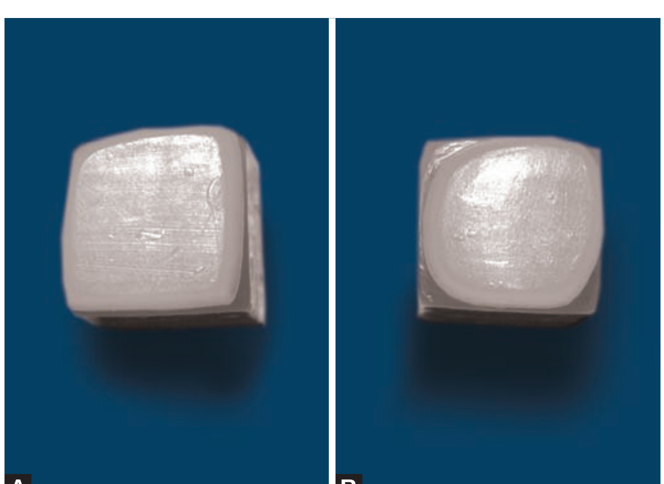
Occlusal Carving

- *Step 3*: Marking of the developmental grooves on occlusal surface (**Fig. 24.62**)
- *Step 4*: Division of occlusal table into buccal and lingual portions which slope towards the center (**Fig. 24.63**)
- *Step 5*: Carving four major cusps with their inclined planes and triangular ridges (**Fig. 24.64**).

This is done by giving obliquely directed strokes on either side of each cusp tip using the distal end of the carver's knife shaped working end.



Figures 24.60A to C



Figures 24.61A and B

Figure 24.62

- *Step 6*: Carving the oblique ridge by merging distal cusp ridge of mesiolingual cusp and triangular ridge of distobuccal cusp (**Fig. 24.65**)
- *Step 7*: Cusp of Carabelli carving and finishing the crown with highlighting all grooves, triangular fossae and ridges (**Fig. 24.66**).

Root Carving

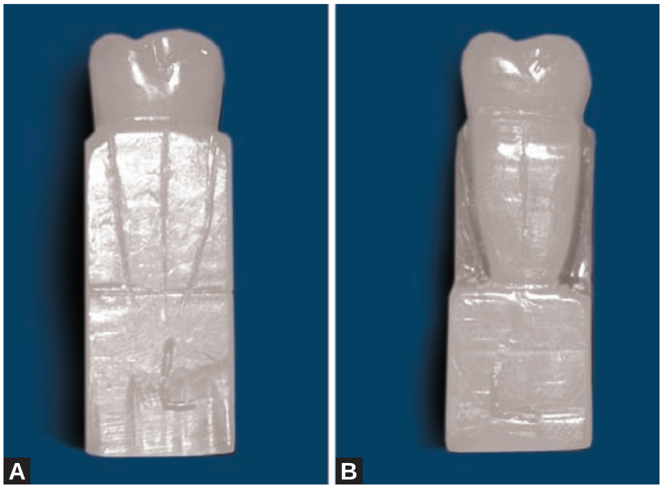
- *Step 8*: Division of the root portion into buccal and palatal halves. Obtaining the conical lingual root form from the lingual aspect (**Figs 24.67A and B**)
- *Step 9*: Obtaining two buccal roots from the buccal aspect (**Figs 24.68A and B**)
- *Step 10*: Finishing the carving with cervical line marking and rounding all the line angles (**Figs 24.69A to E**).

Figure 24.65

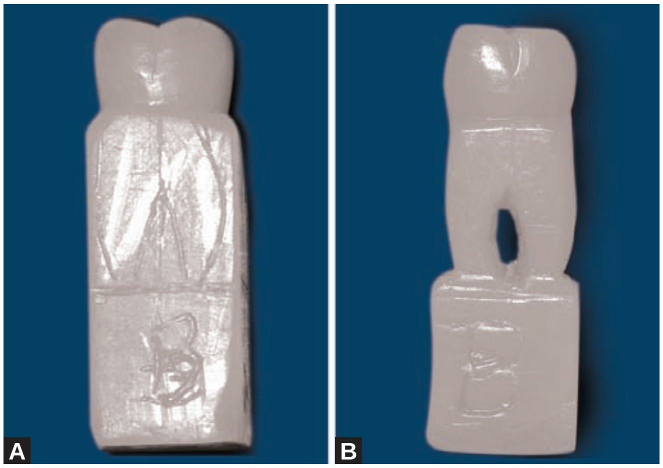
Figure 24.63

Figure 24.66

Figure 24.64



Figures 24.67A and B



Figures 24.68A and B

CARVING OF MAXILLARY 2ND MOLAR

The carving procedure differs from that of the maxillary 1st molar in that:

