Design of a Removable Partial Denture

By Taseef Hasan Farook, BDS (final year, University of Dhaka)

Taseef

Denture Design: ***A planned visualization of the form and extent of a dental prosthesis arrived at after a study of all factors involved***

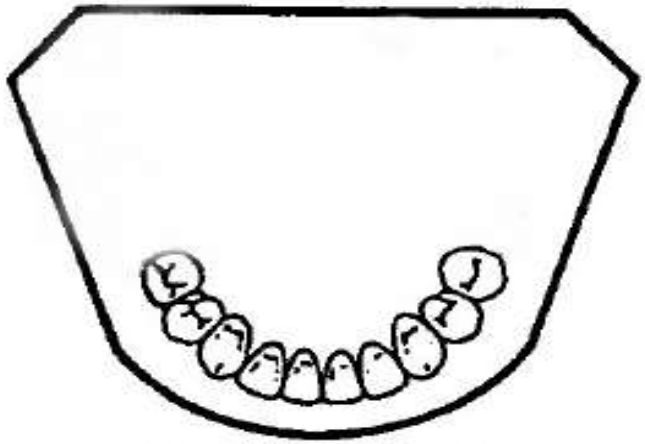
- **GPT**

Kennedy's Classification of partially edentulous jaw

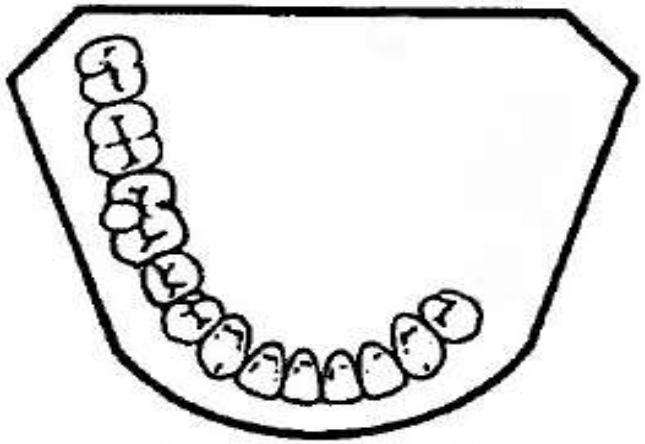
- **Classification I**- bilateral edentulous area situated posterior to natural teeth
- **Classification II**- unilateral edentulous area situated posterior to natural teeth
- **Classification III-** edentulous space bounded on both side by natural teeth
- **Classification IV**- A single, but bilateral edentulous area located anterior to the natural teeth

Applegate's 8 rules are used in diagnosing a case according to Kennedy's classification

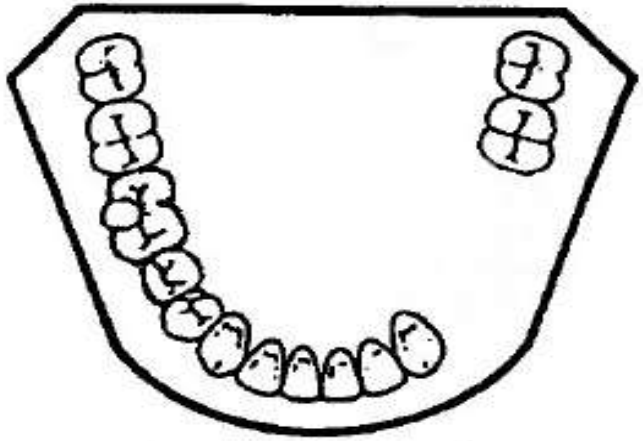
Types of partially edentulous jaw According to the Classification by Edward Kennedy in 1923:



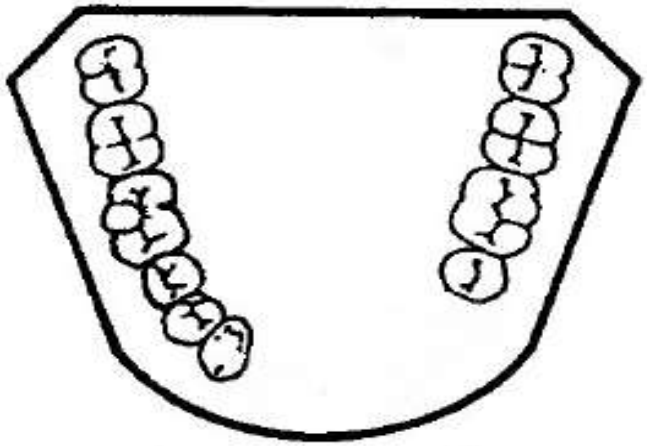
Type I



Type II

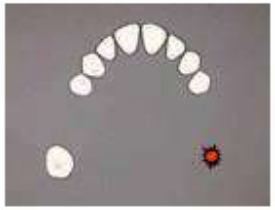


Type III



Type IV

Applegate's Rules

Rule 1- Classification follows extraction		Rule 5- The most posterior edentulous area determines the class	
Rule 2- If the third molar is missing and is not to be replaced then it is not considered		Rule 6-Edentulous areas other than those determining classification are referred to as <u>modifications</u> and are designated by number	
Rule 3- If the third molar is present and is to be used as an abutment then it is considered		Rule 7- The *extent* of the modification is not considered, only the *number*	
Rule 4- If the second molar is missing and not to be replaced it is not considered		Rule 8- There are *NO* modification areas in class IV arches	

Basic Considerations

Biomechanics at play within the oral cavity must be taken into consideration and the denture design must be made in accordance, to counteract the mechanical forces/stress acting within the oral cavity.

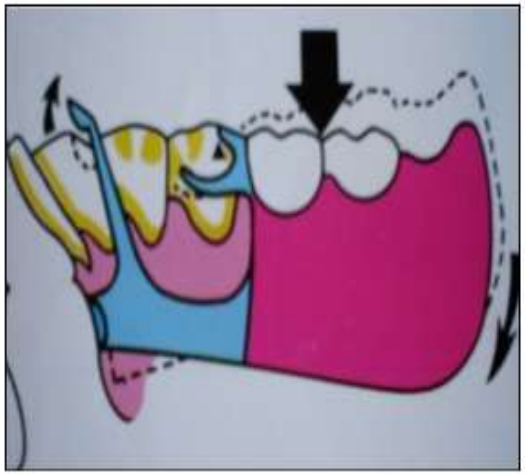
Forces to consider: **1. Vertical – Displacing**

- Dislodging forces

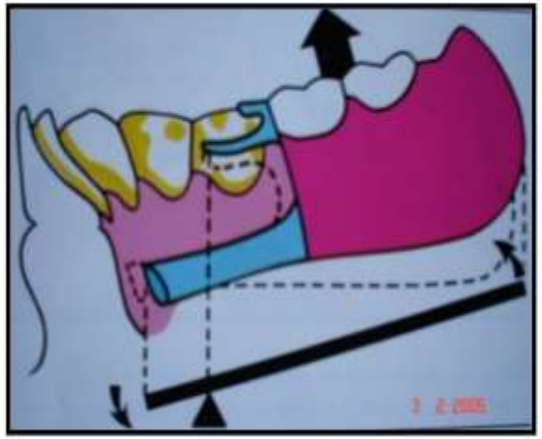
2. Horizontal forces

3. Torsion

Displacing stress

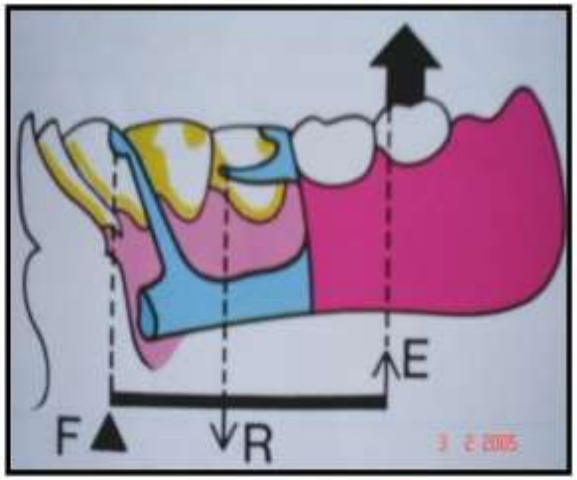


Dislodging stress



Horizontal stress

Torsional stress



Biomechanics and Types of RPD

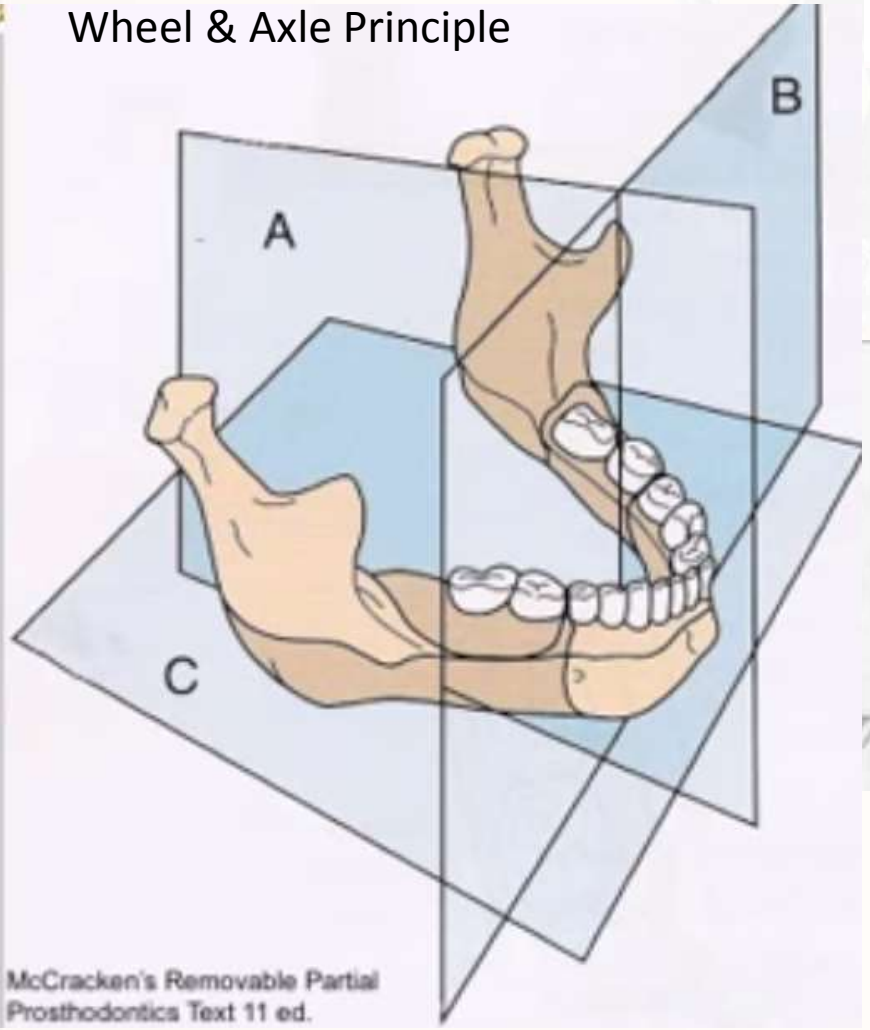
Most common mechanical forces at play:

