General Considerations

In Prosthodontics we will review general considerations, occlusion and articulators, edentulous anatomy, pre-prosthetic surgery, complete dentures, phonetics, support stability & retention, denture processing, Kennedy classification, connectors, rest & proximal plates, clasps design, tooth preparation, pontic & connector design, impression materials, gypsum materials, metal alloys, mechanical properties, provisionals crowns, types of crowns, shade selection, dental cements, lab fabrication of crowns

Prosthodontics is the branch of dentistry focusing on the design, manufacture and fitting of artificial replacements for teeth and other parts of the mouth.

1 Bridge

Anatomy & Definitions

- **Abutment** = a specific tooth that the bridges latches onto
- **Retainer** = a specific crown that sits on top of the abutment
- **Pontic** = fake tooth in between retainers
- **Connector** = between retainer & pontic
- **Cantilever** = fake tooth only supported on one side by a retainer
- **Pier** = abutment tooth that has no adjacent teeth in proximal contact

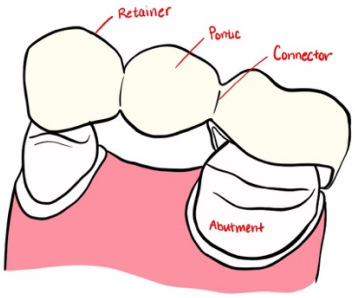


Figure 1.01 Bridge anatomy

Prognosis of a Bridge

Patients with **poor prognosis** for a dental bridge can exhibit the following characteristics:

- Equal or less than half alveolar bone support around abutment tooth
- **Connectors not strong**
  - Lock and key mechanism for bridge to connect to abutment teeth
  - Comprise of a tenon (male component) and mortise (female component)
- Pier (intermediate abutments)
  - More occlusal force on pier abutment can lead to torquing of abutment
- Single retainer cantilever
  - Not ideal for posterior cantilever due to heavy occlusal forces
- Multiple-splinted abutment teeth

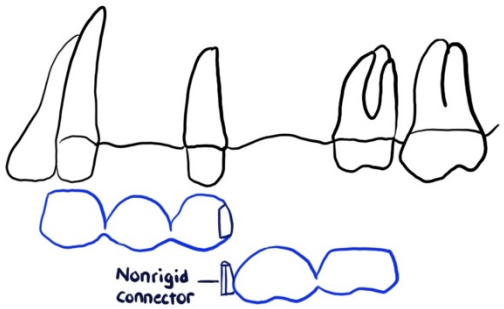


Figure 1.02 Nonrigid Connector

The following teeth should never be considered as an abutment tooth:

1. Compromised periodontal teeth
2. Endodontically treated teeth
   - Less internal dentin after RCT thus it is a weaker tooth

Crown to Root Ratio

Crown to root ratio refers to ratio of the length of the clinical crown to the length of the clinical root. The ratios can indicate to tooth to be ideal to having poor prognosis of an abutment tooth.

Crown: Root Ratio	Indication
1:2	Ideal
2:3	Realistic
1:1	Minimum
2:1	Poor (contraindicated)

	Clinical	Anatomical
Crown	Above the gingiva	Above the CEJ
Root	Below the gingiva	Below the CEJ

Ante's Law

Ante's Law states that the total periodontal surface area of the abutment teeth should be greater than or equal to the surface area of the teeth they are replacing.
The following scenario in the image below illustrates this law

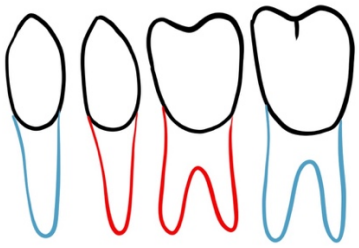


Figure 1.03 Ante's law

- The blue outline demonstrates the PDL space of the abutment teeth of the bridge
- The PDL space of the imaginary teeth are in red
- Blue area ≥ red area for these teeth to be appropriate as abutment teeth

Splinting

- Used when the periodontal surface area of the abutment tooth is insufficient to attach a bridge and Ante's Law can not be obeyed
- Distribute occlusal forces across multiple teeth
- Central and lateral incisors must be splinted together when **canines** are replaced
  - Prevents lateral drifting of the bridge

Root Shape

Overall, root shape will dictate the amount of PDL space available of the abutment teeth that will support the bridge.

- **Preferred characteristics**
  - Broad roots
  - Divergent
  - Curved
  - Multiple
- **Non-preferrable characteristics**
  - Round roots
  - Fused
  - Conical
  - Single

INBDE Pro Tip:
Remembering desirable root characteristics can relate to how easy or difficult certain teeth are to extract. Teeth that are more difficult to extract have roots that exhibit desirable traits for an abutment tooth.

2 Other Denture Types

Removable Partial Dentures (RPD)

Removable partial dentures (RPD) are indicated over bridges in certain scenarios

- Bridge or implant is too costly
- Distal extension
  - All of teeth distal to a certain point are missing
- Bone loss around potential abutment spaces
- Long Span of edentulous teeth

Figure 1.04 Removable partial denture

Complete Denture (CD)

Complete dentures are used when all teeth are missing

- Upper denture should be used with caution when only mandibular anterior teeth available
  - Combination syndrome

Figure 1.05 Complete denture

Overdenture

- Classic implant placement = 4 implants in maxilla, 2 implants in mandible

Figure 1.06 Overdenture

- Alternative option for edentulous patients

Cement-Retained Implant

- Inexpensive
- Used for minor angle correction
- More chair time, same propensity to loosen as a screw retained implant
- Excess cement can cause **peri-implantitis**
  - Important to clean implant area after cementation

Figure 1.07 Cement-retained implant

Screw-Retained Implant

- Easy to remove the crown to clean it and place it back on
- Screw may loosen while chewing

Figure 1.08 Screw-retained implant

Occlusion & Articulators

1 Alginate

Alginate is the most universally used impression material for diagnostic casts

- Alginate powder components
  - Insoluble calcium alginate produced by a chemical reaction between salts
  - Setting rate controlled by **trisodium phosphate**
- More volume = less dimensional change
  - Alginate should be thick enough to capture anatomy of patient's teeth
- Remove tray from patients mouth after 2-3 minutes seating in patient's mouth
- Pour impression with stone within 15 minutes
  - Cast sets within 30-60 minutes

2 Maxillo-Mandibular Relations (MMR)

There are two main relationships where the maxilla and mandibular relationships can relate to each other.

Centric Relation (CR)

- Teeth position irrelevant
- At the articulation between the **condyles** and the thinnest portion of the upper and lower discs in the most **anterior-superior position** against the articular eminences

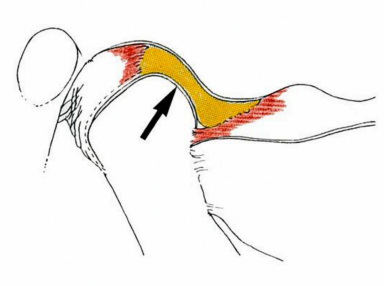


Figure 2.01 Centric Relation

Maximum Intercuspation (MI)

- Condylar position irrelevant
- Complete interdigitation of teeth
- Sometimes referred to as **centric occlusion (CO)**
  - When CO = MI (rare)

Figure 2.02 Maximum Intercuspation

CR vs. MI

- MI and CR rarely match and most people slide from CR into MI
- Casts are mounted in either:
  - MI for single fixed procedures or when MI can be maintained
  - CR for restoring multiple teeth or when MI can not be maintained or determined
- **CR is the most reliable and reproducible jaw relationship in the mouth**

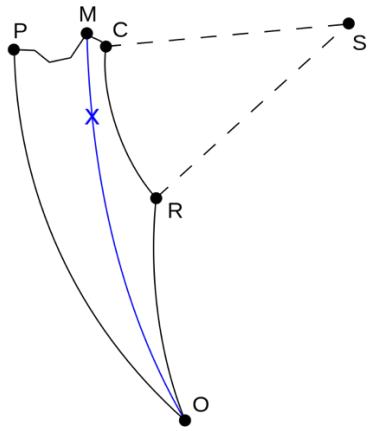


Figure 2.03 Maxilo-mandibular relations

Bimanual Manipulation

Positioning a patient in CR position can be achieved through bimanual manipulation method. It is an accurate method to obtain CR interocclusal records.

1. With patient lying back
   - Hold the posterior mandible with finger
   - Hold chin with thumbs
2. Deprogram the jaw
   - Patient relaxes their jaw as much as possible
3. Recognize first CR tooth contact and repeat until a consistent first tooth contact is identified
4. Keep anterior teeth slightly apart in CR with acrylic resin jig
5. Lastly, measure an interocclusal record of posterior teeth with PVS

3 Facebow Record

A **facebow record** aims to replicate the articulator relationship of maxillary arch to the skull and the mandible to the hinge axis of the TMJs of the patient.