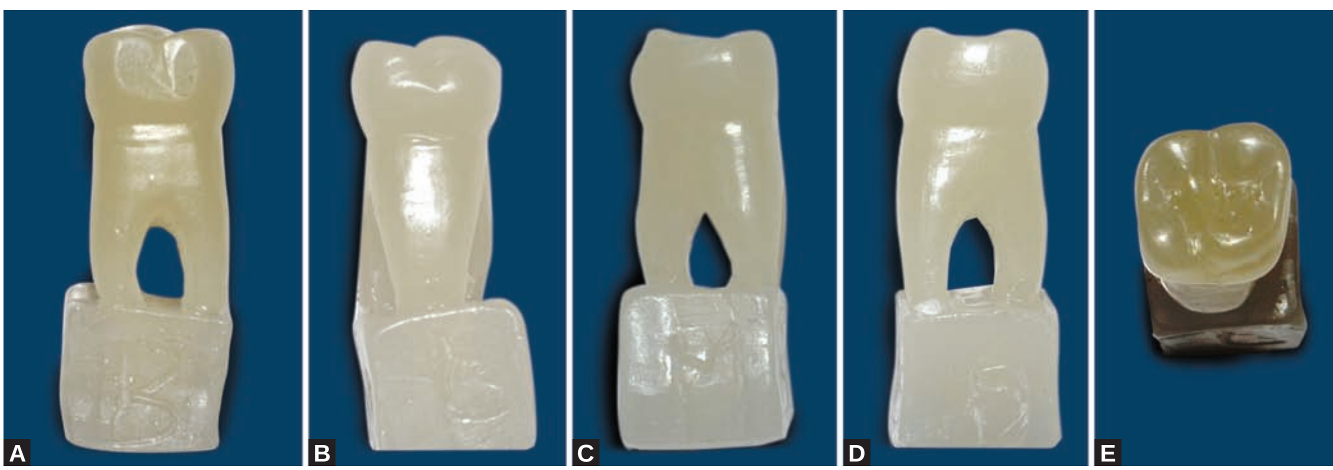
- No cusp of Carabelli
- Oblique ridge is less prominent
- Distolingual cusp is smaller
- Roots are parallel, less divergent and curve more distally. **Figures 24.70A to E** show a specimen carving.

CARVING A MANDIBULAR 1ST MOLAR

Mandibular 1st molar is bifurcated and has five cusps.

Crown Carving

- *Step 1*: Obtaining the crest of curvature on buccal (at cervical third), lingual (at middle third) and proximal (at occlusal third) surfaces (**Figs 24.71A to C**)



Figures 24.69A to E

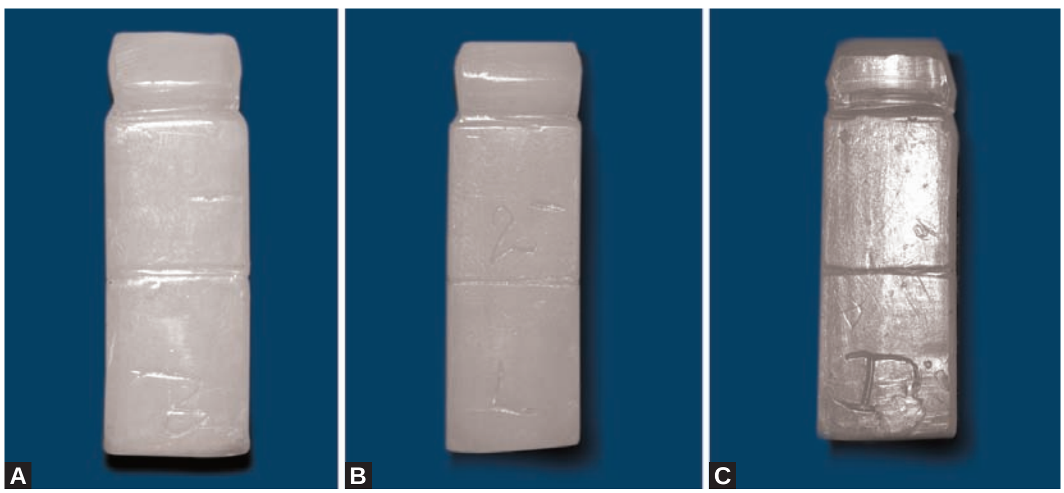
Figures 24.60 to 24.69 Stepwise procedure for carving a maxillary 1st molar

Figures 24.70A to E A specimen carving of maxillary 2nd molar

- *Step 2*: Obtaining rhomboidal proximal form by slanting the buccal surface above the cervical ridge (**Fig. 24.72**)
- *Step 3*: Obtaining mandibular occlusal form by rounding all the line angles and lingual convergence of the crown (**Fig. 24.73**)
- *Step 4*: Division of the occlusal table into buccal and lingual halves which slopes towards the central developmental groove (**Figs 24.74A and B**)
- *Step 5*: Division of occlusal table into five portions for five cusps and marking the developmental grooves and triangular fossae (**Fig. 24.75**)
- *Step 6*: Carving the five cusps with their inclined planes and triangular ridges (**Fig. 24.76**)
- *Step 7*: Finishing the crown by deepening the developmental grooves and carving the triangular fossae (**Figs 24.77A to C**).