1. **Lever principle (all Kennedy Class I and II cases)**
2. **Inclined principle (all rest and retainers)**
3. **Wheel and axle principle (rotation)**

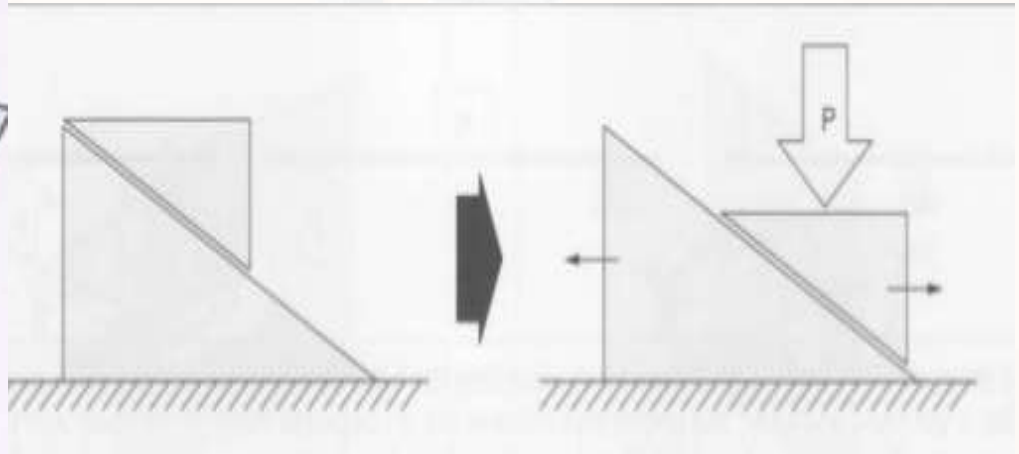
the prosthesis constructed can either be:

1. **Tooth supported- (all Kennedy Class III dentures)**
2. **Tissue supported (Kennedy Class I & II dentures)**

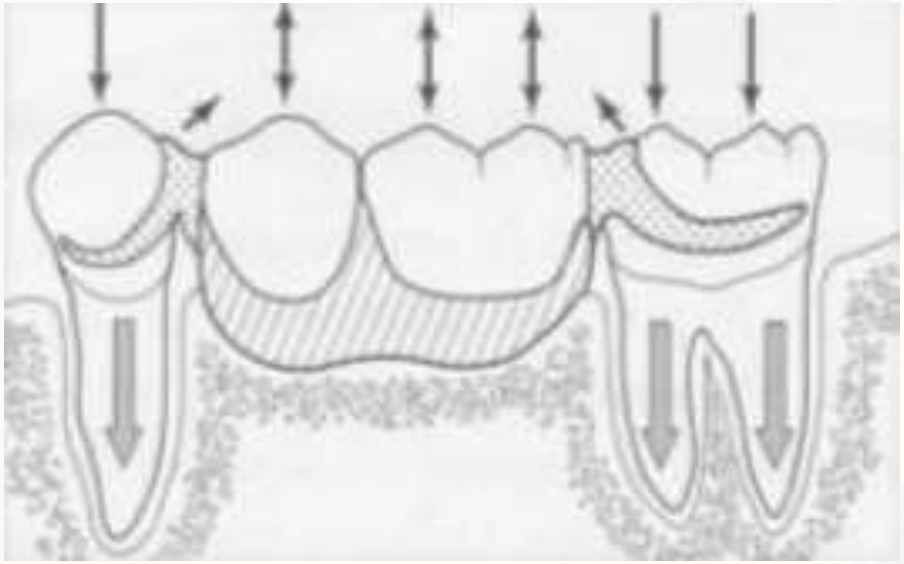
Wheel & Axle Principle



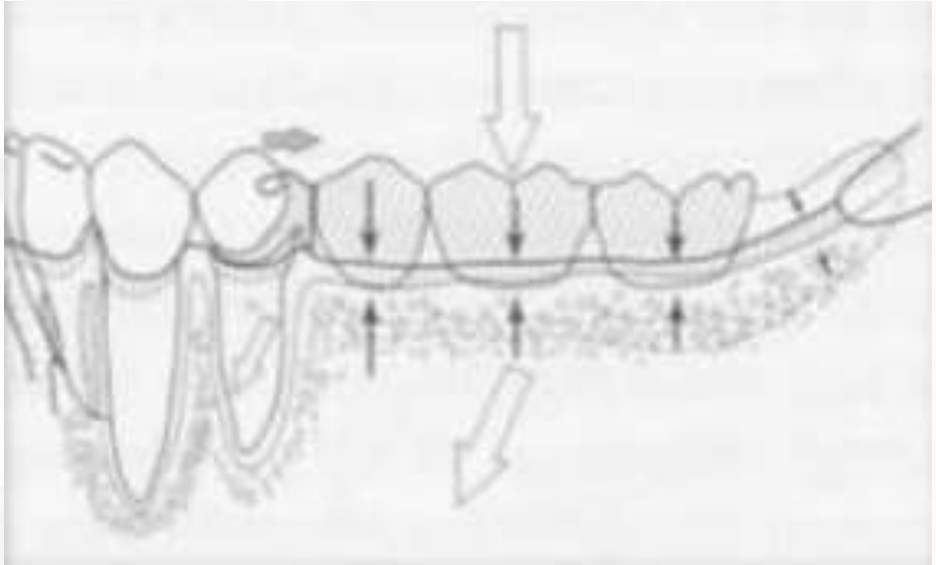
Lever and Fulcrum Principle



Inclined plane principle



Tooth Supported prosthesis
(Kennedy Class III)



Tissue Supported Prosthesis
Kennedy Class I & II)

Biological factors to consider during design

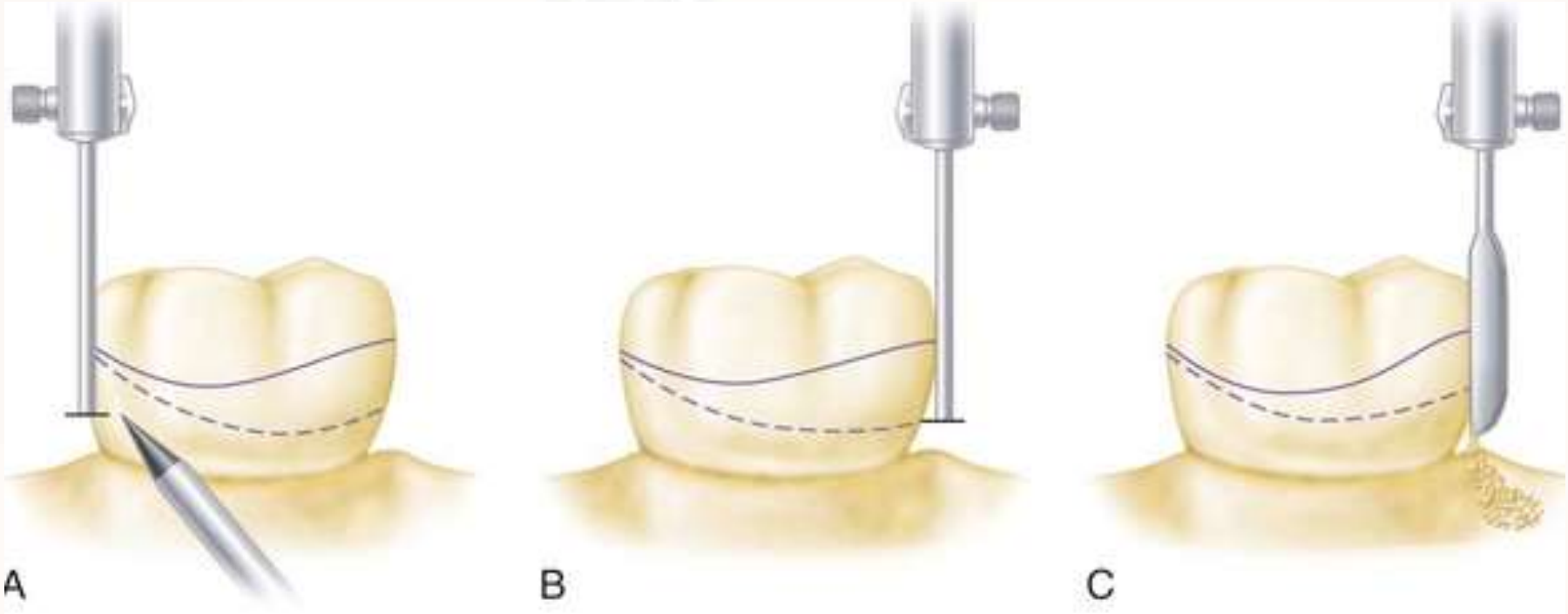
- **Length** of edentulous span
- Type of **oral mucosa**
- Quality of **ridge support**
- **Clasp design** – (type, length, flexibility, material used)
- **Occlusal harmony**

Initial Step is Surveying of the cast

- To determine **path of insertion**
- To mark the **height of contour**
- Mark **undercuts** otherwise not visible to the naked eye

Survey Lines: ***line produced on a cast of a tooth by a surveyor or scriber marking the greatest height of contour in relation to the chosen path of insertion of a planned restoration-*** **GPT**

Survey Lines



Types of survey lines: 1. High

2. Medium

3. Low

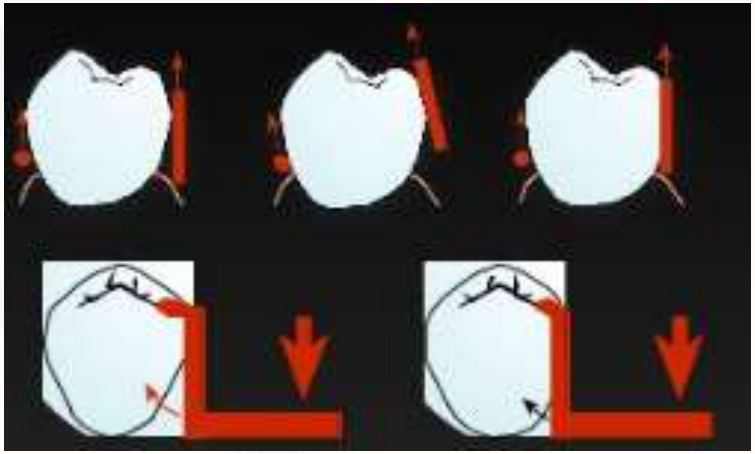
4. Diagonal

1. Path of insertion

- **Kennedy Class I case**: may have **multiple paths** of insertion. A single path obtained by additional guiding planes on the lingual surface
- **Kennedy Class II:** Path of insertion **depends on the modification space** and their guiding plane
- **Kennedy Class III**: **Single path** of insertion depending on the proximal abutment teeth
- **Kennedy Class IV**: **Single path** of insertion