- The facebow record is taken on the patient with their interocclusal record in the mouth
- The facebow record is then transferred onto an articulator

Figure 2.04 Arbitrary face bow

4 Articulators

The facebow record transfer the relationship of the maxilla and the rest of the skull to the articulator. The interocclusal record is used to mount the mandibular cast, on the articulator, relative the maxillary cast. There are many different types of articulators used in clinic, but there are some parts common to all of them that represent different parts of masticatory system.

- Upper area = maxilla
- Lower area = mandible
- Hinge axis = TMJ

Non-adjustable Articulator

- Cannot entirely represent the movements of mandible
  - Only opens and closes
- Much shorter distance between hinge and teeth thus can cause premature contacts

Semi-adjustable Articulator

- Includes **Bennett angle** (15°) and **Horizontal condylar inclination** (30°)

Figure 2.05 Semi-adjustable articulator

Fully Adjustable Articulator

- **Pantograph –** most complex articulator that is used to record mandibular border movements

Mounting Casts

- Casts made with the alginate impression are better mounted with wax records
- Casts made with elastomeric materials are better mounted with ZOE paste or elastomeric materials (PVS)

Figure 2.06 Mounting casts

Disclusion

Disclusion describes how the teeth separate from one another in order to protect the teeth from wearing or receiving too much occlusal force.

1. **Incisal guidance**
   - Determines anterior occlusion
   - Occludes between incisal edges of lower incisors & lingual slopes of upper incisors
     - Varies between patients
   - Shown by pin and guide table on the articulator
2. **Condylar guidance**
   - Determines posterior occlusion
   - Slope of articular eminence
     - Varies between patients
   - Shown by horizontal condylar inclination (HCl) on articulator
3. **Canine guidance**
   - During lateral movements, posterior teeth disclude as contact is solely between upper and lower canines

Figure 2.07 Canine guidance

4. **Anterior guidance**
   - Involves both incisal and canine guidance

That following are important to note when analyzing the different forms of guidance.

- Condylar and incisal guidance may or may not work in harmony with each other
- During protrusive movement, both the incisal and condylar guidance supply clearance for all posterior teeth
- During lateral movement, canines on the working side and condyle on balancing side supply clearance for posterior teeth on the balancing area

Guide table

- **Custom incisal guides tables**, are made from acrylic resin, and are preferred over **mechanical guide tables** as they move in curves and can follow patients lingual anatomy.
- During restorative treatments, anterior guidance should be protected because they can modify the "guiding" teeth

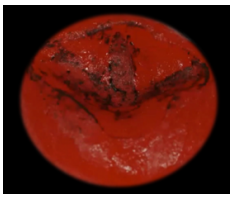


Figure 2.08 Guide table

Mutual Protection

Mutual protection demonstrates the following concepts

- Front teeth preserve the back teeth
  - During protrusive and lateral movements, anterior teeth disclude back teeth
- Back teeth preserve the front teeth
  - Back teeth possess flat occlusal surface and rigid roots to preserve front teeth from bite forces

Edentulous Anatomy

1 Maxillary Edentulous Anatomy

There are several important anatomical landmarks in discussing the anatomy of the maxilla

- **Alveolar Ridge**
- **Buccal and Labial Frenum** – thin fold of mucous membrane with enclosed muscle fibers that control the movement of mobile tissue
- **Buccal Vestibule** – area between the cheek and the lips
- **Labial Vestibule** – area between the lips and alveolar ridge
- **Vibrating Line** – boundary spanning from hamular notch to hamular notch
  - Often 2mm away from **fovea palatini** (pits in the palate)
  - When patient says "ah", the vibrating line will divide the vibrating tissue to the non-vibrating tissue on the palate
- **Hamular Notch** – notch/fissure at junction of maxilla and hamular process of sphenoid bone
  - Distal to the most distal process of the alveolar ridge
- **Posterior Palatal Seal**
  - Marks the area that a denture sufficiently compresses the soft palate with enough suction
  - Master cast of maxilla is slightly carved around the area of the vibrating line to create more acrylic thickness to make up for polymerization shrinkage of denture material = creates an ideal posterior palatal seal

- **Coronoid Notch** – distobuccal side of impression/denture
  - Patient moves in lateral excursion during impression to capture anterior process of the coronoid notch

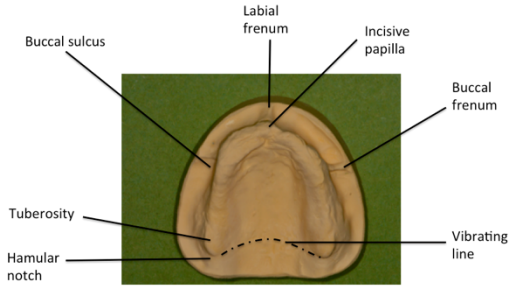


Figure 3.01 Max. Edentulous Anatomy

- **Pterygomandibular Raphe** – fibrous tissue that links superior pharyngeal constrictor muscle and buccinator
  - Captured in the impression if the patient opens wide (pterygomandibular raphe moves forward)

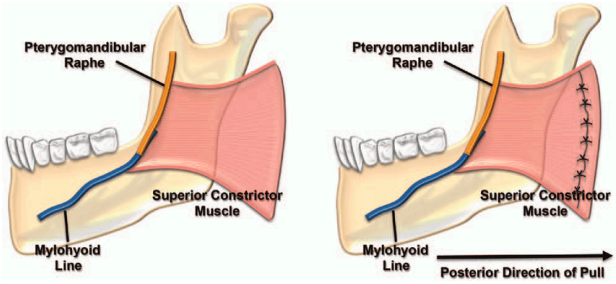


Figure 3.02 Pterygomandibular raphe

2 Mandibular Edentulous Anatomy

Like the maxilla, the mandible has important landmarks to locate when making prosthodontics.

- **Alveolar Ridge** – less broad and wide than the maxilla
- **Buccal Frenum** – attached to orbicularis oris and buccinator
- **Labial Frenum** – at the midline, attached to orbicularis oris
- **Lingual Frenum** – attached to genioglossus
- **Buccal Vestibule** - attached to buccinator
- **Labial Vestibule** – attached to mentalis
- **Masseteric Notch** – distobuccal area on the impression/denture
  - Masseter muscle - contracts when the mouth closes on resistance
  - Analogous to the coronoid notch of maxilla
- **Retromolar Pad** – determines distal extension of edentulous ridge
  - Should be covered by denture for retention and support since it has attachments from the following muscles:
    - **Superior pharyngeal constrictor**
    - **Pterygomandibular raphe**
    - **Buccinator**
    - **Temporalis**
- **Alveololingual Sulcus** – between mandibular alveolar ridge and tongue
  - Runs posterior to lingual frenum
  - Follows an 'S' shaped pattern
  - Divided into 3 regions:
    - Anterior
    - Middle
    - Posterior

1. **Anterior region** – from lingual frenum to **premylohyoid fossa**
   - Sublingual gland located above mylohyoid muscle
   - **shorter flange** of the denture and touches the mucosa of the floor of the mouth
2. **Middle region** – from premylohyoid fossa to distal end of mylohyoid ridge
   - Flange medially deflected away from mandible due to medial contraction of mylohyoid muscle and prominence of mylohyoid ridge
3. **Posterior region** – reaches the retromylohyoid fossa
   - Although mylohyoid located higher posteriorly, **flange** is **higher** and denture is deeper because the fibers are vertically directed
   - S-form of lingual sulcus due to laterally deflected flange toward the ramus of the mandible
   - **Limited** denture **extension** due to superior constrictor & palatoglossus muscles

- **Buccal shelf** – lateral to posterior alveolar ridge
  - Supports denture
  - Attachment to buccinator muscle
  - Perpendicular to occlusal forces

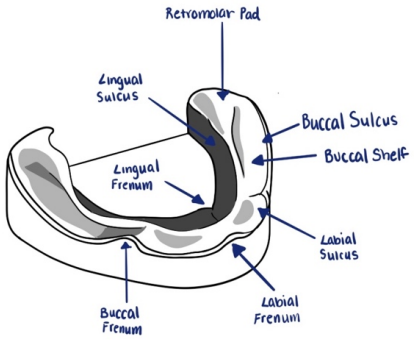


Figure 3.03 Buccal shelf

Pre-Prosthetic Surgery

1 Pre-Prosthetic Surgeries

Pre-prosthetic surgeries are carried out prior to creation of a denture for better outcomes and long-term results for the patient. There are many types of these kinds of conditions where surgeries may be permitted before the final denture is made.