Root Carving

- *Step 8*: Obtaining the conical root form from the proximal aspects (**Figs 24.78A and B**)
- *Step 9*: Obtaining bifurcated roots from the buccal and lingual aspects (**Figs 24.79A and B**)



Figures 24.71A to C

Figure 24.72

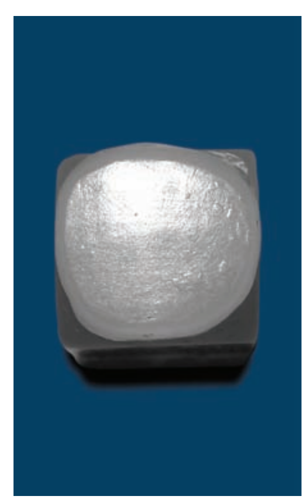
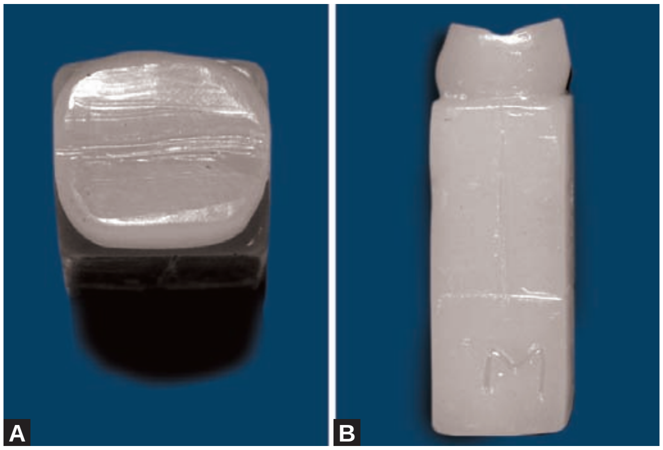


Figure 24.73



Figures 24.74A and B

- *Step 10*: Finishing the carving by rounding the line angles and carving the cervical lines (**Figs 24.80A to E**).

CARVING OF MANDIBULAR 2ND MOLAR

While carving the mandibular 2nd molar, the following differences are to be considered:

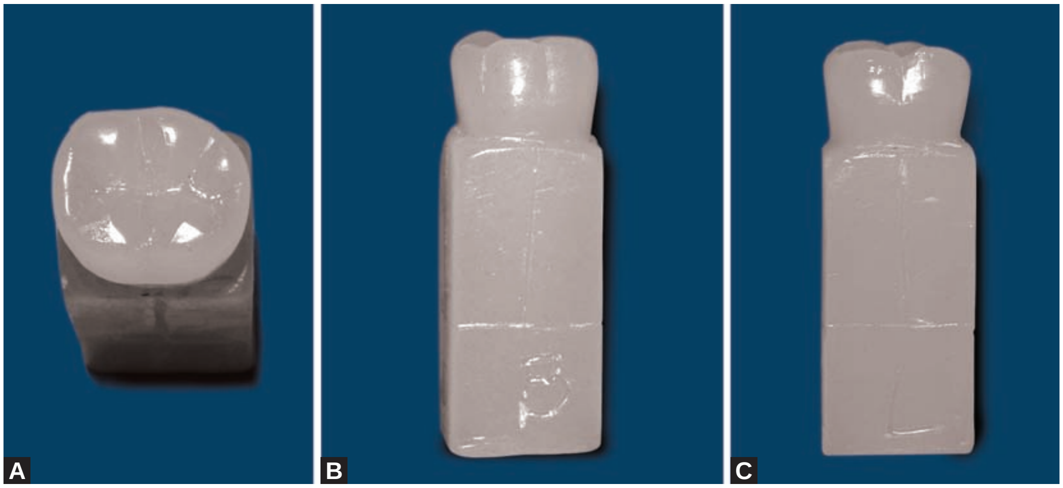
- No distal cusp
- Crown has a rectangular occlusal form
- There is a bulge at the mesiobuccal line angle cervically
- Roots are less spaced.

Figures 24.81A to E show a specimen carving.

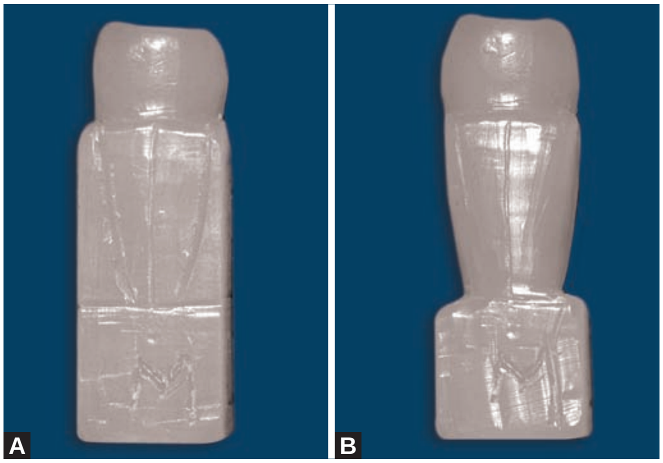
The finished carvings can be preserved and displayed by arranging them in dental arch form as shown in **Figure 24.82**.