Factors influencing Path of insertion

- Retentive undercuts
- Interference
- Guiding plane
- Denture Base



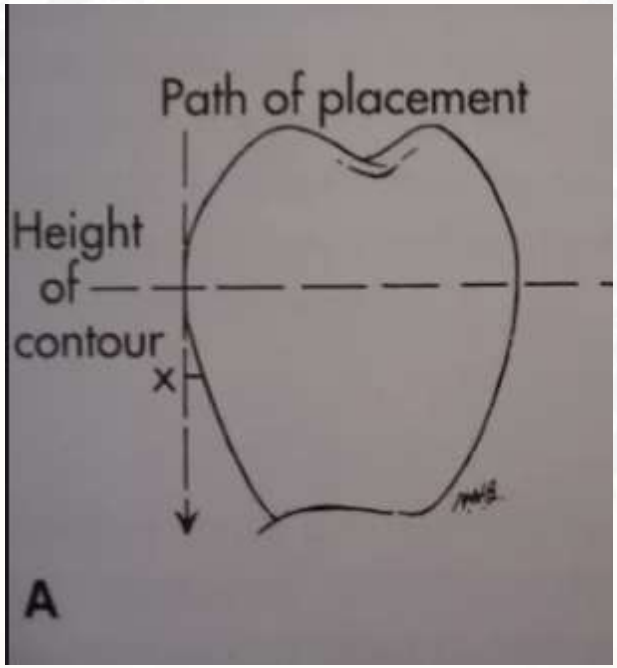
Guiding plane: ***Two or more vertically parallel surfaces of abutment teeth so oriented as to direct the path of placement of removable partial denture-*** **GPT**

Use short guiding planes for Class I & II cases, use long guiding planes for Class III and IV cases

2. Height of Contour

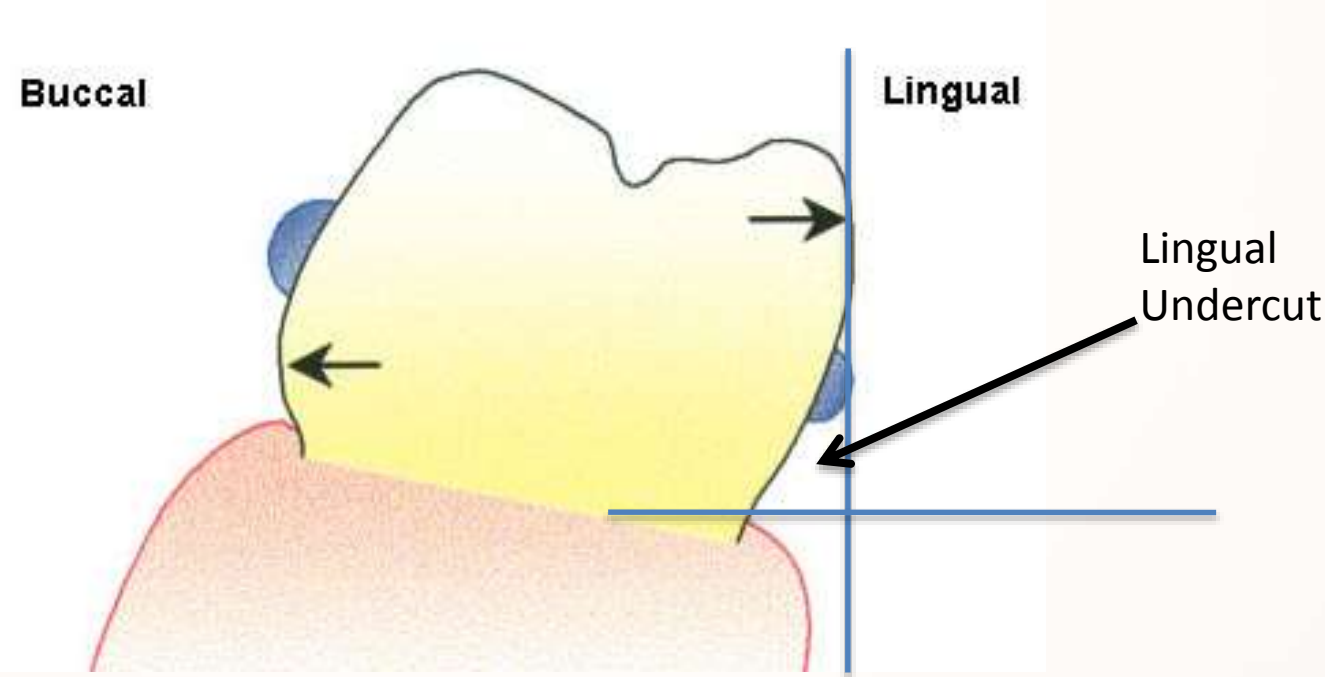
Line encircling a tooth designating its greatest circumference at a selected position – **GPT**

The area below the height of contour is a potential undercut and if feasible, can be used for designing the retentive components of an RPD.



3. Undercuts

The area enclosed by the vertical drop and horizontal surface of any given structure.



After Surveying, the next step is to **DESIGN THE COMPONENTS** of the RPD

Parts:

- Major connectors
- Minor Connectors
- Rests
- Retainers
- Denture base

Kennedy Class II modification I cast partial denture

Major connectors

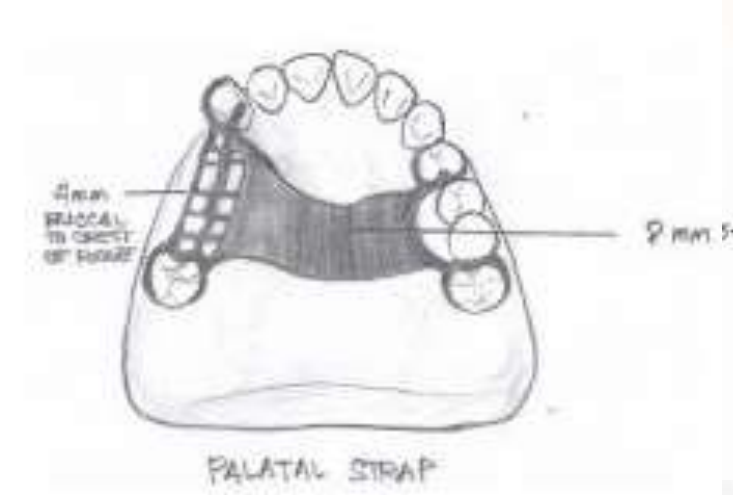
Basic Design principles:

- The borders should be **6mm (maxillary)** and **3mm (mandibular)** away from the marginal gingiva
- The **borders** should be **parallel** to the gingival margin
- The metal framework should cross the gingival margin only at 90 degree (**right angle**) and cross the palate in a straight line
- Anterior border of maxillary major connectors should **not lie on the crest of the palatal rugae**

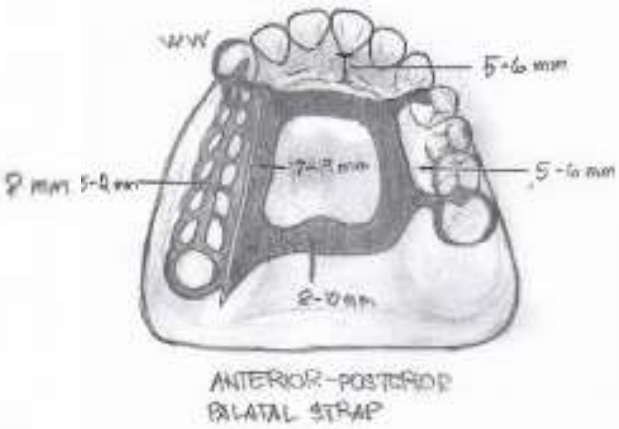
Maxillary major connectors: (and their uses)

- **Single posterior palatal bar** (Kennedy Class III)
- **Palatal Strap** (bilateral short span Class III)
- **Palatal plate** (Kennedy class I)
- **Antero-posterior palatal bars** (Class II and IV)
- **Horse shoe shaped plate** (Class I and II)
- **Complete palate** (Kennedy Class I)