Frenectomy

- When the frenum attaches too far into the alveolar ridge, interfering with seating of the denture
- **Lingual < buccal < labial (least to most common)**

Figure 4.01 Frenectomy

Free Gingival Graft (FGG)

- Required for overdenture teeth
- Expands range of **keratinized tissue** around implants or teeth
  - Tissue is firmer and not as sensitive as non-keratinized mucosa
  - Easier to maintain oral hygiene

Fibrous (Pendulous) Tuberosity

- Commonly occurs when large tuberosities touch retromolar pads
- Interferes denture fabrication by restricting interarch space
- Requires **surgical excision** of bone and/or fibrous tissue for correction

Papillary Hyperplasia

- Multiple papillary projections of the palate caused by the following:
  - **Candidiasis** (most common cause)
    - Treat with **-statin** or **-azole**
  - wearing dentures for too long
  - local irritation
  - ill-fitting denture
  - poor oral hygiene
- Treatment
  - Tissue conditioner
  - Leave dentures out at night
  - Soak dentures in 1% bleach and rinse
  - Brush irritated area lightly with soft brush
  - OHI

Epulis Fissuratum

- Hyperplastic tissue reaction, commonly in vestibule
- Causes – overextended flange or ill-fitting denture
- **Tissue conditioner** used for treatment and adjusts denture flange
- May require surgery if response is severe

Combination Syndrome

- Specific bone resorption pattern in the anterior edentulous maxilla when only opposing mandibular anterior teeth present
- Papillary hyperplasia in hard palate
- Multiple tuberosity overgrowth
- Bone loss below the partial dentures
- Extrusion of lower anterior teeth

INBDE Pro Tip:
Questions about Papillary Hyperplasia, Epulis fissuratum, and Combination Syndrome are common questions on the INBDE.

Hypermobile Ridge

- Mobile edentulous ridges, commonly observed in maxilla
- **Tissue conditioner** used to treat inflamed tissue
- **Electrosurgery** or **laser surgery** used when tissue conditioner is ineffective
  - ▸ Removes tissue
  - ▸ Risk of eliminating the vestibule – not ideal

Vestibuloplasty

- Raises the relative height of the alveolar process = Raises the base of denture area
- Useful for Apically repositioning the alveolar mucosa, and the mylohyoid, mentalis, and buccinator muscles
  - ▸ Insert into the mandible
- Lingual vestibuloplasty is more traumatic and rarely done

Alveoloplasty

- Primarily used for spiny, sharp, or extremely irregular ridges
- Reshaping alveolar bone with surgery
- **Tori (mandibular) removal**
  - When it hinders posterior palatal seal or forms an undercut
  - Tori are easily irritated as well

Retained Root Tips

- Residual root tips (non-RCT) are risk factors
- They can be left if they have no PARL and have intact lamina dura

Bone Augmentation

- Horizontal > Vertical
- **Hydroxyapatite** – biocompatible bone substitute
- **Bone-grafts** – sources (iliac crest of hip & rib)

Paget's Disease

- Etiology is unknown
- Poor fitting dentures require to be periodically remade
  - ▸ Due to deformities forming
- Deformities led by bone resorption & repair

Complete Dentures

1 Vertical Dimension

Vertical Dimension of Rest (VDR)

- Height between nose and chin @ rest
- **Physiological Rest Position (PRP)** - elevator and depressor muscles are in a state of equilibrium
- Typically 3mm space between upper and lower premolars

Vertical Dimension of Occlusion (VDO)

- Height between nose and chin during occlusion
- Used to illustrate the relationship of the maxilla and mandible during occlusion in MI

Interocclusal Space

- VDR - VDO
- Ideal distance = 2-4 mm
- **VDR = VDO + 3mm**

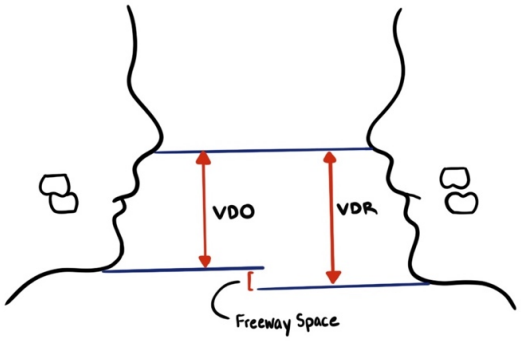


Figure 5.01 Interocclusal space

Excessive VDO

Excessive VDO occurs when the interocclusal space is less than 2mm. There are many issues associated with excessive VDO.

- Muscles of mastication fatigue
- Clicking noise of posterior teeth during speaking
- Both excessive trauma to supporting tissues and display of mandibular teeth
- Unable to wear dentures
- Gagging

Insufficient VDO

Insufficient VDO occurs when the interocclusal space is more than 4mm and has a long distance of closing. The following are associated with insufficient VDO:

- **Angular cheilitis** – fungal infection of the corners of the mouth
- Aging appearance of lower 1/3 of face
  - overlapping corners of mouth, thin lips, wrinkles, chin too near the nose
- Decreased occlusal force

2 Intraoral Examination

CR Record

For an edentulous patient, taking a record in centric relation provides the clinician with the ability to increase or decrease the VDO when making a denture.

- The record provides a radius of mandible arc of closure
- Facebow carries the relationship between the maxilla and mandibular hinge axis to the articulator

Protrusive Record

Protrusive record shows the anterior-inferior condyle path in translational movement of the condyles

- **Christensen's phenomenon** – distal gap between the maxilla and mandibular teeth during the mandible protrusion
  - Cause - downward and forward movement of condyles down to their articular eminences
  - Often results in a posterior open bite

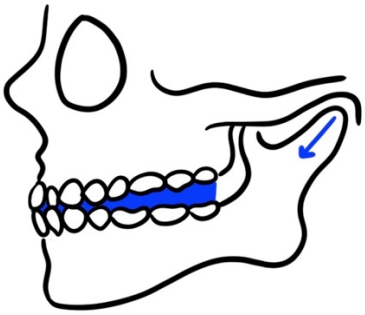


Figure 5.02 Protrusive record

3 Occlusion

Plane of Occlusion

- **Interpupillary line** – theoretical line between pupils of the eyes
- **Camper's line** – theoretical line from ala of nose to tragus of ear
- Maxillary occlusal wax rim must be parallel to both lines
  - **Fox plane** (metal instrument) used for measurement

Lingualized Occlusion

Lingualized occlusion occurs when only the palatal cusps of the maxillary posterior teeth contact the mandibular posterior teeth.

- Eliminates the destabilizing buccal forces on the dentures

Balanced Occlusion

Balanced occlusion is a type of occlusion where there is both anterior and bilateral posterior contacts (**tripodization**) in centric and eccentric movements.

- Helps sustain the seating of dentures
- Anterior guidance inhibited for complete denture occlusion
  - Avoids the dislodging of denture bases
- On the balancing side
  - maxillary lingual cusps contact lingual incline of mandibular buccal cusps
- On the working side
  - maxillary lingual cusps contact facial incline of mandibular lingual cusps + mandibular buccal cusps contact lingual incline of maxillary buccal cusps

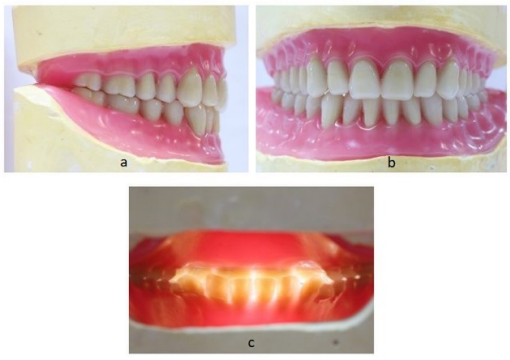


Figure 5.03 Balanced occlusion

Bennett

- **Bennett angle** – created due to nonworking condyle moving anteriorly & medially relative to the sagittal plane
  - 15° on average
- **Bennett movement** – lateral movement of both condyles toward the working side
- **Bennett shift** – lateral movement of mandible toward the working side during lateral excursions

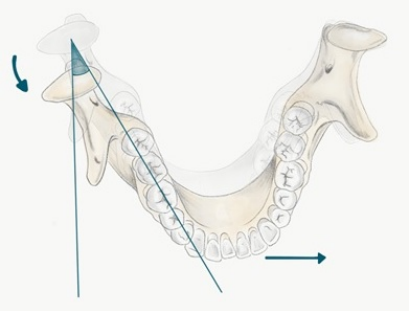


Figure 5.04 Benett

Compensating Curves

- **Curve of Spee** – the curve of the mandibular occlusal plane recognized from the beginning of the tip of lower cuspid and following the buccal cusps of the posterior dentition and stopping at the terminal molar.
  - More mesial inclination distally
  - Flatter curve = faster separation of teeth (disclusion)
- **Curve of Wilson** – mediolateral curve that follows posterior cusp tips to ensure proper loading into the long axis of each tooth
  - More lingual inclination distally
  - Flatter curve = faster separation of teeth (disclusion)

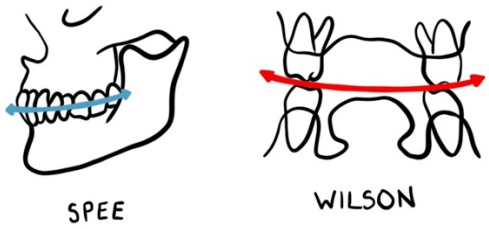


Figure 5.05 Compensating curves

Factors that Favor Disclusion

Factors that favor disclusion (no eccentric contacts) of posterior dentition when entering and leaving MI

Ant Guidance	Horizontal movement: Steep incisal guidance Lateral movement: Steep canine guidance
Post Guidance	Horizontal movement: Steep horizontal condylar inclination Lateral movement: Less Bennett movement/side shift
Cusp Anatomy	Short and shallow inclines
Tooth Arrangement	Less curve of Spee Less curve of Wilson
Occlusal Plane	Less parallel to orientation of the condylar path

INBDE Pro Tip:
Factors that favor eccentric occlusion on posterior teeth are the direct opposite of the factors that favor disclusion. If you know one, you know the other.