Figure 24.75

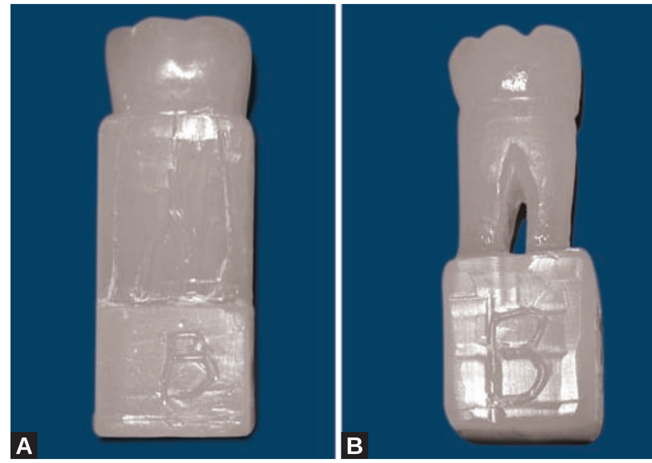
Figure 24.76



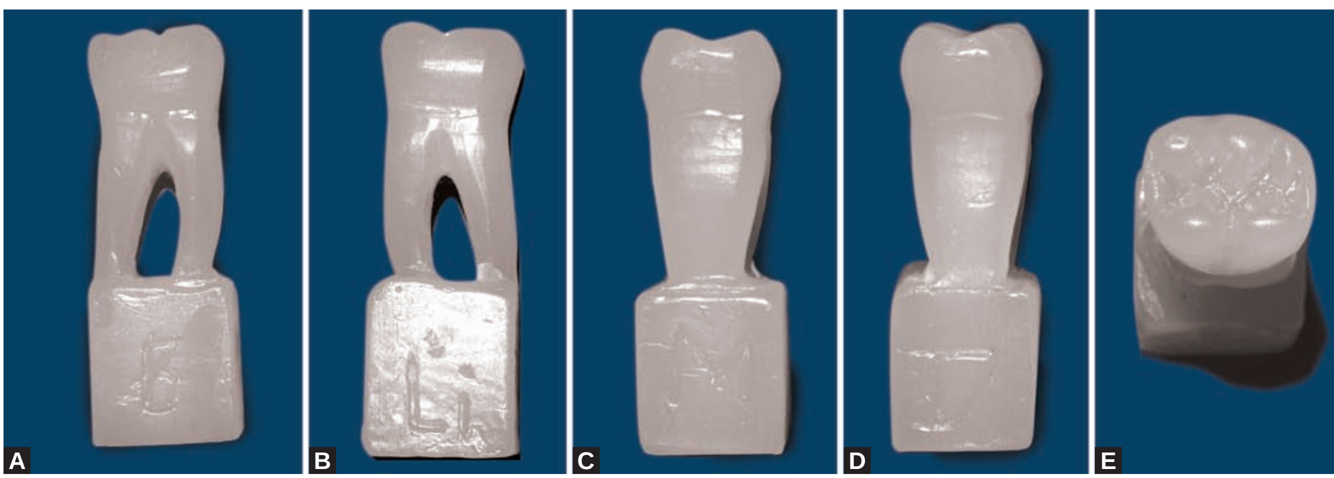
Figures 24.77A to C



Figures 24.78A and B



Figures 24.79A and B



Figures 24.80A to E

Figures 24.71 to 24.80 Stepwise procedure for carving a mandibular 1st molar

Figures 24.81A to E A specimen carving of mandibular 2nd molar

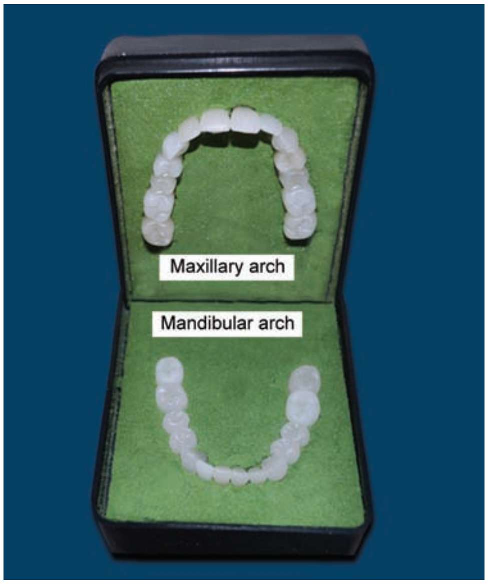


Figure 24.82 Preservation and display of tooth carvings

BIBLIOGRAPHY

1. Dental Functional Morphology: How Teeth Work (Cambridge Studies in Biological and Evolutionary Anthropology), Peter W Lucas, Cambridge University Press. 2004;1.
2. Nature's Morphology: An atlas of tooth shape and form, Shigeo Kataoka, Yoshimi Nishimura and Avishai Sadan, Quintessence Publishing (IL). 2002;1.
3. Rantanen AV. A study of variation in tooth carvings European Journal of Oral Sciences. 1970;78(1-4):28-33.
4. Siésseree S, et al. Educational Material of Dental Anatomy Applied to Study the Morphology of Permanent teeth. Braz Dent J. 2004;15(3):238-42.