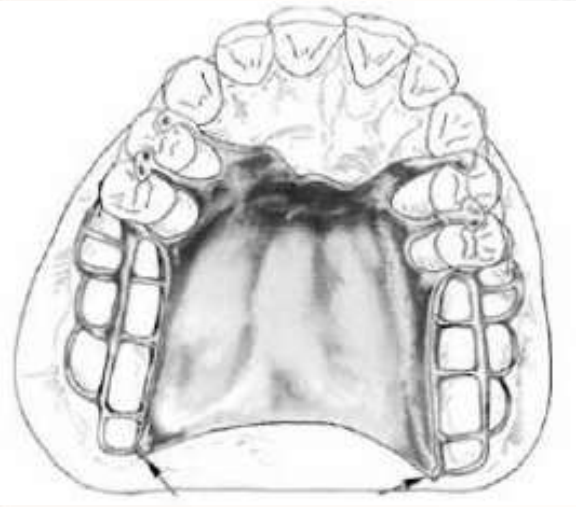
PALATAL BAR



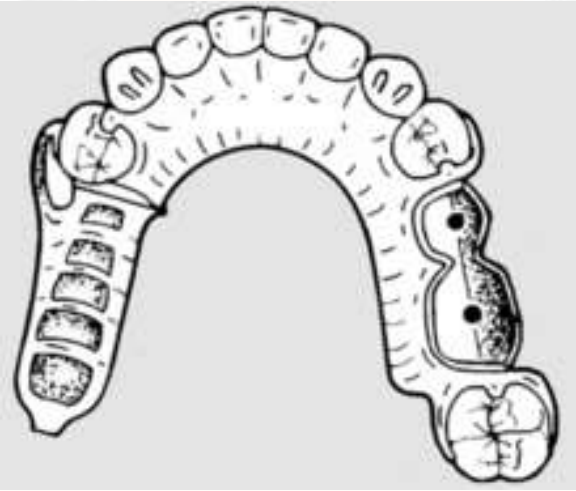
PALATAL STRAP



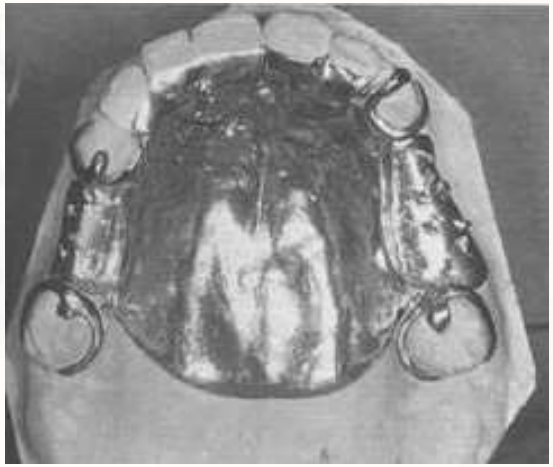
ANTERO-POSTERIOR PALATAL STRAP



PALATAL PLATE



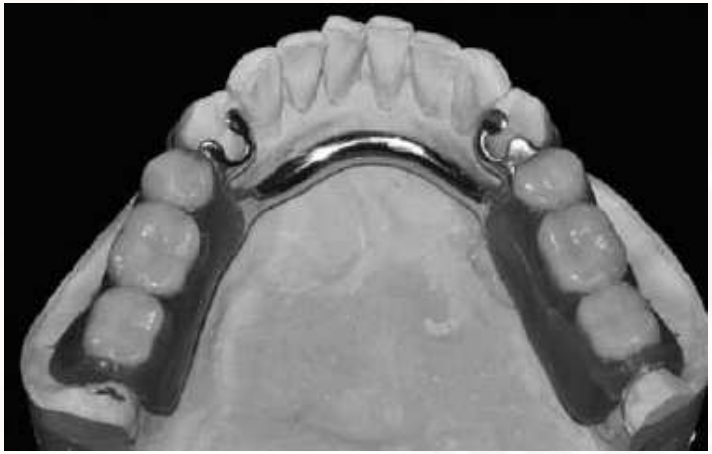
HORSESHOE PLATE



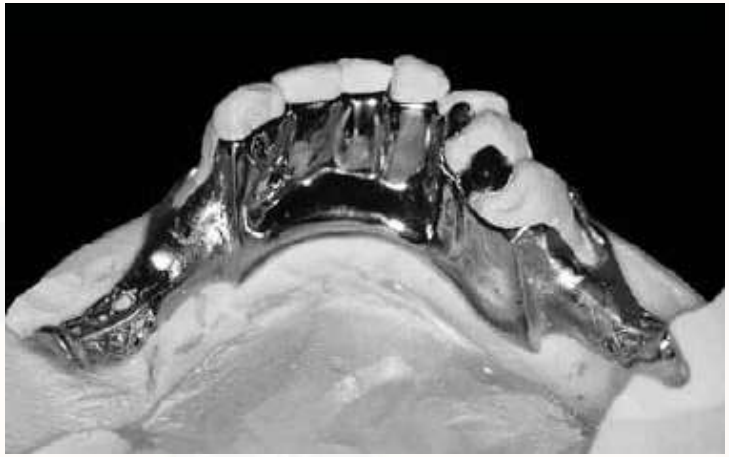
COMPLETE PALATE

Mandibular major connectors

- **Lingual bar**
- **Lingual Plate**
- **Double lingual bar/ Kennedy bar**
- **Sublingual bar**
- **Mandibular cingulum bar**
- **Labial bar**



LINGUAL BAR



LINGUAL PLATE

DOUBLE LINGUAL BAR

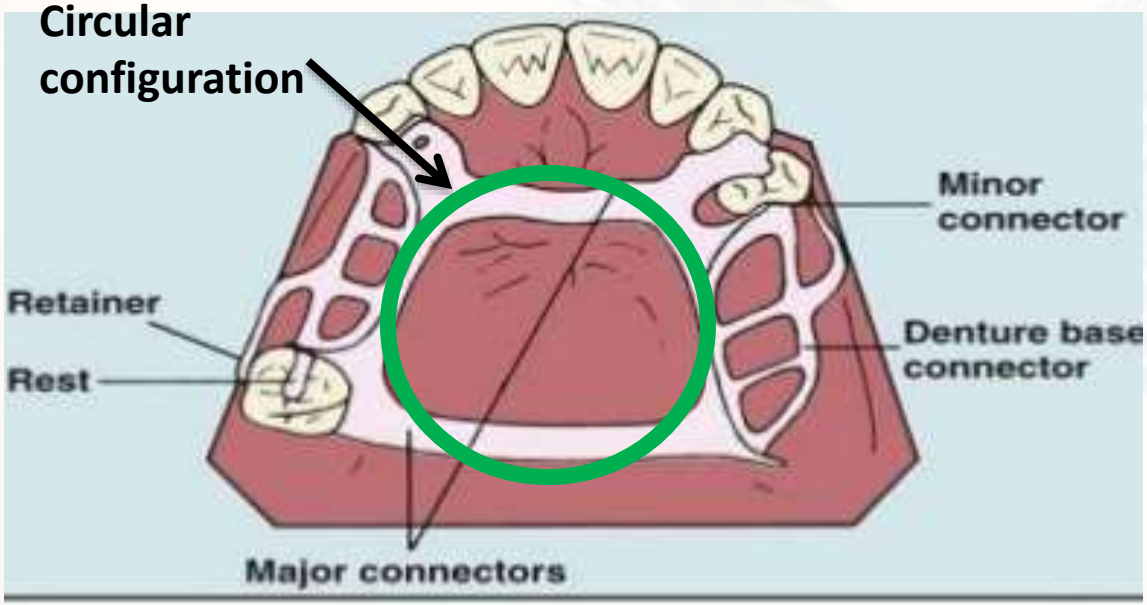
SUBLINGUAL BAR

Major Connectors of Choice

For **maxillary** arches**: broad palatal plate connector**

Modifications:

1. L-beam priniciple
2. Circular configuration
3. Strut configuration



For **mandibular arches, lingual plate** with retainers can help distribute stress.

Minor Connectors

These are the connecting links between the major connector and clasps, retainers and rests.

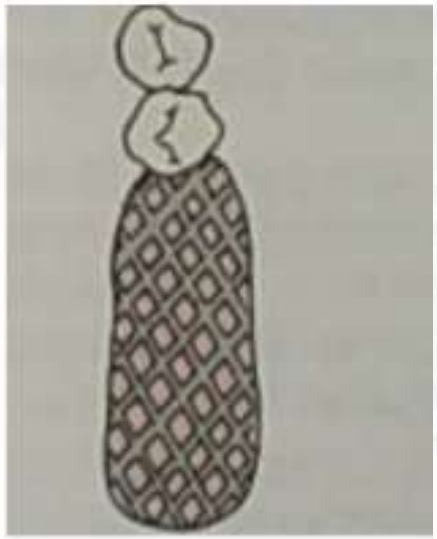
Basic Design principles:

- **Broad bucco-lingually, thin mesio-distally**
- **Triangular cross-section** with thickest portion **near the lingual line angle**
- If not placed on the abutment teeth, the connector should be placed in the embrasure.
- Should **NEVER be placed on the convex lingual surface**
- The area to hold the connector should be **devoid of undercuts** and parallel to **path of insertion**
- Mandibular distal extension should **cover 2/3rd the length of the edentulous ridge**

Types of minor connectors

- Lattice work
- Meshwork
- Bead, wire or nail head

LATTICE WORK



MESHWORK

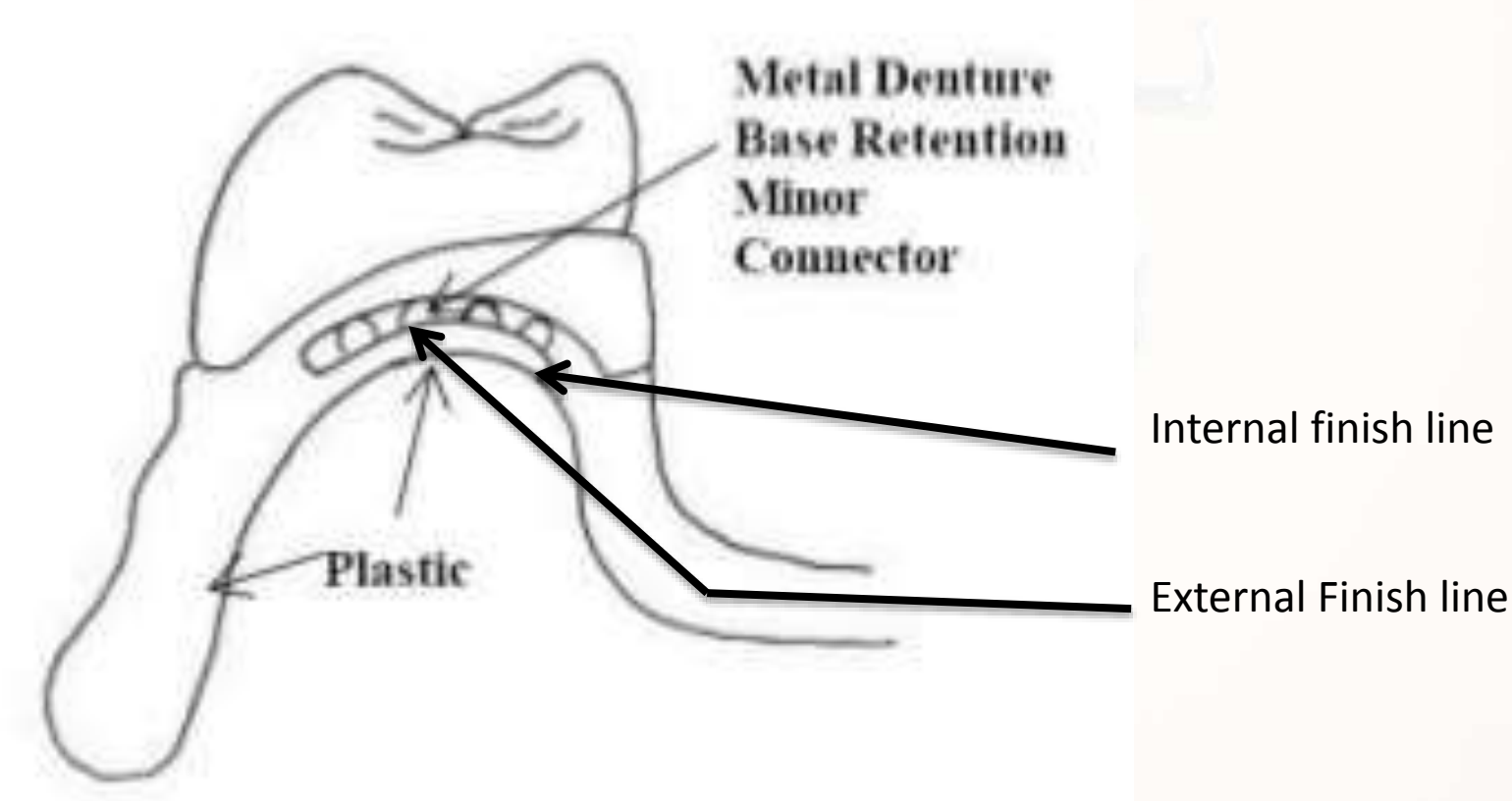
NAIL HEAD TYPE

Finish Line

The term denotes the junction between the acrylic denture base and the major connector.