Phonetics

1 Sibilant/Linguoalveolar Sounds

Sibilant or **Linguoalveolar** sounds begin with a **s-**, **z-**, **sh-**, **ch-** or **j-** sound.

- Lingual surface or anterior palate of teeth contact with the tip of the tongue
- Can be heard when counting through 60s
- Determines vertical overlap and length of anterior teeth
- Lisp (s- instead of sh-) = arch too wide
- Whistling sounds = arch too narrow
- Uses closest speaking area (s sounds) to establish vertical dimension during pronunciation of s-sound
  - Interincisal separation = 1-1.5mm

2 Labiodental Sounds

Labiodental or **fricative sounds** are pronunciations that usually begin with a **f-**, **v-**, or **ph-** sound.

- Maxillary incisors contact the wet/dry line of the lower lip
- Useful for identifying the position of the incisal edges of maxillary anterior teeth on dentures
- Ask the patient to counting through 40s to hear fricative sounds

INBDE Pro Tip:
The linguoalveolar and labiodental sounds are the most important to know for the exam.

3 Linguodental Sounds

Linguodental sounds begin with the **th-** sound.

- Upper and lower teeth contact with the tip of the tongue
- Labiolingual position of anterior teeth can be identified
  - If tongue is not visible= teeth need to be reset more backward
  - If tongue more anterior than the teeth = teeth need to be reset more forward

4 Bilabial Sounds

Bilabial sounds begin with a **b-**, **p-** or **m-** sounds.

- Both lips contact
- Sounds could also be produced during insufficient lip support by teeth or by the labial flange

5 Guttural Sounds

Guttural sounds begin with a **g-** or **k-** sound.

- Back of tongue and throat contact

Support, Stability & Retention

1 Support, Stability & Retention

Support

Support refers to resistance to vertical seating forces

- Structures providing the most support to the upper ridge (due to resistance to resorption):
  - **Alveolar ridge**
  - **Palate**
- Structures providing the most support to the lower ridge:
  - **Retromolar pad**
  - **Buccal shelf**
- These supporting structures are what the denture base sits on

Stability

Stability refers to the resistance to horizontal dislodging forces.

- Stability in the upper and lower upper ridges is determined by the following:
  - Depth of vestibule
  - Ridge height
  - For dentures the flange will provide the stability

Retention

Retention refers to the resistance to vertical dislodging forces.

2 Peripheral Seal

- Achieved by the **peripheral seal** by the denture

In order to understand the peripheral seal, we need to understand some molecular concepts.

Cohesion

- Attraction of similar molecules
- Demonstrated by attraction between saliva molecules
- Thick and ropy saliva is unfavorable
- Thin and watery saliva are favorable allowing for better retention
  - Creates a thin and undisturbed film layer of saliva between the denture and soft tissue

Adhesion

- Attraction of dissimilar molecules
- Saliva to tissues and saliva to denture base
  - Intimate contact of denture base to tissues creates the best seal

Surface Tension

- Adhesion and cohesion forces that maintain film layer integrity
- Water molecules are prefer to attach to each other to the surroundings
  - Allows for the creation of the **peripheral seal** that is resistant to dislodgment

3 Denture Extension Issues

- Too long dental flange
  - Can result in an ulcer or sore **spot** from continued wearing
  - Treat by relieving the denture followed by re-evaluation
- Too far back denture extension
  - Denture teeth can extend onto the ramus
  - Causes denture **dislodgment**

Underextension

- Too short dental flange = less surface area = lack of retention

INBDE Pro Tip:
The alveolar ridge is the best indicator of denture success (wide & broad preferred).

Denture Materials & Processing

1 Pink Acrylic (Gums)

Heat-Cured Acrylic

Heat-cured acrylic – material cures by thermal reaction.

- **PMMA** = polymer (powder)
  - Salts of iron, cadmium, or organic dyes = pigment
  - **Benzoyl peroxide** = initiator
- **MMA** = monomer (liquid)
  - **Hydroquinone** = inhibits MMA monomers from polymerization on its own
  - **Dimethyl-p-toluidine** = activator (breaks down benzoyl peroxide into its radical form)
  - **Glycol dimethacrylate** = cross-linking agent during curing

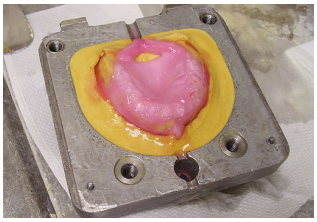


Figure 8.01 Heat-cured acrylic

Denture Processing

- **Polymerization shrinkage** always occurs, but excessive shrinkage can occur if more monomer is used
  - Monomers bonded together take up less space than unbonded monomers
- Ideal ratio = 1:3 (monomer : polymer)
- Porosity happens due to underpacking with resin during the processing phase or rapid heating

2 Denture Teeth

There are two main options for denture teeth material.

1. **Porcelain**
   - More stain and wear resistant (more esthetically pleasing)
   - Brittle
   - Mechanical retention is necessary
   - May wear opposing teeth
2. **Acrylic**
   - Better retention
     - Due to bonding with acrylic resin of the denture base

Kennedy Classification

1 Kennedy Classification

Kennedy classification is used to classify the patient's pattern of edentulism.

Class I
- Bilateral distal extension

Class II
- Unilateral distal extension

Class III
- Unilateral edentulous space with natural teeth remaining both anterior and posterior to it.

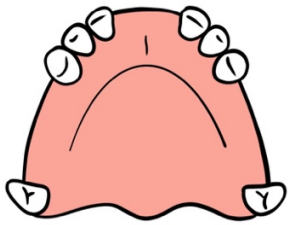
Class IV
- Single edentulous space that crosses the midline which is located anterior to the remaining natural dentition.

2 Applegate's Rules

Applegate's rules can be used to assign Kennedy classification without any confusion.

	Rule
#1	Classification follows extraction
#2	Missing third molars are not considered
#3	Abutment third molars are considered
#4	Missing second molars are not considered
#5	The most posterior edentulous area determines the classification
#6	Other edentulous areas are referred as modifications
#7	Extent of modification does not matter
#8	Class IV cannot have any modifications by definition

Examples

Example	Classification
	Kennedy Class III Mod 1
	Kennedy Class II Mod 3
	Kennedy Class III Mod 2
	Kennedy Class I Mod 1

Connectors

1 Major Connector

- Thickest central component of the metal framework
- Primary function - gives rigidity to the denture
- Combines all other components of the metal framework
- Not located on movable tissue
  - Palate (maxilla)
  - Lingual aspect of mandibular alveolar ridge (mandible)
- All major connectors should cross the midline at a right angle

Figure 10.01 Complete palatal plate (left), Horseshoe complete palatal plate (right), Palatal stap (bottom)

Maxillary Major Connector

There are several different designs for maxillary major connectors.

1. **Complete palatal plate**
   - Most rigid
   - Indications
     - periodontally compromised teeth,
     - when all posterior teeth are missing bilaterally
     - flabby ridges
     - shallow vault
2. **Horseshoe Complete palatal plate**
   - Least rigid
   - Solely used if there is a large palatal torus
3. **Palatal Strap**
   - Metal strap that spans across the midline

Beading

- This concept is exclusive for maxillary major connectors and has the scribing of a 0.5mm rounded groove in the cast at the borders of the major connector
- Adds strength and maintains tissue contact to prevent food impaction

Mandibular Major Connector

There are different designs for mandibular major connectors.