MULTIPLE CHOICE QUESTIONS

1. The methods used for tooth carving include:
   a. Wax reduction method
   b. Wax addition method
   c. Both a and b
   d. None of the above
2. The type of instrument grasp ideal for holding the carver is:
   a. Pen grasp
   b. Modified pen grasp
   c. Palm and thumb grasp
   d. Any of the above
3. Tooth carving exercises help in:
   a. Understanding the morphology of teeth in 3-dimensions
   b. Improves hand dexterity
   c. Improves clinical practice
   d. All of the above
4. How many aspects of a tooth are depicted while drawing a tooth?
   a. 2 aspects
   b. 3 aspects
   c. 4 aspects
   d. 5 aspects
5. The material commonly used to carve the tooth is:
   a. Modeling wax block
   b. Paraffin wax block
   c. Modeling clay
   d. Impression compound

Answers

1. c 2. b 3. d 4. d 5. b

Index

Page numbers followed by ***f*** refer to figure and ***t*** refer to table

A

Accessory
  canals 234
  foramina 234
  muscles of mastication 297
Adolf Zsigmondy 24
Advance bell stage 36
Advantages of universal numbering system 23
Afferent fibers 289
Alveolar process 280, 282
Alveoli of mandibular teeth 285*f*
Ameloblasts 36
Amelogenesis imperfecta 33, 34*f*
American
  Dental Association 22, 24
  Society of Forensic Odontology 22
Anastomoses of infraorbital nerve 290, 291
Angle's key of occlusion 197*f*
Angular gyrus 300
Anterior
  belly of digastric muscles 285
  centric occlusal contacts 316
  palatine nerve 290
  teeth 56
Anteroposterior curve 60, 318
Anterosuperior alveolar nerve 290, 291
Antrum of Highmore 281
Apex 74, 123, 132, 177
  of root 15
Apical foramen 15, 234
Arrangement in dental arches 4
Arterial supply of dento-osseous structures 286*f*
Articular
  eminence 295*f*
  surfaces of TMJ 295*f*
Auriculotemporal nerve 292

B

Bilateral balanced occlusion 305
Bite marks 331
Body of maxilla 281, 281*f*
Boley's gauge 16, 342
Bone
  of neurocranium 280
  remodeling 37
Bony fishes 326
Bosworth system 22
Boundaries of occlusal surface 161, 194, 216
Branches of maxillary artery 286
Broca's area 300
Buccal
  aspect 85, 88, 90, 95, 157, 163, 173, 179, 189, 197, 204, 212, 219, 224
  cusp ridge 12
  developmental groove 88, 90, 190, 195, 199, 224
  pit 15
  ridge 159
  triangular ridge 162
Buccolingual diameter of crown 19, 157, 172, 180, 189, 200, 206
Buccopharyngeal membrane 33
Bud stage 35
Bundle bone 282

C

Canine 5
  eminence 141, 281
    of mandible 284
  fossa 281
  protected occlusion 306
Cap stage 35
Carabelli's
  cusp 334
  trait 189, 189*f*, 192, 196, 334
Carnivorous mammals 327
Cartilaginous fishes 326
Carving of
  mandibular
    1st molar 360
    1st premolar 353
    2nd molar 362
    2nd premolar 355
    canine 349
    central incisor 346
    lateral incisor 346
  maxillary
    1st molar 356
    1st premolar 349
    2nd molar 360
    canine 346
    central incisor 344
    lateral incisor 346
Categories of teeth 333
Cementoenamel junction 37
Cementum 9
Central
  developmental groove 88, 90, 96, 162, 184, 195, 224
  fossa 14, 90
  pit 184, 195
Centric
  holding cusp 315
  occlusal contacts 316
Cervical ridge 12
Cervicoincisal length of crown 128, 150
Cervico-occlusal length of crown 157, 172, 180, 189, 200, 206
Chronology of
  permanent dentition 45*t*
  primary
    dentition 41*t*
    teeth 70*t*
  tooth development 31, 33
Cincinnati system 22
Cingulum 11, 113
Classes of teeth 4
  in human dentitions 5*t*
Classification of
  root canals 234
  sounds 300
Common carotid artery 286
Components of tooth 8*f*
Coronoid and condylar processes 285
Cribriform plate 282
Cross-section of roots 217
Crown 71, 74, 76, 77, 79, 81, 85, 88, 90, 95, 113, 120, 128, 134, 144, 148, 157, 163, 173, 179, 334
  carving 344, 346, 350, 353, 358, 360
Curvature of
  cementoenamel junction 18, 19
  cervical line 51, 116, 150, 157, 180, 189, 206
  root 74, 132, 203
Curve
  occlusal plane 60, 318
  of Spee 60, 62*f*, 318, 318*f*
  of Wilson 61, 62*f*, 318, 318*f*
Cusp 10
  embrasure occlusion 317*f*
  fossa occlusion 317, 317*f*
  of Carabelli 89, 90, 194, 198
    of permanent maxillary 1st molar 189*f*