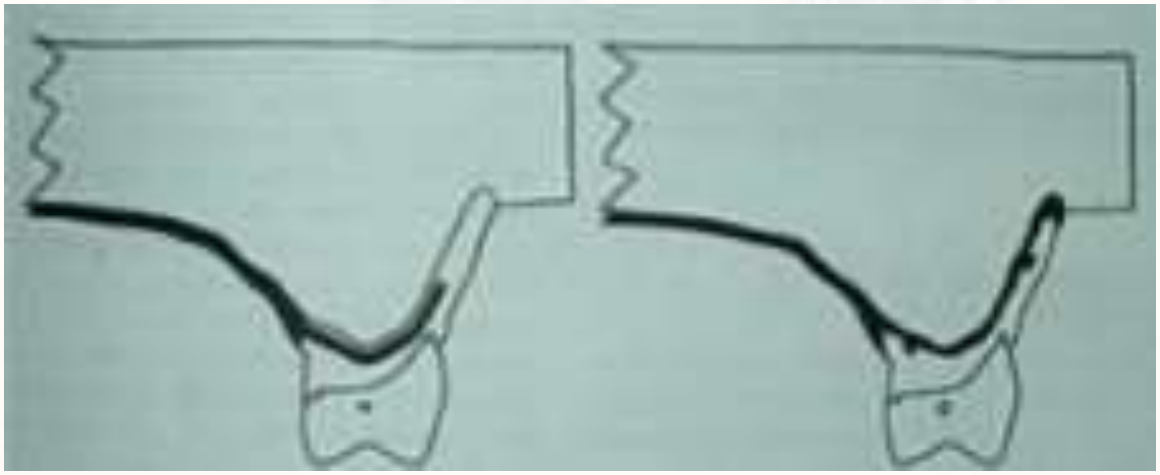
Types:

- Internal finish line: *metal to tissue surface*
- External finish line: *acrylic to metal surface*



Finish Line Design

- Acrylic around **lattice or meshwork** minor connectors should be smooth and present with **internal and external finish lines**
- **Bead type** minor connectors require **only external finish line**



Rests

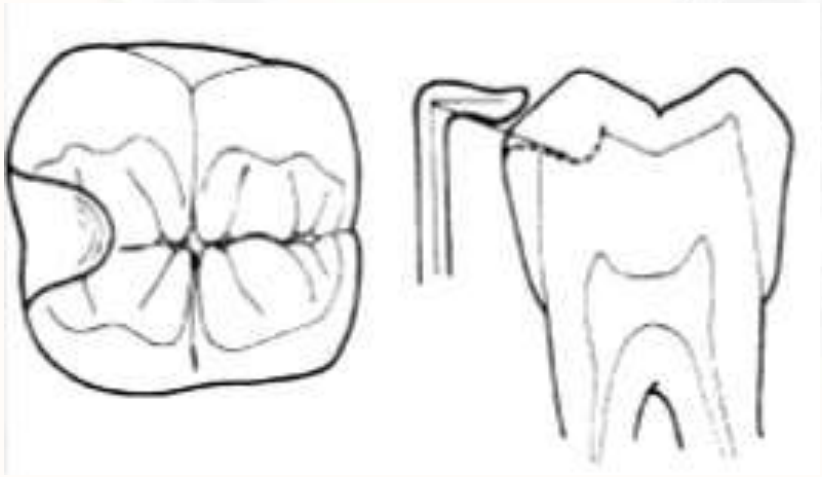
Rest: *rigid stabilizing extension of a partial denture which contacts a remaining tooth/teeth to dissipate vertical and horizontal forces*

Types:

1. External
   - Occlusal rest
   - Incisal rest
   - Cingulum rest
   - Lingual rest
2. Internal

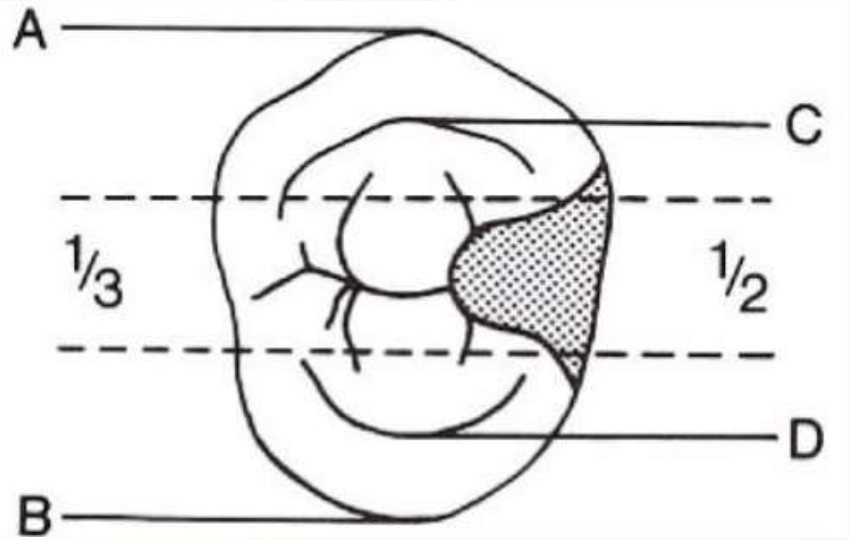
Rest seat

That portion of natural tooth or a cast restoration of a tooth selected or prepared to receive an occlusal, incisal, lingual, internal or semiprecision rest - **GPT**



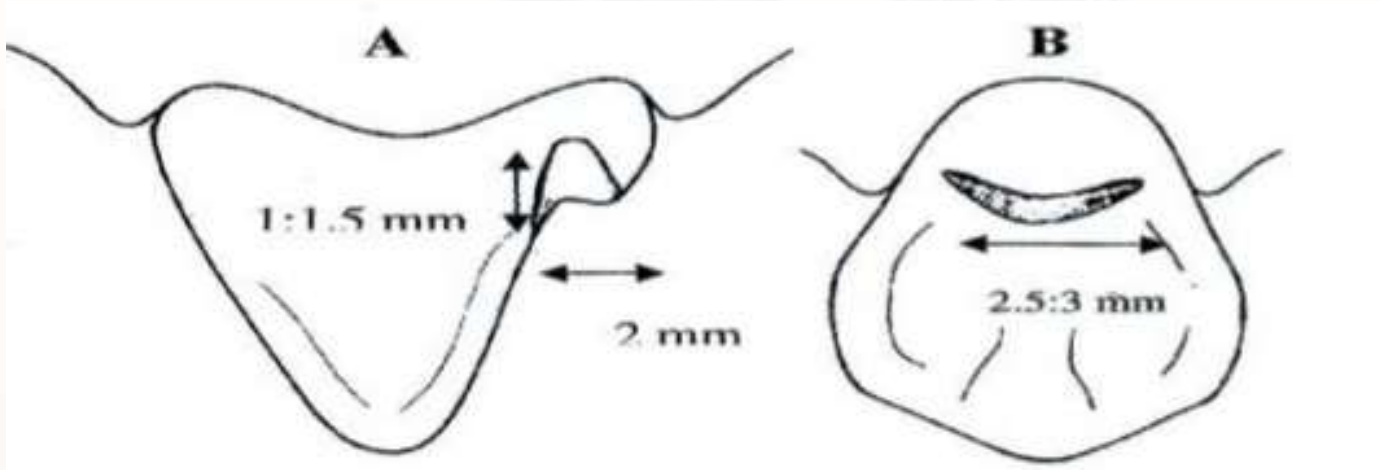
Design of an occlusal rest seat

- **Triangular shape** with apex at the centre of the tooth and base at the marginal ridge
- **½ buccolingual** width
- **1/3 mesiodistal** width
- **Angle** between floor of the prosthesis and proximal surface of tooth **<90 degree**
- **0.5mm thick at thinnest point** and 1-1.5 mm thick at margin.



Design of lingual and cingulum rest

- **2.5-3mm mesiodistal** length
- **2mm labiolingual** width
- **1.5mm deep**
- **V-shaped notch-** labial inclination parallel to labial surface, lingual inclination perpendicular to the labial incline
- Apex of the V directed incisally



Direct retainer

- ***Component of a removable partial denture that is used to retain and prevent dislodgement consisting of a clasp, assembly or precision attachment*** – **GPT**

Types:

Extra-coronal	**Intra-coronal**
Occlusal Approach	Internal Attachment
- *Aker's Clasp*	External Attachment
Gingival Approach	Stud attachment
- *Bar Clasp*	Bar attachment
	Special attachment

Parts of clasp assembly

Design of a clasp

- The retentive arm terminal 1/3rd should be flexible to engage undercuts
- The proximal 1/3rd of the retentive arm to be placed above the height of contour
- The rigid components are to be placed in the non retentive areas of the tooth
- The retentive part must make use of the retentive undercuts present on the tooth

Design of clasp

Selection of clasp material according to the buccolingual width of the undercut: (*more flexible material is required to facilitate insertion of the RPD into deeper undercuts)*

- 0.010 inch undercut- cast chrome alloy
- 0.015 inch undercut- gold and its alloys
- 0.020 inch undercut- wrought wire

-The **longer** the clasp arm**, greater the flexibility**.