1. **Lingual Bar**
   - Depth of **lingual vestibule ≥7mm**
2. **Lingual Plate**
   - Depth of lingual vestibule <7mm
   - Anticipated additional tooth loss
   - All bilateral posterior teeth are missing
   - Lingual tori
3. **Labial Bar (Swinglock)**
   - Labial bar has a hinge on one end and swing on the other
   - Indicated when a canine is missing
   - Questionable periodontal prognosis
   - Not the best option for soft tissue contour

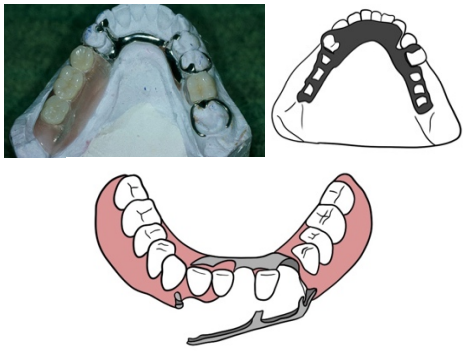


Figure 10.02 Lingual bar (left), Lingual plate (right), Swinglock (bottom)

2 Minor Connector

Minor connectors connect major connectors to the following:

- Indirect retainers
- Clasps
- Rests

Rests & Proximal Plates

1 Rests

Rests

- Firm metal extensions of an RPD framework that attaches to the occlusal, incisal or lingual surface of an abutment tooth
- Provides a rigid vertical stop for the partial
- Distributes force through long axis to provide support

2 Rest seats

Rest seats are prepared into the occlusal, incised or lingual surface of abutment tooth

- Not part of the metal framework of denture, but are part of the tooth
- Receives and supports a rest

Occlusal Rest

- Spoon shaped = rounded, semicircular outline form
- Depth **1.5mm** for base metal
- **1/2** intercuspal width
- **1/3** mesiodistal width
- Angle formed with vertical minor connector and occlusal rest is <90°
- Floor inclination apical towards center

Cingulum Rest

- Inverted V or U shape
- Depth **1.5mm**
- **2mm** labiolingual width (ledge)
- **2.5-3mm** mesiodistal length
- Common for canines
- Mandibular incisors contraindicated
- Benefits - strength from closeness to major connector, good distribution of occlusal load

Incisal Rest

- Rounded notch at incisal angle
- Depth **1.5mm**
- **2.5mm** mesiodistal length
- Can also be used as indirect retainer
- Not commonly used due to esthetics compromise
  - Visible in facial view

Figure 11.01 Rest seats

3 Proximal Plates

Proximal plates are metal plates that contacts the proximal surfaces of an abutment tooth

Guides Planes

- Flat surfaces of abutment teeth that establish path of insertion
  - Teeth may need to be contoured for the proximal plates to fit
- Contacts the proximal plates
- **2-3mm** vertical extension from marginal ridge
- **1/3** buccolingual width

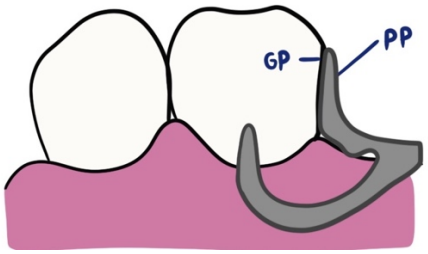


Figure 11.02 Proximal plates

4 Indirect Retainer

If the distal extension of a partial denture is not anchored posteriorly, that area of the denture will not be stably secured. In fact, rotation movement is centered along the axis of an imaginary line formed by the most **distal sites**. Thus, an **indirect retainer** will benefit by being directly perpendicular and anterior to the fulcrum line. This will resist the rotational movement of the distal extension area.

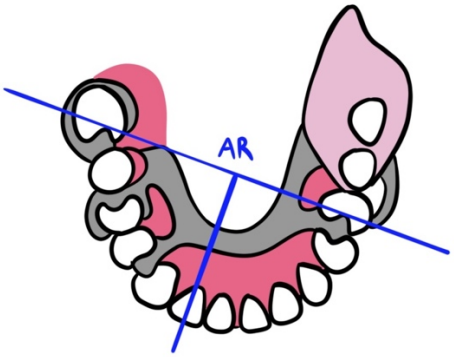


Figure 11.03 Indirect retainer

Clasp Design & Selection

1 Clasp Assembly

Clasp arms are place on direct retainer to provide additional retention and stability to the RPD.

- **Reciprocal clasp arm** used for stability
- **Retentive clasp arm** used for retention

Depending on the type of direct retainer, the clasp assembly may vary

- **Extracoronal retainer**
  - ▸ More common
  - ▸ Convention clasp design
    - Clasps should surround at least **180 degrees**
- **Intracoronal retainer**
  - Accurate attachment with key and keyway pattern
  - More esthetic

Reciprocal Clasp (Stabilizing Clasp)

Reciprocal clasps attach the tooth above the HOC/survey line

- Braces abutment tooth to prevent torquing by the retentive clasp
- Opposite side to the retentive clasp

Retentive Clasp

Retentive clasps attach the tooth below the height of contour (HOC)/survey line.

- Comes from minor connector and rest
- Only tip under HOC, (shoulder above HOC)
- Tip designed to engage in undercut
  - ▸ Resists dislodging forces
  - ▸ Typically passive, and only activates when dislodging forces are applied

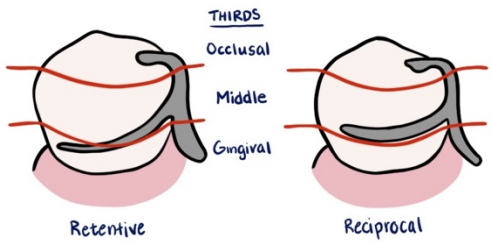


Figure 12.01 Clasp assembly

2 Clasp Designs

Suprabulge

Suprabulge clasps originate above the HOC

- **Circumferential (Akers)**
  - ▸ Most common design
  - ▸ Retentive and reciprocal clasp arm are together as one unit
    - Both arms above the HOC
- **Ring**
  - ▸ Commonly used in molars
  - ▸ Used when an undercut is next to the bounded edentulous space
- **Embrasure**
  - ▸ Two Akers clasps attached to each other that work on two adjacent teeth
  - ▸ Requires rests that sit on both adjacent teeth
    - Prevents clasps from wedging teeth apart over time
- **Combination**

Infrabulge

Infrabulge clasps originate below the HOC

- **Bar type**
- **T bar**
- **I bar**
- **Y type**

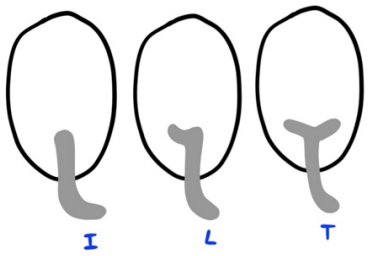


Figure 12.02 Clasp design

3 Clasp Assemblies & Selection

Clasp Assembly

Class assembly refers to the assembly of the rest, minor connector and clasp arms together to make the direct retainer. The following are common clasp assembly terms:

- **RPA (or RPC)**- rest, proximal plate, Akers clasp (circumferential clasp)
  - Both are the same
- **RPI** - rest, proximal plate, I bar

Clasp Selection

- **Wrought wire** – more flexible than a typical clasp design, applies less torque on teeth
  - **Periodontally compromised and endo-treated teeth**
- Bounded edentulous space require **Akers clasp** + rest seats next to edentulous space
- For distal extensions the following can be used: **RPI, RPA, wrought wire** (more preferred to less preferred)

Cobalt-Chromium

- Metal alloy of the metal framework
- **2.3% shrinkage**
  - Results irregularities and porosity
- **Cold-Working**
- Also known as **'plastic deformation'** or **'work hardening'**
  - **Major cause for clasp breakage***
  - Clasp assembly is cold-worked every time a partial is seated and unseated

Fixed Prosthodontics - Tooth Preparation

Tooth preparation is performed for fixed prosthodontics in order to reduce tooth structure from the coronal portion of a tooth while preserving the natural anatomy. Adequate reduction is made in order to place a prosthetic crown on the preparation.

1 Tooth Preparation Terms

- **Occlusal reduction** – occlusal surface reduced while maintaining its original cusp anatomy
- **Incisal reduction** – reduction of incisal surface of anterior teeth
- **Functional cusp bevel** – reduction of cusps
- **Axial wall** – vertical walls along the reduced circumference of the tooth
- **Margin/finish line** – bottom margin of the tooth prep
- **Core build-up** – filling of tooth structure (ex. due to caries removal) as a part of tooth prep for a crown

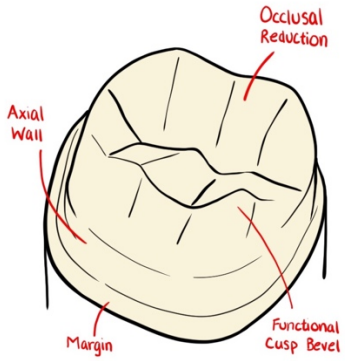


Figure 13.01 Tooth preparation terms

2 Three Principles of Tooth Preparation

There are three crucial principles that must work in harmony to establish a successful outcome of any tooth prep. Within each principle, there are special considerations that must be accounted for in order to achieve success.