D

Dane or Haderup system 22
Deciduous
canines 79
dentition 65, 156
period 7
stage 307
Deflective malocclusion 306
Deglutition 299
reflex 300
Dens
evaginatus 184*f*
invaginatus 126
Dental
anthropology 332, 333
deoxyribonucleic acid 331
follicle 33
periodontal ligament complex 37
formula
for permanent dentition 6
for primary/deciduous dentition 6
in humans 6
groove 306
lamina 33
papilla 9, 33
sac 33
Dentinogenesis imperfecta 33, 34*f*
Dento-osseous structures 277, 279
Depression of mandible 298
Dermal scales of bony fish 324*f*
Development of
clear speech 69
human dentitions 39*f*
occlusion 306
permanent teeth 44
placoid scales 324*f*
primary dentition 38
skull/craniofacial complex 279
Developmental
anomalies 117, 126, 132, 140, 146, 163, 169, 177, 184
depressions 217, 224
groove 14, 177, 196
Digastric fossae 285
Diphyodont dentition 333
Distal
aspect 73, 87, 89, 96, 116, 122, 129, 138, 145, 152, 160, 166, 176, 183, 193, 202, 215, 222, 228
cusp 96
developmental groove 88, 90, 177, 183
fossa 90
marginal ridge 162
pit 184
surface 10
within outlines 116, 122, 161, 176, 183, 193, 202, 215, 223
triangular fossa 162
Distobuccal
cusp 96
developmental groove 96
Distolingual cusp 89
Divisions of
crown 15
mandibular nerve 291
maxillary nerve 290
root 16
trigeminal nerve 290
Dutch system 22

E

Early bell stage 35
Ectomesenchyme 33
Efferent fibers 289
Elevation of mandible 298
Emergence of
first permanent molars 311
primary teeth 38
Enamel organ 33, 324
Epithelial diaphragm 37
Eruption of
mandibular central incisors 307*f*
permanent
2nd molars 314
canines 312
incisors 311
premolars 313
Eruption sequence of permanent teeth 45*f*
Ethmoid bone 280
Ethnology 5, 332
Evolution of
teeth 321, 323
tritubercular molars from triconodont tooth 326*f*
External
carotid artery 286
surface of mandibular body 283, 284*f*

F

Facial and lingual contours of teeth 60*t*
FDI
notation for
permanent dentition 27, 27*f*
primary dentition 28, 28*f*
notation system 26
tooth notation system 29
Federation Dentaire Internationale System 22
Fibrous capsule 295, 295*f*
Fifth
cranial nerve 290
cusp groove 195
First transitional period 43
Flatter cervical ridge 104*f*
Fluorosis 33
Flush terminal plane 310
Forensic
anthropology 332
odontology 330
Fossae 14, 176
French system 22
Frontal process 280, 282
Functions of
embrasures 58
incisors 111
TMJ, teeth and muscles 299

G

Gemination of maxillary central incisor 118*f*
Genioglossus 285
Geniohyoid 285
Geometric crown outlines of teeth 63
Gingiva 53*f*
Gingival
crevis 37
groove 306
papilla 52
Ginglymoarthrodial joint 294
Glenoid fossa 295*f*
Greater palatine artery 282

H

Hard palate 289
Height of buccal contour 200, 226
Hertwig's epithelial root sheath 37, 37*f*
Holland system 22
Horizontal jaw reflex 299

I

Impacted mandibular 3rd molars 229*f*
Incisal aspect 73, 76, 77, 81, 83, 117, 123, 131, 139, 145, 152
Incisive
fossa 281
nerve 292
Incisor index 337
Infantile open bite 306
Inferior alveolar nerve 292
Infraorbital
foramen 281
margin 281
nerve 290, 291

Innervation of
mandible 292
maxilla 292
palate and lips 292
Interdental
papilla 52
septa 282
spacing 307
Intermediate band 294
Internal surface of mandibular body 285, 285*f*
International
Association for Dental Research 27
Numbering System 26
Interproximal spaces 52
Inter-radicular septa 282
Intertransitional period 312
Intra-articular disk 294

J

Jaw reflexes 299
Jugulodigastric lymph nodes 289

L

Labial
aspect 71, 74, 76, 77, 79, 81, 113, 120, 128, 134, 144, 148
gingival of mandibular anterior teeth 289
ridge 144
surface within outlines 113, 120, 128, 135, 144, 148
Labiolingual diameter of crown 18, 128, 150
Lamina dura 282
Lateral pterygoid muscle 297
Latin numeral system 22
Lecron carver 341
Leeway space of Nance 85, 313, 314, 314*f*
Length of
crown 18, 19
root 18, 19, 128, 150, 157, 172, 180, 189, 200, 206
Leong's premolar 184*f*
Ligaments of temporomandibular joint 295, 296*f*
Lingual
aspect 72, 74, 76, 77, 79, 83, 87, 89, 92, 95, 113, 120, 129, 135, 144, 149, 159, 164, 173, 180, 190, 199, 205, 212, 220, 226
convergence 216
cusp ridge 12
developmental groove 96, 183, 190, 200, 226
fossa 14, 113, 115
surface within outlines 113, 120, 129, 135, 145, 150, 159, 164, 173, 182, 192, 200, 214, 220
triangular ridge 162
Location of
contact areas of teeth 57
proximal contacts 56
Lower
molar groove pattern 335
part of face 288, 289
Lowlands system 22
Lymphatic
drainage of
dento-osseous structures 289*f*
orodental tissues 288, 289*t*
palate 289