-The clasp arm should be **tapered towards the tip**

Types of Clasp

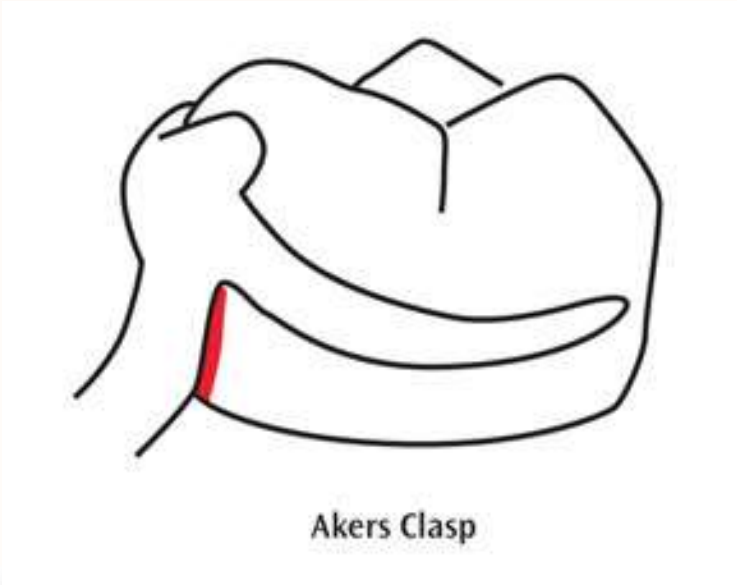
- Circumferential Clasp/ Aker's Clasp
  - **Simple circlet** (NOT used for distal extension cases)
  - **Reverse circlet** (used in distal extension cases)
  - **Multiple circlet** (used for abutment with weak periodontal support)
  - **Modified crib clasp** (used in Kennedy Class II and III without any modifications)
  - **Ring clasp** (used in distolingual undercuts and lingually tipped molars)

Other types of circumferential clasps

- **Fish hook clasp** (used when undercut is adjacent to an edentulous area)
- **Onlay clasp** (used when abutment teeth are below occlusal level. Thus the onlay restores occlusal harmony while the clasp provides retention)
- **Combination clasp** (wrought wire retentive arm and cast wire bracing arm)
- Vertical reciprocal, horizontal retentive arm clasp **VRHR**-(Used in posterior teeth with high survey lines)

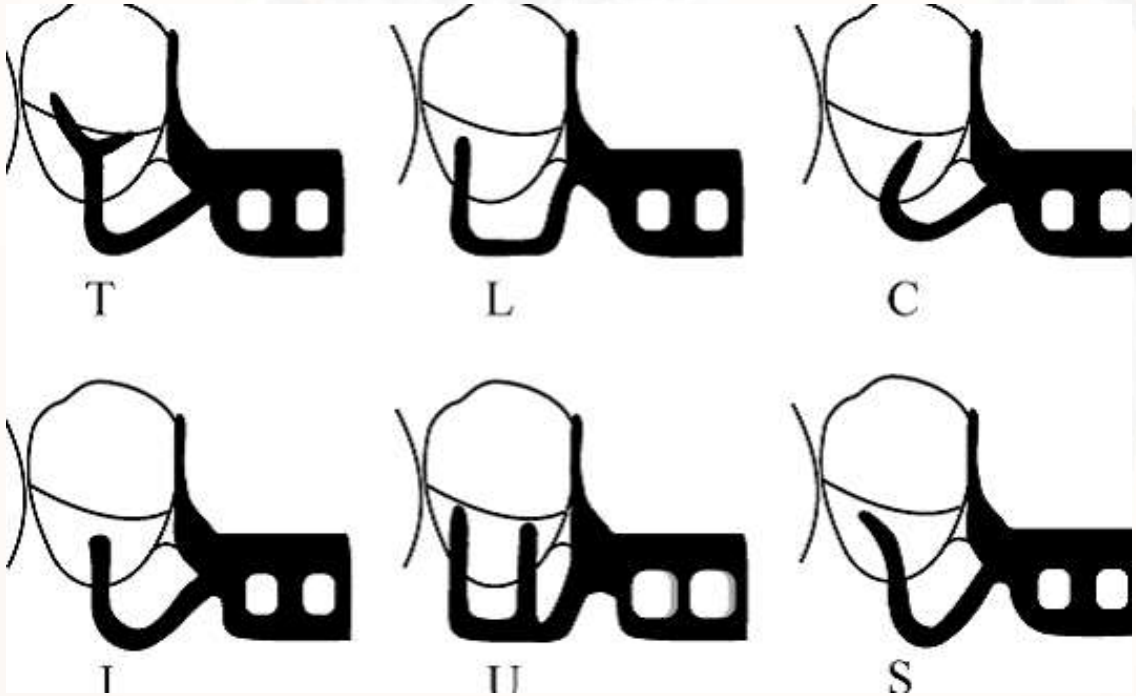
Bar clasps

- **T-clasp** (used in distal extension cases. Should NOT be used in terminal abutments with undercuts facing away from the edentulous space)
- **Modified T clasp** (used in canine and premolars for better aesthetics)
- **Y-clasp** (used for high heights of contour)
- **I-clasp**- (used on distobuccal surface of canine with only tip in contact with the tooth



Occlusal Approach:

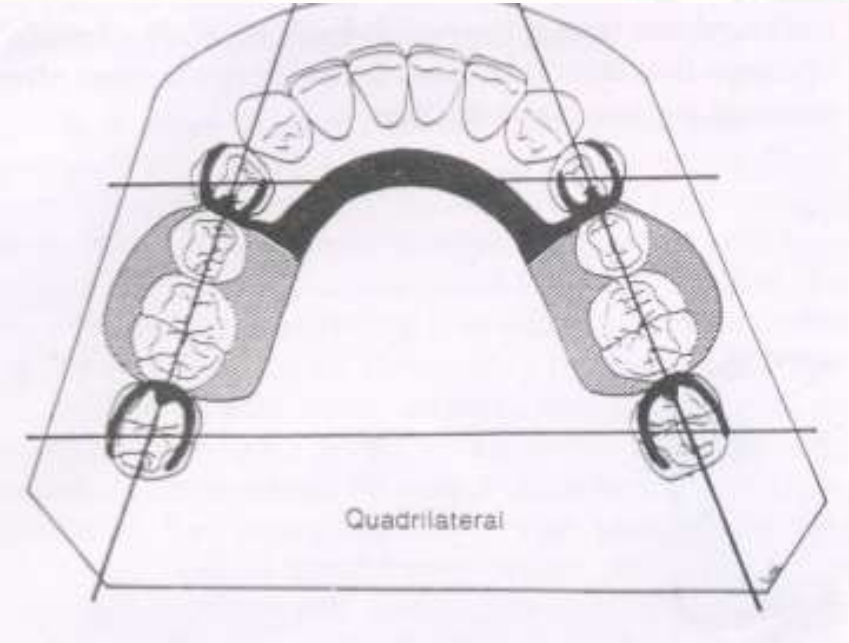
Circumferential clasp



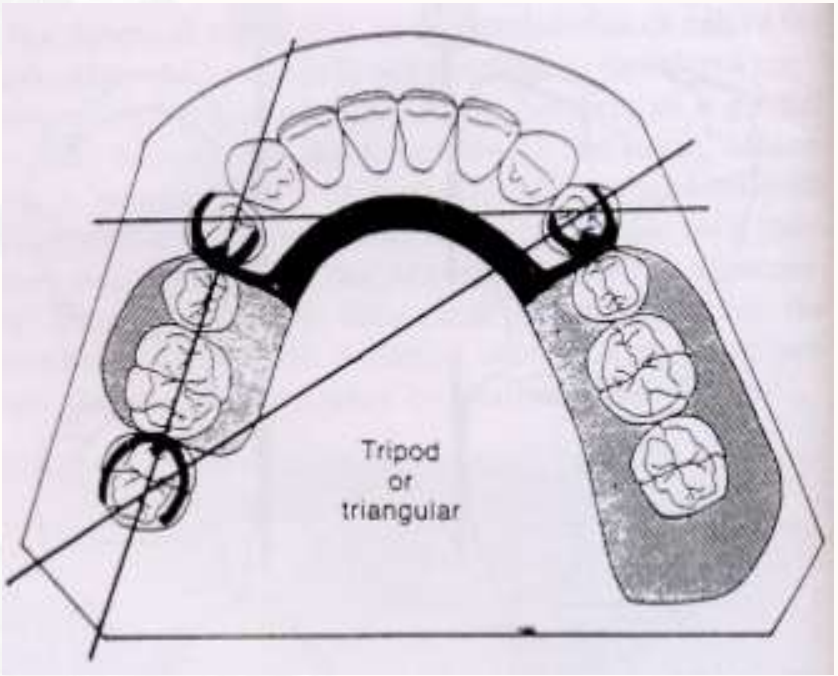
Gingival Approach:

Bar type of clasps

Clasp design configuration

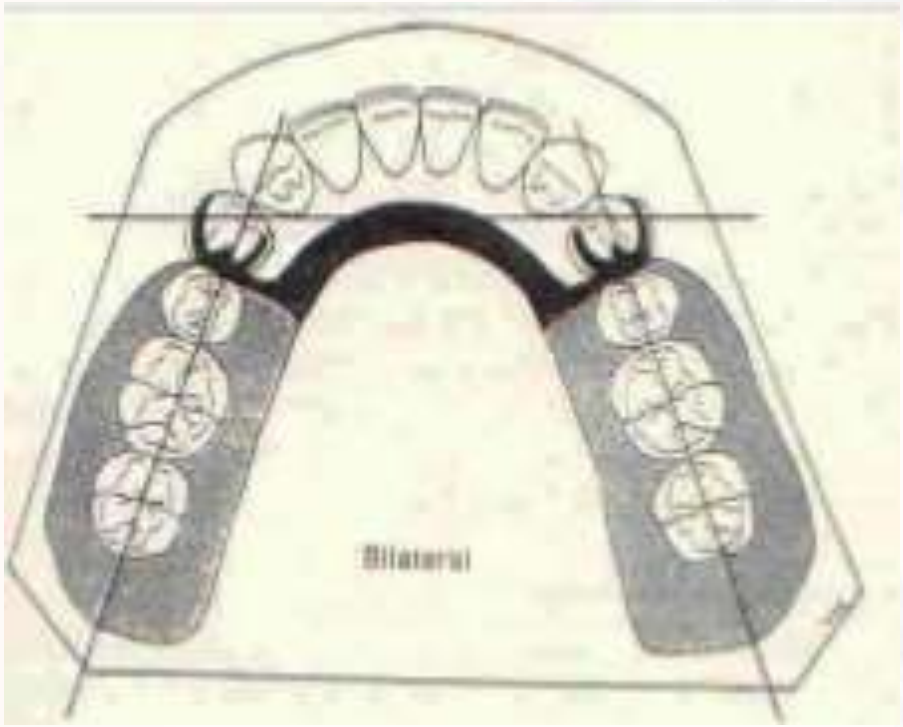


Quadrilateral Configuration: Usually seen in ***Kennedy Class III*** with a modification on the opposite side of the arch