1. **Biologic** – health of oral tissues
2. **Mechanical** – integrity and durability of restoration
3. **Esthetic** – appearance of restoration

Biologic

- **Mechanical injury**
  - More prone at thinnest gingival tissue = facial premolars and lingual molars
- **Thermal injury** – related to proximity to pulp
  - Use sharp cutting, water spray, instruments and intermittent light pressure
- **Bacterial injury**
  - Due to marginal discrepancy between crown and preparation margin
- **Chemical injury**
  - Soaked retraction cord
  - Certain cements can induce pulpal reaction

Mechanical

- **Retention form** – helps to prevent removal of a crown along the long axis of the tooth prep
- **Resistance form** – helps to prevent removal of crown by occlusal forces
- **R & R form** – short for retention and resistance form

- **Taper/Parallelism** – converging angle between two prepared opposite axial surfaces
  - Less taper = more retention
  - Greatest operator control
- **Width** – faciolingual or mesiodistal dimension of base
- **Height or Length** – measures from occlusal/incisal surface to crown margin
  - Incisors and premolars - minimum 3mm
  - Molars - minimum 4mm
- **Height to Base Ratio** – 0.4 (minimum)
  - Indicates that a taller prep can allow more taper
- Features indicated for short preps:
  - **Proximal grooves** for resistance
  - **Buccal grooves** for retention
- Thickness of ceramic/metal must be strong enough
  - **Minimum porcelain thickness**
    - 1.5mm
  - **Minimum metal thickness**
    - Margins = 0.5mm
    - No-contact areas = 1mm
    - Contact areas = 1.5mm
  - **Minimum PFM thickness** (no-contact areas)
    - 1.5mm (1.2mm porcelain + 0.3mm metal)
  - **Optimal PFM thickness** (contact areas)
    - 2.0mm (1.5mm porcelain + 0.5mm metal)
- **Clearance**
  - Gap between tooth prep and opposing tooth
  - 1.5-2mm
  - May exist before reduction of the tooth → less reduction required for tooth preparation
- **Reduction**
  - Occlusal tooth structure reduced during crown prep design
  - 1.5-2mm

Esthetic

- Ceramics are more esthetic than metals
- Metal vs PFM vs all-ceramic

3 Margins

Margins can refer to the margin on a tooth preparation or the crown itself.

- Edge at the base of a crown preparation
- Section of the crown that creates the outer boundary and attaches to the cavosurface margin of the prepared tooth

Margin Location

The location of a tooth margin can vary

1. **Supragingival** – above the gingival crest
2. **Equigingival** – at the gingival crest
3. **Subgingival** – below the gingival crest

Margin Types

1. **Heavy chamfer**
   - Thickness 1.0-1.5mm
   - PFM crowns and some all-ceramic crowns
2. **Light chamfer**
   - Thickness - 0.3-0.5mm
   - Gold crowns
3. **Shoulder**
   - Thickness - 1.0-1.5mm
   - More invasive preparation, increasing chance of pulpal embarrassment
   - Maximizes esthetics due to eliminating display of metal
   - All-ceramic crowns
4. **Feather Edge** – very precise, thin margin
   - **Optimal marginal seal***
   - Less invasive
   - Hard to identify
   - Insufficient clearance for most materials to provide adequate material thickness

Figure 13.02 Margin types

4 Inlays, Onlays & Partial Crowns

Inlays, onlays and partial crowns are indirect tooth restorations with their name describing the part of the tooth structure being prepared.

- **Inlay** – tooth prep within cusps
- **Onlay** – tooth prep includes cusps
- **3/4 and 7/8 crowns** – onlay and full crown prep hybrid
  - Maintains tooth structure
  - Not common, difficult to do
  - Easier seating during cementation
  - The prep design often has margins away from gingival tissues compared to other crown designs.

Figure 13.03 Inlays, Onlays, & Partial crowns

INBDE Pro Tip:
Questions about partial crowns are very common on the INBDE.

Pontic & Connector Design

As previously discussed, bridges can include the following elements:

- **Abutment** = a preselected tooth that the bridge is placed onto
- **Retainer** = the part of the crown that contacts the abutment
- **Pontic** = fake tooth
- **Connector** = connects retainer to pontic

1 Pontic Types

Hygiene/Sanitary

- Space between pontic and ridge
- Requires adequate VDO/restorative space
- Promotes excellent hygiene
- Poor esthetics due to gap
- Posterior mandible

Conical

- Like the hygienic pontic, but a small point contacts the ridge allowing a slightly improved esthetics
- Often indicated for molars

Saddle/Ridge Lap

- Firmly wraps around the ridge making it hard to clean and thus not often recommended

Modified Ridge-Lap

- Partially contacts the ridge, usually buccally
- Often indicated for anteriors
- Offers good esthetics
- Not as cleansable as sanitary or conical

Ovate

- Pontic is embedded into a concavity in the soft tissue of the ridge done via surgery
- Anteriors only
- Superior esthetics, as it simulates a tooth emerging out of the soft tissue

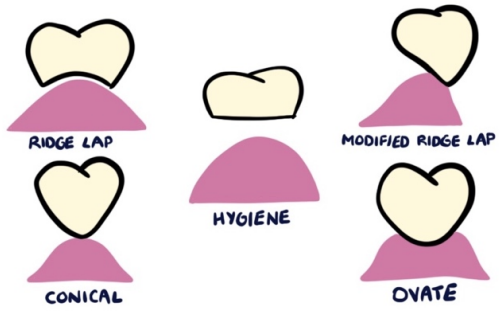


Figure 14.01 Pontic types

2 Connector Design

There are mainly two types of connectors.

- **Rigid** – cast in one piece or soldered
- **Nonrigid** – when the common path of insertion between abutments is not available
- Height of connectors for PFM bridges – requires a minimum of 3mm in height

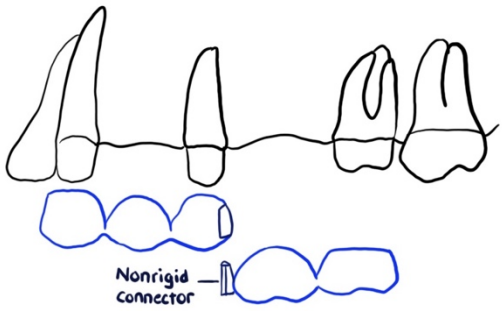


Figure 14.02 Connector Design

Impression Materials

1 Tissue Management

Fluid control

- Local measures of isolation used:
  - Suction and cotton rolls

Tissue displacement

- **Retraction cords** – inserted into gingival tissue around the margin of the prep
  - Extend circumferential periodontal fibers
- **Impregnated cords** – retraction cords impregnated with chemicals that prevent bleeding of soft tissues
  - **Epinephrine**
  - $FeSO_4$ = **ViscoStat**
  - AlCl = **Hemodent**
- **Electrosurgery**
  - Electrode cannot contact teeth
  - Avoid using in patients with implanted medical devices (ex. pacemakers)

2 Impression Materials

Impression materials can be divided into two categories.

- **Aqueous Hydrocolloids** – water based
  - Powder mixed with water
  - Recommended to pour the powder into a bowl of water
- **Non-aqueous Elastomers** – not water based

Aqueous Hydrocolloids

- **Agar - Reversible Hydrocolloids**
  - Transformations between sol and gel phase based on temperature
  - Very precise
  - Requires complex procedure of multiple water baths of different temperatures
- **Alginate – Irreversible Hydrocolloid**
  - Setting time = 3-4 minutes
  - Add gypsum within 10 minutes
  - Potassium alginate – active ingredient
  - Diatomaceous earth – primary ingredient
  - Most are inaccurate*
    - Do not use for taking final impressions
- Hydrocolloids can experience syneresis and imbibition
  - **Syneresis** – water loss, impression shrinks
  - **Imbibition** – water absorption, impression expands
  - Important to keep impression moist but not overly wet

INBDE Pro Tip:
It is important to know factors that influence setting time of alginate.

↓ Setting Time	↑Setting Time
Hot water	Cold water
Less water	More water

Elastomers

- **Polysulfide Rubber**
  - Pour within 30-45 minutes
  - Tolerant to moisture
    - Prone to syneresis
    - **Hydrophobic - releases water**
- **Polyether**
  - Pour within 1 hour
  - Normally stable but readily affected by water/humidity
    - Prone to imbibition
    - **Hydrophilic**
  - Very rigid so hard to separate from the cast
    - Teeth on cast prone to fracture

- **Condensation Silicone**
  - Pour within 30 minutes
  - **Release alcohol as byproduct**
    - Evaporation can cause shrinkage of the impression
- **Addition Silicone (PVS)**
  - PVS – Polyvinyl Siloxane
  - **No by-products**
  - Inhibited by sulfur in **latex gloves** or rubber dam
  - Elastic recovery allows ideal detail and dimensional stability

Gypsum Materials

Gypsum is the stone material used to make a cast from an impression.

- Collected as **calcium-sulfate dihydrate** ($CaSO_4 \cdot H_2O$)
- Use heat to remove excess water to form **calcium-sulfate hemihydrate** ($CaSO_4 \cdot \frac{1}{2}H_2O$)
- All products posses the same chemical formula, but their sizes and shapes of particles are all different

There are 5 types of Gypsum Materials

1. **Type I** – impression plaster
2. **Type II** – model plaster
3. **Type III** – dental stone
4. **Type IV** – dental stone with high strength, lower expansion
5. **Type V** – dental stone with high strength, high expansion

INBDE Pro Tip:
The gypsum types with the higher numbers have more strength and less porosity.