M

Maintenance of normal
eruption schedule of permanent successors 70
facial appearance 69
Mandible 282, 287
Mandibular
1st molar 211*t*, 212*f*-216*f*, 218, 218*f*, 219, 242*f*, 272-275
1st permanent premolar 263-266
1st premolar 172*t*, 173*f*-177*f*, 178, 179, 241*f*
2nd molar 220*f*, 220*t*, 221*f*-223*f*, 225, 226, 242*f*, 272-275
2nd permanent premolar 263-266
2nd premolar 180*t*, 181*f*-184*f*, 185, 186, 241
3rd molar 226*t*, 227*f*-229*f*, 230, 231, 243*f*, 272-275
body 283
canine 150*f*, 150*t*, 151*f*, 152*f*, 153, 154, 240*f*
central incisor 128*t*, 129*f*, 131*f*-133*f*, 134, 240*f*
lateral incisor 135*t*, 136*f*, 137*f*, 138, 139, 140, 240*f*
molars 267, 268, 269
nerve 290, 291
permanent
2nd premolar 186
canine 255-257
central incisor 251, 251*t*, 252, 253
incisor 247, 248
lateral incisor 251, 251*t*, 252, 253
premolar 259, 260
ramus 285, 285*f*
right 1st premolar 173*f*
right 2nd premolar 180*f*
Marginal ridges 162, 177, 195
and fossae 162, 169
Masseter muscle 296
Masticatory cycle 299
Maturity indicators 46
Maxilla 280, 287
Maxillary
1st molar 189*t*, 190*f*-196*f*, 198, 199, 228*f*, 269-271
1st permanent premolar 260-263
1st premolar 157*t*, 158*f*-163*f*, 164, 165, 237*f*
2nd molar 200t, 200*f*-203*f*, 204, 205, 269-271
2nd permanent premolar 260-263
2nd premolar 166*t*, 166*f*-168*f*, 169, 170, 238*f*
carving 352
3rd molar 206*t*, 206*f*-208*f*, 209, 210, 239*f*, 269-271
and mandibular
central incisors 10*f*
dental arches 4
molars 267*t*
permanent canines 255*t*
permanent incisors 247*t*
permanent premolars 259*t*
teeth 288
canine 48, 142*t*, 143*f*-147*f*, 149, 237*f*
central incisor 112*t*, 112*f*-117*f*, 118, 119, 122*f*, 236*f*
lateral incisor 119*t*, 120*f*-123*f*, 125, 126, 236*f*
molar 267-269
primary cusp triangle 194, 194*f*
nerve 290
permanent
1st premolar 156
2nd premolar 163
canine 255-257
central and lateral incisors 248*t*
central incisor 248-251
incisors 247, 248
lateral incisor 248-251
premolar 259, 260
right 1st premolar 157*f*
right canine 142*f*
sinus 282
teeth 236
tuberosity 281
Measurements of teeth 16, 20*t*
Medial
part of lower lip 289
pterygoid muscle 297
Median palatine suture 282
Mental
foramen 285

nerve 292
protuberance 284
tubercles 284
Mesial
and distal aspects 74, 77, 81, 83, 205
of anterior teeth 62
of mandibular posterior teeth 62
of maxillary posterior teeth 62
and distal
cusp ridges 12
fossae 176
aspect 72, 87, 89, 92, 95, 115, 122, 129, 137, 145, 150, 160, 164, 175, 182, 192, 200, 214, 222, 226
developmental
depression 160
groove 160, 177, 183
marginal developmental
depression 160
groove 160, 162
marginal ridge 162
pit 184
surface within outlines 116, 122, 129, 138, 145, 150, 160, 166, 175, 182, 193, 202, 215, 222
triangular fossa 162
Mesiobuccal
and distobuccal
cusp ridges 162
developmental grooves 162
and mesiolingual cusps 88
cusp 96
developmental groove 96
line angle 16
Mesiodistal
diameter of crown 18, 19, 128, 150, 157, 172, 180, 189, 200, 206
dimension of crown 18, 104*f*
section of mandibular molar 233*f*
Mesiolingual
and distolingual cusp ridges 162
cusp 89
developmental groove 175, 177
Mesodermal origin 9
Metcalf system 22
Method of measuring
anterior teeth 18*f*
posterior teeth 19
Middle
palatine nerve 290
superior alveolar nerve 290, 291
Midpalatine raphe 282
Minor fossae 195
Mixed
dentition period 7
dentition stage 310
Modern mammals 327
Modified pen grasp 342*f*
Monophyodont dentition 333
Motor
aspect 300
fibers 289, 291
Mucogingival line 52
Multiple supplemental grooves 195
Muscles of joint 296
Mylohyoid
line/ridge 285
nerve 292

N

Nasopalatine nerve 282, 290
Natal
teeth 38, 307
tooth in newborn child 307*f*
Nerve
of oral cavity 289
supply of dento-osseous structures 289*f*
Nomenclature of teeth 6
Non-metric variations in teeth 334

O

Occipital bone 280
Occlusal
aspect 87, 90, 94, 96, 161, 166, 176, 183, 193, 202, 205, 216, 223, 229
carving 358
curvatures 51
surface within boundaries 194, 216, 223
Ophthalmic nerve 290
Oral ectoderm 33