Tripod Configuration: Usually seen in ***Kennedy Class II*** arches

Clasp design configuration



Bilateral configuration: Used in case of ***Kennedy Class I*** cases

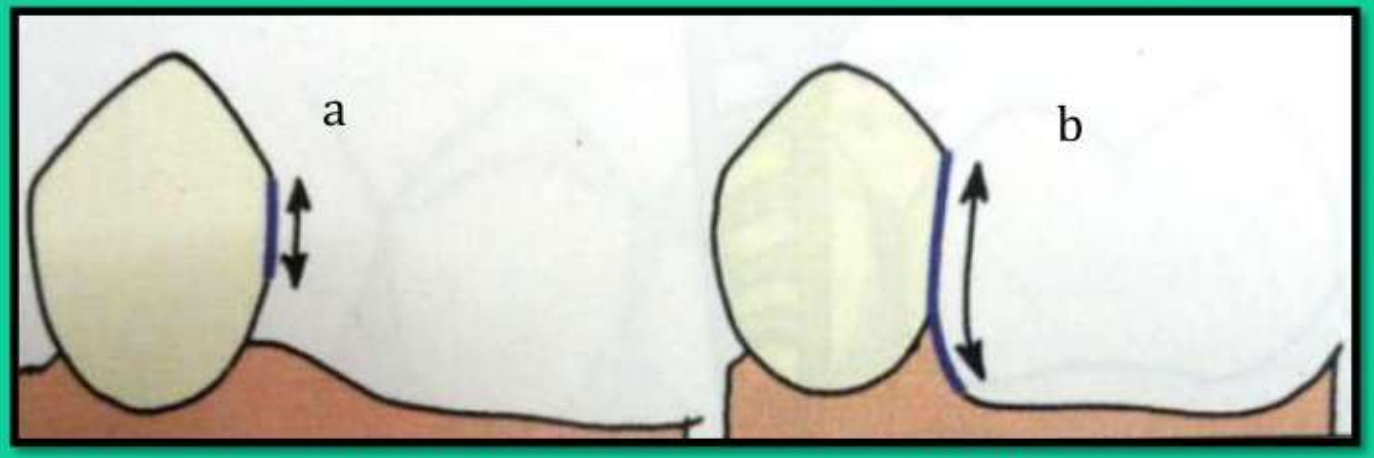
I-bar system (RPI system)

- Modified type of roach clasp designed to reduce tooth contact
- **R** –Rest **P** -Proximal plate **I -**I-bar clasp.

I- Bar RPD	Regular RPD
1. Mesial rest instead of distal rest. In other words, the rest is on proximal side away from edentulous space.	1. Distal rest
2. I- bar retainer is used for direct retention.	2. Occlusally approaching retainer is used
3. Long guide planes extending into tooth tissue junction	3. Normal guide planes

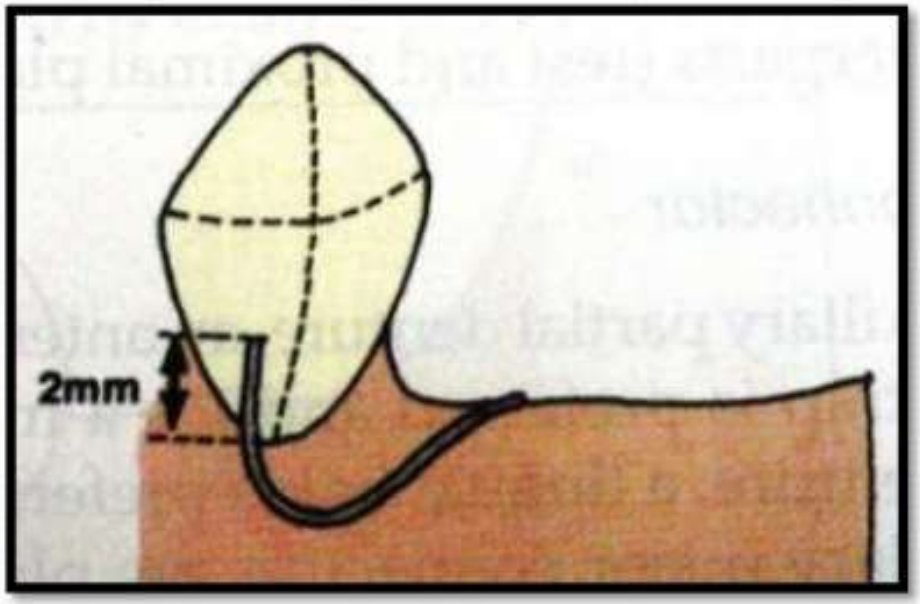
I-bar system (RPI system)

- Additional proximal plate on distal surface.
- The proximal plate covers the guide plane from marginal ridge to the tooth tissue junction and extends onto the attached gingiva for 2mm.



a. **Extention of proximal plate in conventional RPD**
b. **Extension of proximal plate in an I-bar RPD**

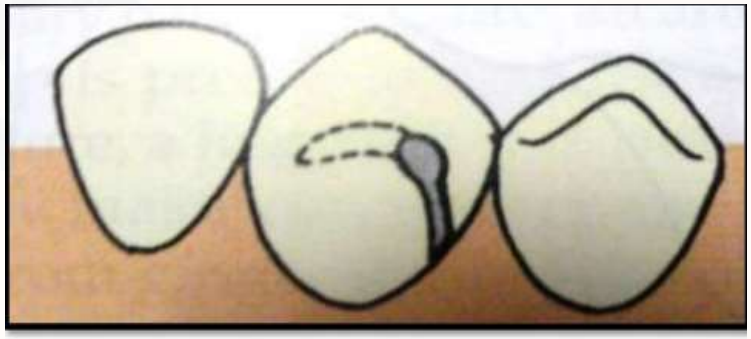
I-bar system (RPI system)



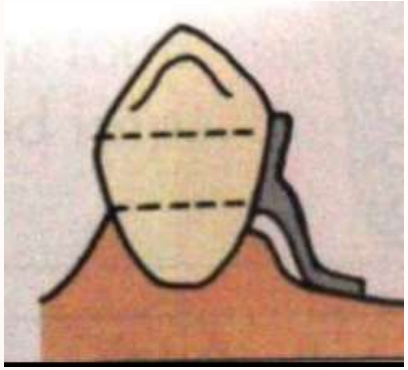
The I-Bar retainer should extend 2mm above the gingival margin to engage an undercut mesial to the mesio-distal height of contour.

Modifications in the RPI system

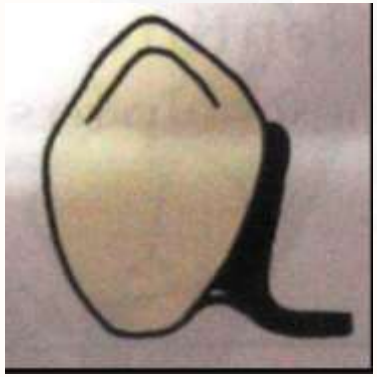
- **RPA** system- When the i-bar is replaced by an Aker's clasp.



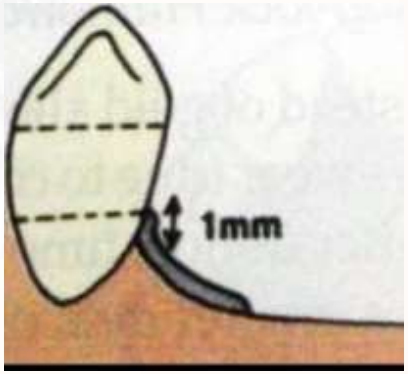
- Mesial rest modification
- Proximal modification
  - Design modification I, II, III



Mod. I



Mod. II



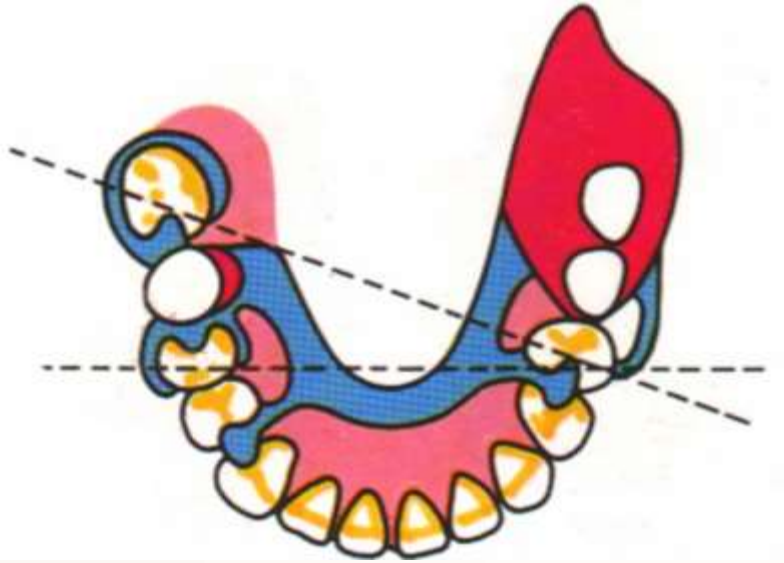
Mod. III

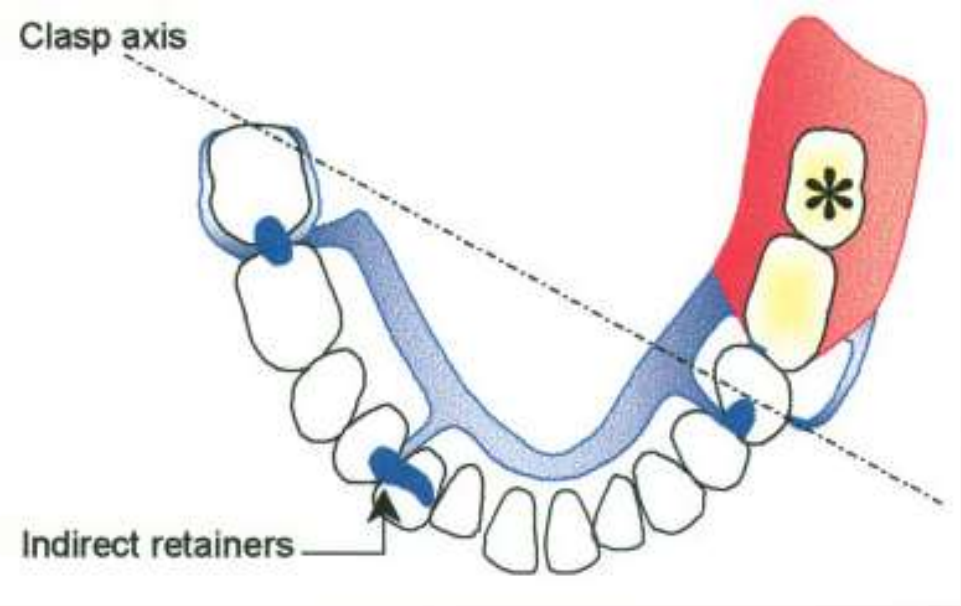
Fulcrum Line

- ***An imaginary line around which a partial denture tends to rotate-*** **GPT**
- This is a line joining the two posterior most rests