1 Water

Gauging water

- Excess water required to create a workable mix of material
- Does not chemically react with gypsum

Effect of Water on Stone

↑ Water	↓ Water
Less strength (gypsum particles farther apart)	More strength
More porosity	Less porosity
Less expansion	More expansion
Increased setting time	Decreased setting time

2 Gypsum Types

Impression Plaster (Type I)

- Low expansion
- Quick setting time, no expansion time
- Used to mount cast in the articulator

Model Plaster (Type II)

- Used for casts that make Essix retainers and mouth guards

Dental Stone (Type III)

- Used for removable prothesis and diagnostic casts

Dental Stone (Type IV)

- **Best** abrasion resistance
- **High strength and least amount of expansion**
- **Least** gauging water
- Used for fabrication of dies

Dental Stone (Type V)

- Also used for fabrication of dies
- **High strength and high expansion**

3 How to Use Gypsum

Gypsum

- Mixing time
  - Vacuum mix = 20s
  - Hand spatula = 30s
- Setting time = 45-60 minutes
- Disinfect with one of the following:
  - 1:10 bleach solution
  - Glutaraldehyde
  - Iodophor spray

Setting Time

↑ Setting Time	↓ Setting Time
Cold water	Hot Water
More water	Less Water
Decreased spatulation time	Increased spatulation time
	Use slurry water (water saturated with calcium and sulfate ions)

Metal Alloys

1 Metal and Alloys

Noble Metals

There are only 3 major noble metals considered in dentistry.

- **Palladium** → strength
- **Platinum** → strength, ↑ melting temp
- **Gold** → tarnish resistance

*In dentistry, silver is considered a precious metal but **not** a **Nobel metal**.

- causes greening of porcelain

Metal Alloys

Metal alloys are when a metal is combined with two or more metallic elements.

- **High noble alloys** ≥60% noble,
  - At least 40% – gold
- **Noble alloys** ≥25% noble
  - Palladium, platinum , gold
- **Base metal alloys** <25% noble
  - Ni-Cr, Co-Cr, Ni-Cr-Be, Ti

2 Gold Alloys

There are 4 types of gold alloys

Type	Properties	Use
I	Soft 98-99% gold	Class V restorations
II	Medium 77% gold	Inlays Onlays
III	Hard 73% gold	Crowns
IV	Extra hard 69% gold	Bridges Post & cores Clasps RPD castings

Mechanical Properties

Strength

1. **Compressive strength** – being able to resist fracturing from compressive forces
2. **Flexural strength** – being able to resist fracturing upon bending
3. **Tensile strength** – being able to resist fracturing from pulling forces

Fracture Toughness

Fracture toughness – being able to resist the propagation of a crack

- Best fracture toughness – **Zirconia** (due to transformation toughening)
  - **Transformation toughening** – tetragonal phase zirconia particles transform into stronger monolithic phase particles upon fracture to prevent further propagation

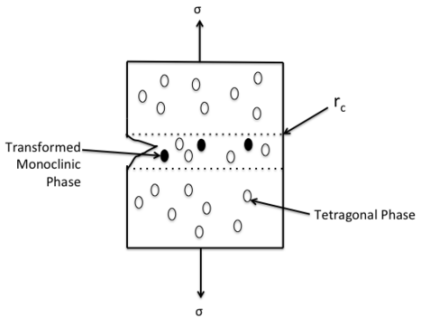


Figure 18.01 Fracture toughness

Modulus of Elasticity/Elastic Modulus

- Measures stiffness or rigidity of material
- Formula = stress/strain
  - **Stress** – internal distribution of a load
  - **Strain** – internal distortion produced by a load
- Describes deformation of a material without permanent change in size or shape
  - **Elastic deformation** – object reverts to original shape once stress is released
  - **Plastic deformation** – object remains deformed, even after stress release
- Represented by the slope of the straight line in a stress-strain curve

- Other properties that can be identified by the stress-strain curve include the following
  - **Brittle** – object fractures easily without substantial dimensional changes (ex. porcelain)
  - **Malleability** – deforms easily under compressive stress (ex. gold)
  - **Ductility** – plastic deformation under tensile strength (ex. orthodontic wires)
  - **Percent Elongation** – described the ability to be burnished
    - Occurs when contact stress surpasses the yield strength of material (ex. gold)

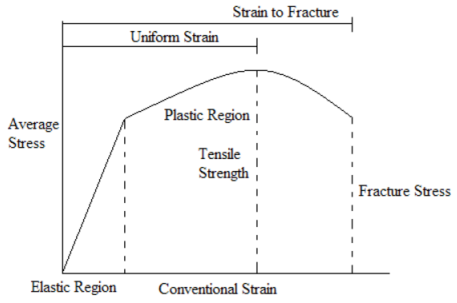


Figure 18.02 Elastic Modulus

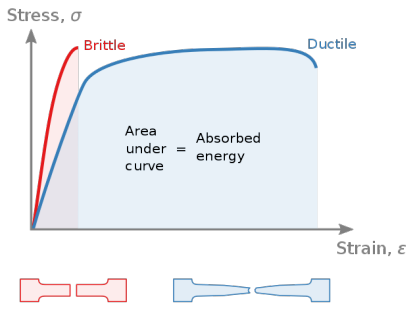


Figure 18.03 Stress-strain curve

Coefficient of Thermal Expansion (CTE)

- Records the fractional change in size (shrinks or expands) per degree change in temperature
- Marked difference between tooth and restoration material = possible break in marginal seal of any restoration can happen
- Higher CTE = higher tendency to change
- Composite>Metal>Tooth>Ceramic

Material	CTE
Composite	30 (unfilled resin worst)
Amalgam	25
Gold	14 (best)
Tooth	11.4
Porcelain	6

Desirable Mechanical Properties

In summary, desirable mechanical properties of a restorative material include the following:

- CTE close to the CTE of tooth
- High elastic modulus
  - Does not flex easily
- High yield strength
  - avoids permanent deformation
- Casting accuracy
  - Gold is more accurate than base metal
- Corrosion resistance
  - More noble = more corrosion resistance
- Minimal wear of opposing dentition
  - Porcelain has poor wear resistance compared to metals
- Biologic compatibility

Provisional Crowns

Crown Fabrication Steps:

1. Crown preparation on tooth
2. Impression of crown prep
3. Gypsum
4. **Provisional crown**
5. Permanent crown
6. Cementation of permanent crown

*Note a digitally scanned tooth prep can eliminate the impression and gypsum steps as well as eliminate the need for a provisional crown by providing a same day crown.

A **provisional crown** is a temporary crown meant to provide functionality and esthetics during the interim period while the final prothesis is being fabricated.

- The provisional crown should still abide by the three principles of tooth preparation (biologic, mechanical, esthetic).

1 Provisional Crown Fabrication

Method

There are two different methods of making a provisional crown.

1. **Direct** = created within patient's mouth
   - Faster process, no lab time
   - More chairside time
   - More common method
2. **Indirect** = created outside of patient's mouth
   - Usually created in the lab on a cast model
   - Avoids chemical and pulpal irritation to tissues
   - Less chairside time

Mold

There are mainly 3 different ways to mold the contour of the tooth during fabrication of the provisional restoration.

1. Prefabricated Crown

- Stainless steel – commonly used in pediatrics
- Polycarbonate
- Aluminum

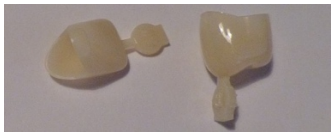


Figure 19.01 Prefabricated crown

2. Putty or shim

- Used to take impression of the tooth before crown prep is performed or with diagnostic wax up
- Filled tooth impression with temporary crown material
  - Place on patients mouth to set (direct)
  - Place on cast to set (indirect)

Figure 19.02 Putty/shim

3. Cellulose acetate crown form

- Comes in different sizes and shapes
- Trimmed to custom fit the margins of the tooth without impinging of soft tissue
- Filled with temporary crown material

Material

- **Bis-Acryl Composite** – direct
  - Less polymerization shrinkage
  - Minimal irritation
  - Lower strength than PMMA
- **PEMA**
  - Not common
- **PMMA**
  - Indirect method
  - Strong
  - Easy to repair
  - Exothermic reaction – easily irritates pulpal tissues (hence indirectly)

Removing Provisional Crown

Once the permanent crown is fabricated, the provisional crown needs to me removed and the tooth prep cleaned before cementation.

- Confirmation of occlusion difficult with anesthesia
  - Try to avoid delivering local anesthesia unless the patient is sensitive
- Eugenol (provisional cement) prevents polymerization of permanent resin cement
  - Use explorer, excavator or wet cotton pellet to remove as much as possible of Eugenol before placing resin cement during crown cementation

Metal-Ceramic & All Ceramic Crowns

1 Metal-Ceramic Crown

Metal-Ceramic crowns have a layer of metal surrounded by a thick layer of porcelain.

- Require **monomolecular oxidative layer** for porcelain to bond/attach to metal alloy
  - Dark color presents an esthetic challenge

Porcelain Layers

A metal-ceramic crown is often without porcelain on the lingual side and only has porcelain layering on the buccal side for esthetics

- Chamfer margin on lingual and shoulder margin on buccal
- Occlusal contacts ≥1.5mm away from porcelain-metal junction

The porcelain can be layered for different effects on each layer.