P

Palatal surface 10
Palate 287
Palatine
nerve 290
process 280, 282
of maxilla 282*f*
Palatogingival groove 122
Palatoradicular groove 122
Parts of tooth 7
Periodontal ligament 9
traction theories 37
Permanent
canines 141
dentition 5, 109
period 7
stage 314
mandibular
1st molar 211, 242
1st premolar 172, 241
2nd molar 217, 242
2nd premolar 178, 241
3rd molar 224, 242
canine 147, 240
central incisor 128, 239
incisors 128
lateral incisor 132, 240
left 1st molar 6
molars 211
maxillary
1st molar 188, 197*f*, 238
1st premolar 237
2nd molar 196, 239
2nd premolar 238
3rd molar 203, 239
canine 142, 236
central incisor 111, 236
incisors 111
lateral incisor 119, 236
molars 188, 188*f*
premolars 156
Pharyngeal group of lymph nodes 289
Placoid scale 323
of cartilaginous fish 324*f*
Polyphyodont 3
dentition 334
Position of cusp tip 146
Posterior
centric occlusal contacts 317
nasal spine 282
of dental arch 156*f*
palatine nerve 290
teeth 56, 156
Posterosuperior alveolar nerve 290
Precocious eruption of primary teeth 306
Primary
and permanent teeth 100*t*
apical foramen 37
dentition 5
period 41
epithelial band 33
mandibular
1st molar 93*f*
2nd molar 97*f*
canine 84*f*
central incisor 78
lateral incisor 80*f*
maxillary
1st molar 86*f*
2nd molar 91*f*
canine 82*f*
central incisor 73*f*
lateral incisor 75*f*
right lateral incisor 6

pulp cavity 106*f*
right mandibular
1st molar 92*f*
2nd molar 96*f*
canine 83*f*
central incisor 76*f*
lateral incisor 79*f*
right maxillary
1st molar 85*f*
2nd molar 89*f*
canine 81*f*
central incisor 72*f*
lateral incisor 74*f*
Prominent cervical ridge 104*f*
Protostylid of molars 335
Pterygopalatine branch of maxillary nerve 290
Pulp 9
canal 9, 234, 238-240
cavity 233
chamber 9, 233, 236-242
morphology 233
stones 235*f*

Q

Quadritubercular molar 325

R

Rationale of tooth carving 341
Reduced enamel epithelium 37
Retrusion 298
Reverse numeration system 22
Root 74, 76, 77, 79, 81, 83, 88, 90, 95, 97, 117, 123, 132, 139, 146, 153, 162, 169, 177, 184
canal 9, 233-242
carving 344, 349, 351, 354, 356, 359, 361
curvature 123

S

Second transitional period 43, 312
Secondary apical foramina 37
Sensory fibers 289, 291
Sharpey's fibers 282
Shedding of primary teeth 41
Shovel-shaped incisors 334
Significance of Leeway space of Nance 314
Sixth cusp on lower molar 336*f*
Smoothening of wax block 343
South African System 22
Sphenoid bone 280
Sphenomandibular ligament 295
Stages of
deglutition 300*f*
dentitions in humans 7
permanent
mandibular tooth formation 49*t*
teeth 49*f*
Stratum intermedium 36
Structure of tooth 8
Stylomandibular ligament 296
Sublingual salivary gland 285
Submandibular
fossa 285
lymph nodes 289
salivary gland 285
Submental group of lymph nodes 289
Succedaneous teeth 4
Succeed deciduous molars 156
Successional lamina 33, 44
Sulcus 14
Supernumerary premolars 184
Surface of
root and crown 16*f*
teeth 9
Symphysis 284

T

Talon's cusp 118*f*, 126
Temporalis muscle 285, 297
Temporomandibular
joint 52, 277, 283, 284*f*, 285, 292, 294, 294*f*
ligament 295
Tongue 287, 288
Tooth
bud 33
carving 339, 341
notation systems 22
Trait categories of teeth 6
Transposition of maxillary canine and 1st premolar 147*f*
Transverse
groove 306
of oblique ridge 195
palatine suture 282
ridge 12
Traumatic occlusion 305
Triangular
fossae 14
nerve 290
ridge 290
Tritubercular molar 325
Tubercle 11
of Carabelli 189
on lingual surface of maxillary lateral incisor 12*f*
Two
digit system 26
rooted lower canine 336
Types of
cusps 315
nerve fibers 289
teeth 5, 5*f*, 57

U

Ugly duckling stage 313
Unilateral balanced occlusion 305
Universal
notation for
permanent teeth 23
primary teeth 23, 24*f*
numbering system 22
tooth notation system 24
US
Army System 22
Navy System 22

V

Vascular pressure 37
Venous
drainage of
dento-osseous structures 288*f*
lips 288
orodental tissues 287
palate 288
tongue 289
Vestibular lamina 33

W

Weine's classification of root canal 234, 234*f*
Wernicke's area 300
Winged incisors 335, 335*f*

Y

Y groove pattern 229
Y shaped pattern 183

Z

Zsigmondy-Palmer
notation 22, 25, 26
for permanent teeth 25
for primary teeth 25
system 22
system 24, 26*f*
for permanent dentition 25*f*
for primary dentition 26*f*
tooth
notation system 27
numbering system 27
Zygomatic
arch 281
nerve 290, 291
process 280, 281