1. **Opaque porcelain** – covers dark oxide with minimum thickness (0.1mm), creates porcelain-metal bond
2. **Body/dentin porcelain** – constitutes most of the crown
3. **Incisal/enamel porcelain** – most translucent layer

Metal-Ceramic Failures

There can be several reasons for failure of a metal ceramic crown.

- **Cohesive Failures** – failure occurs within the same material
  - Oxide layer is too thick
  - Voids or inclusion in porcelain-porcelain layering
  - Does not occur in metal-metal
- **Adhesive Failures** – failure occurs between different material
  - In oxide-metal layer if metal is contaminated
  - In porcelain-oxide layer if porcelain is contaminated
  - In porcelain-metal layer if oxide does not form
- Long-span PFM bridges
  - Fractures due to flexure forces

2 All-Ceramic Crowns

All-ceramic crowns are mainly used for their esthetic principles. There are two different types.

1. **Glass infiltrated ceramics** – can be bonded to the tooth
   - Using **hydrofluoric acid** etch and **silane coupling agent (allows bonding)**
   - More esthetic
2. **Ceramics with no glass content-** do not bond
   - Attached to the tooth with luting cement
   - Stronger, but less esthetic

3 Porcelain Veneers

Porcelain veneers only cover the facial side of a tooth. They are purely esthetic in function.

Porcelain veneer tooth prep is as follows.

- **Intra-enamel preparation**
- Incisal reduction = 1-2mm
- Facial reduction = **0.5mm**
- Gingival third reduction = **0.3mm**

4 Maryland bridge (resin bonded bridge)

A **Maryland bridge** consists of teeth made of porcelain or PFM with metallic wings on one or both sides that attach to natural teeth.

- Debonding with resin-bonded bridge is more likely in comparison
- More removal of tooth structure needed with conventional bridge

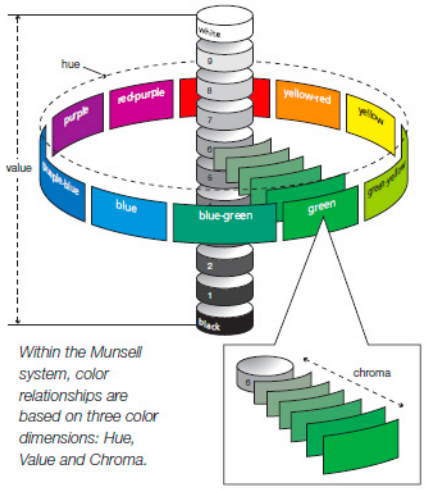
Shade Selection

1 Color Theory

Munsell Color System

There are 3 main ways to describe color.

1. **Hue** – color family
2. **Chroma** – color saturation
3. **Value** – lightness or darkness
   - Ideal for shade selection of crown



Within the Munsell system, color relationships are based on three color dimensions: Hue, Value and Chroma.

Figure 21.01 Munsell Color System

   - 0 (black) to 100 (white)

Effect of Light Source

The light source that is present is crucial to selecting the best shade. There are 3 concepts related to how light can affect how we perceive color.

- **Metamerism** – Difference of color appearance with different lighting
  - *Ex. color looks different under direct sunlight vs indirect sunlight vs artificial light*
  - Ideal light – **5500K (kelvin) and 100% CRI** (color rendering index)
  - Important to stay consistent in light source when shade matching
- **Fluorescence** – releasing visible light under UV light
  - Tooth vs composite can fluoresce at different shades
  - Material with higher fluorescence tends to match teeth more better
- **Opalescence** – observed when a translucent object appears blue when under reflected light and red-orange under transmitted light
  - Shorter wavelengths scatter in the tooth
  - Longer wavelengths go through the tooth

Shade Selection and Color

Shade selection should be conducted in a certain order to best match the adjacent teeth.

1. Value – found in middle third of the crown
2. Chroma – found in cervical third of crown
3. Hue – found in incisal third of crown

2 Characterization

Characterization of a tooth refers to the reproduction of natural defect on a crown. There are several ways this can be achieved.

- **Staining** – loss of fluorescence, ↑ metamerism, ↓ value
  - Affects color of tooth
- **Glazing** – melting porcelain surface to fill in defects
  - Mainly affects surface texture
- Porcelain can get darker by adding more color (stain), but reversing is not possible
  - When in doubt, pick a shade with less saturation and higher value because you can correct it later on

3 Crown Delivery

The following is the general order of steps of what to evaluate in the crown before it is cemented.

1. Shade (esthetics)
2. Proximal contacts
3. Margins
4. Fit
5. Retention and resistance form
6. Occlusion
7. Contour
8. Cement

Dental Cements

1 Types of Cements

Dental cements or luting agents that connect the underlying tooth structure to the prosthesis. There are mainly 6 types of cements.

1. **Zinc Oxide Eugenol**
   - Inhibits polymerization of resin
   - Temporary/provisional cement
   - Base and accelerator mixed
   - Eases pulp
2. **Zinc Polycarboxylate**
   - Powder and liquid
   - Minimal pulp irritation
   - Chelation to calcium = weak bond to tooth
3. **Zinc Phosphate**
   - Phosphoric acid disturbs pulp
   - Exothermic reaction
   - No chemical bond to tooth = luting agent
4. **Glass Ionomer**
   - Powder and liquid
   - Releases fluoride
   - Attaches to enamel and dentin
5. **Resin Modified Glass Ionomer**
   - Stronger & lower solubility than Glass Ionomer (GI)
     - Due to addition of resin
   - Not used with all-ceramic crowns (except zirconia) due to expansion from water absorption
   - Ex. RelyX Luting Plus
6. **Resin**
   - Binds to dentin & most compressive strength
   - Chemical, light cure, or dual cure varieties
     - Dual cure (RelyX Unicem and RelyX Ultimate) – have light and chemical cure component
     - Light cure (RelyX Veneer cement) is more color stable than dual cure

INBDE Pro Tip:
From 1-6 on the dental cements list, technique sensitivity increases while solubility decreases.

2 Crown and Cements Armamentarium

Crowns made of different materials should be paired with certain cements over other cements.

Crown	Cement
Zirconia (ceramic but no silica)	Luting cement (GI or RMGI)
Metal (PFM or full gold)	Luting cement (GI or RMGI)
Lithium Disilicate (emax)	Resin cement (dual cure)
Feldspathic porcelain (veneers)	Resin cement (light-cure)

Out of all the zinc cements, only zinc oxide eugenol is used today as a temporary cement.

Resin cement and Crowns

Resin cement requires additional steps in the cementation process.

1. Dentin or etched enamel applied with primer and bonding agents
2. The crown is etched with hydrofluoric acid and then line it with silane coupling agent
3. Fill with resin cement
4. Seat the crown on the tooth

Lab Processing of Crowns

1 Die Creation

After the master cast of a patient's dentition has been created. Then, a **die** is created for the tooth receiving the crown

- **Die** - a positive reproduction of the tooth prep
- **Ditching a die** – cleans away any stone below the margin to expose the tooth prep
- **Die spacer** – thin painted on layer that accounts for the cement layer
  - Provides space for cement

2 Crown Processing Steps

After die creation, there are a series of steps for producing the crown.

1. Waxing

Waxing - creates a positive of the crown

2. Spruing

Spruing – a pathway for metal to flow into the prosthesis as it is being casted

3. Investing

Investing – Use investment material to create a negative by covering the wax

- Investment material
  - Phosphate-bonded investments → PFM
  - Gypsum-bonded investments → gold
  - Silica-bonded investments → base metal

4. Burnout

Burnout – wax positive is melted

1. Casting

Casting – metal is melted into the investment

2. Recovery

Recovery – breaking the investment to recover the metal cast framework

3. Quenching

Quenching – immediately placing hot cast metal into the cool water

- Process allows cast to be more malleable for finishing

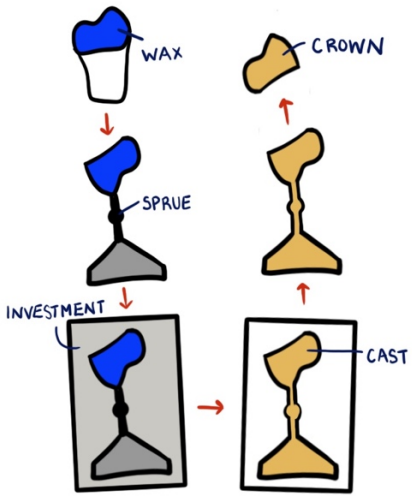


Figure 23.01 Crown processing steps

3 Porosity Issues

Several errors can arise during lab processing of the crown.

- Heating too fast can cause porosity of acrylic
- Inadequate condensing of porcelain can cause the porosity of porcelain
- Sprue being too short can cause back-pressure porosity of metal
  - A short sprue does not allow gas to leave which subsequently blocks fluids from entering
- Sprue too thin can cause shrinkage porosity of metal