Indirect retainer

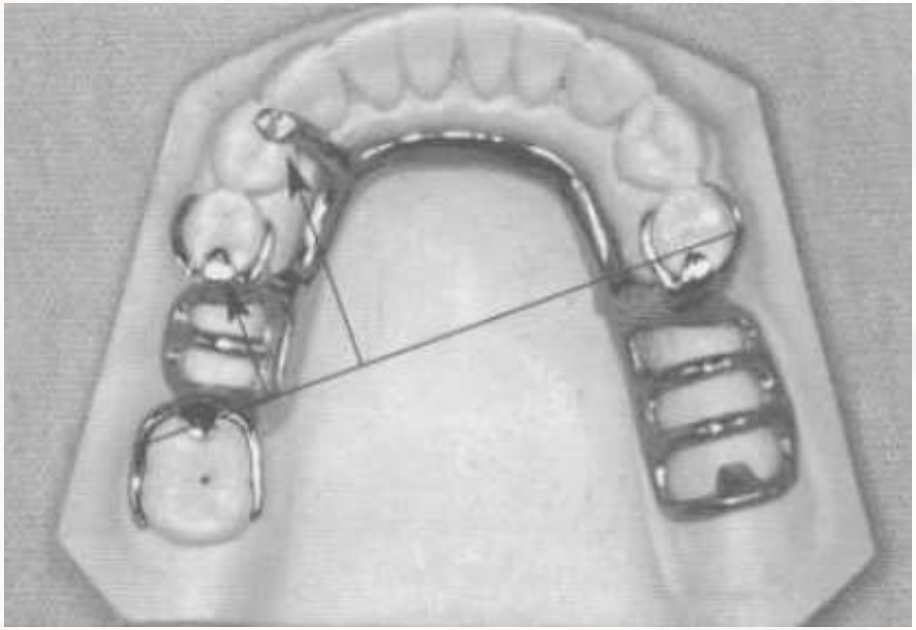
- *Part of a removable partial denture which assists the direct retainers in preventing displacement of the distal extension denture bases by functioning through lever action on the opposite side of the fulcrum-* **GPT**



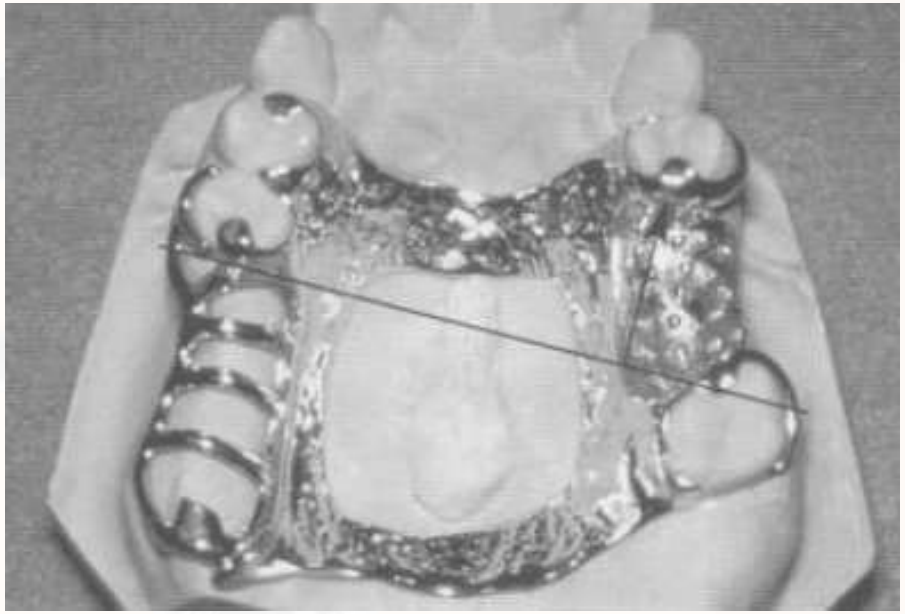


Design of Indirect retainer

- Ideally, the indirect retainer should be located at a point **perpendicular to the midpoint** of the fulcrum line
- Should be placed as **far away from the fulcrum line** as possible
- Should generally be made of **rigid material**. (Flexibility loses efficacy)
- Inclined or **weak abutment** teeth should **NOT** be used.



The indirect retainer should be perpendicular to the fulcrum line



The indirect retainer should be as far away from the fulcrum line as possible

Types of indirect retainer

1. **Auxiliary occlusal rest** –

   -Used on 1st premolars bilaterally for Kennedy Class I cases

   -Used on 1st premolar of opposite side for Kennedy Class II cases

2. **Canine Extension**- When premolars must act as a primary abutment

3. **Canine rest**

Types of indirect retainer

4. **Continuous lingual bar/plate retainers** – Used for Kennedy Class I and II cases. The bar should be placed above the middle 1/3rd of the tooth to prevent unwanted tooth movement
5. **Rugae support**
6. **Direct-indirect retention** (from the reciprocating arm anterior to fulcrum line)
7. **Indirect retention from the major connectors**

When to use indirect retainer?

- **Kennedy Class I**: indirect retainers are necessary and should be placed as far away from fulcrum line as possible
- **Kennedy Class II**: indirect retainer on **both sides** of the arch
- **Kennedy Class III**: indirect retainer is **NOT** required

Denture Base

- Types:
  - Metallic
  - Non Metallic (acrylic, plastic, etc.)
  - Combination

Design of denture base

- Should have **long flanges** to resist horizontal forces
- **Distal extension** should extend onto the retromolar pad or cover the entire tuberosity
- Since **metallic dentures** can be made rigid in thin sections, mandibular dentures benefit greatly by the **thin rigid plate**.
- **Maxillary dentures** benefit from **non metallic** denture materials due to the **aesthetic** form factor although **lack the good thermal conductivity that metallic dentures offer.**

Tooth selection for the denture

(According to Deepak Nallaswamy)

- **Anterior teeth replacement**
  - Acrylic teeth
  - Porcelain teeth
  - Metal teeth with facing
  - Tube teeth
  - Reinforced acrylic pontic

  Posterior teeth replacement

  -porcelain teeth
  - metal teeth
  - acrylic teeth
  - metal teeth with acrylic window

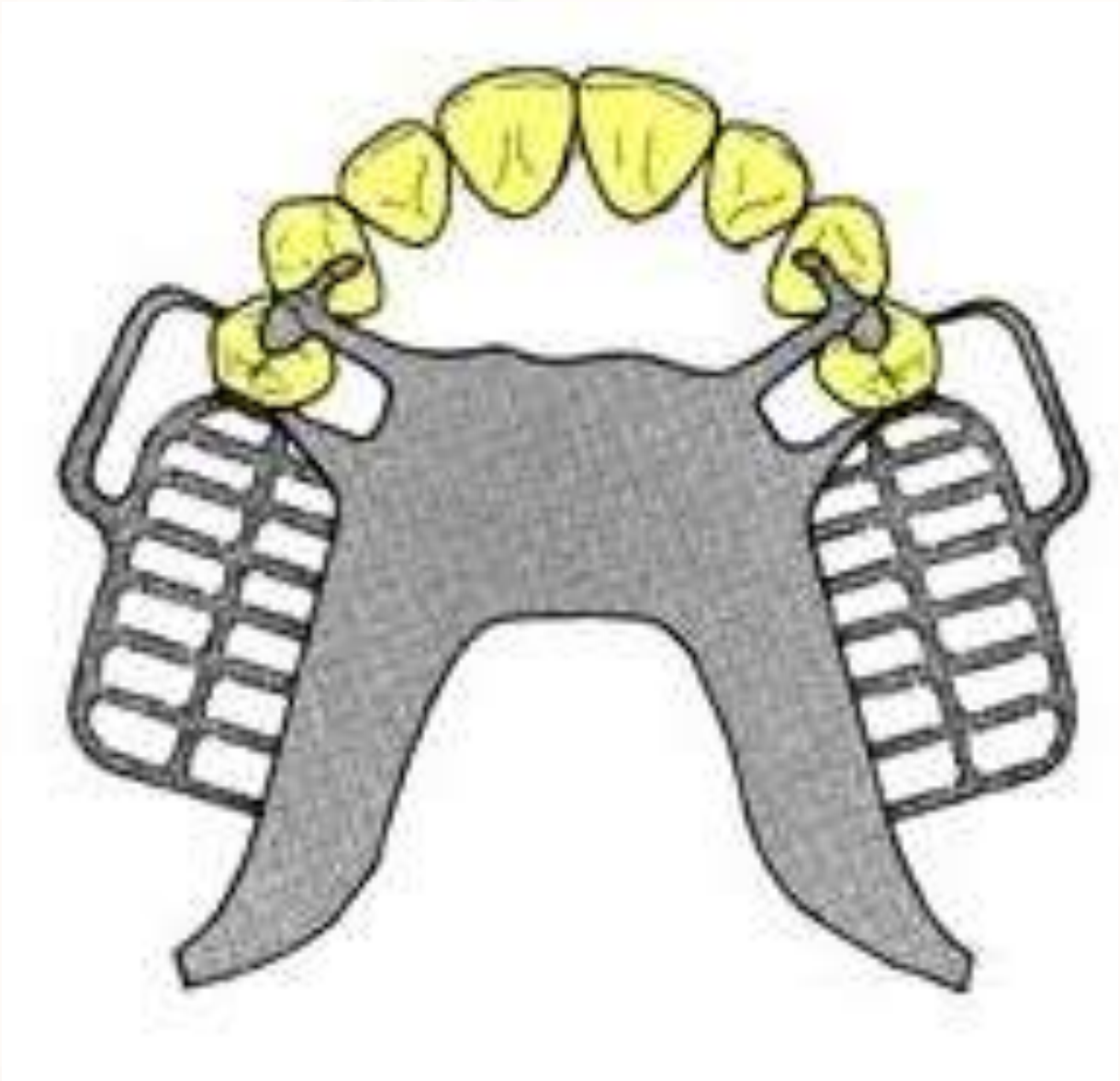
In summary

- Design consideration depends on a variety of factors.
- Design of a removable partial denture changes with respect to some form of edentulous classification. We prefer to follow the classification proposed by Edward Kennedy.

Kennedy Classification I

- **Direct retainer**: essential. The position of the undercut determines the type of retainer (i.e gingival/occlusal approach)
- **Clasp: 2 clasps on terminal abutments bilaterally. This follows bilateral configuration**
- Rest: to be prepared on tooth with maximum support
- **Indirect retainer: 2 retainers are needed**
- Major connector: Palatal Plate, complete palate, horse shoe palates, lingual plate, cingulum plate.

Kennedy Classification I Design

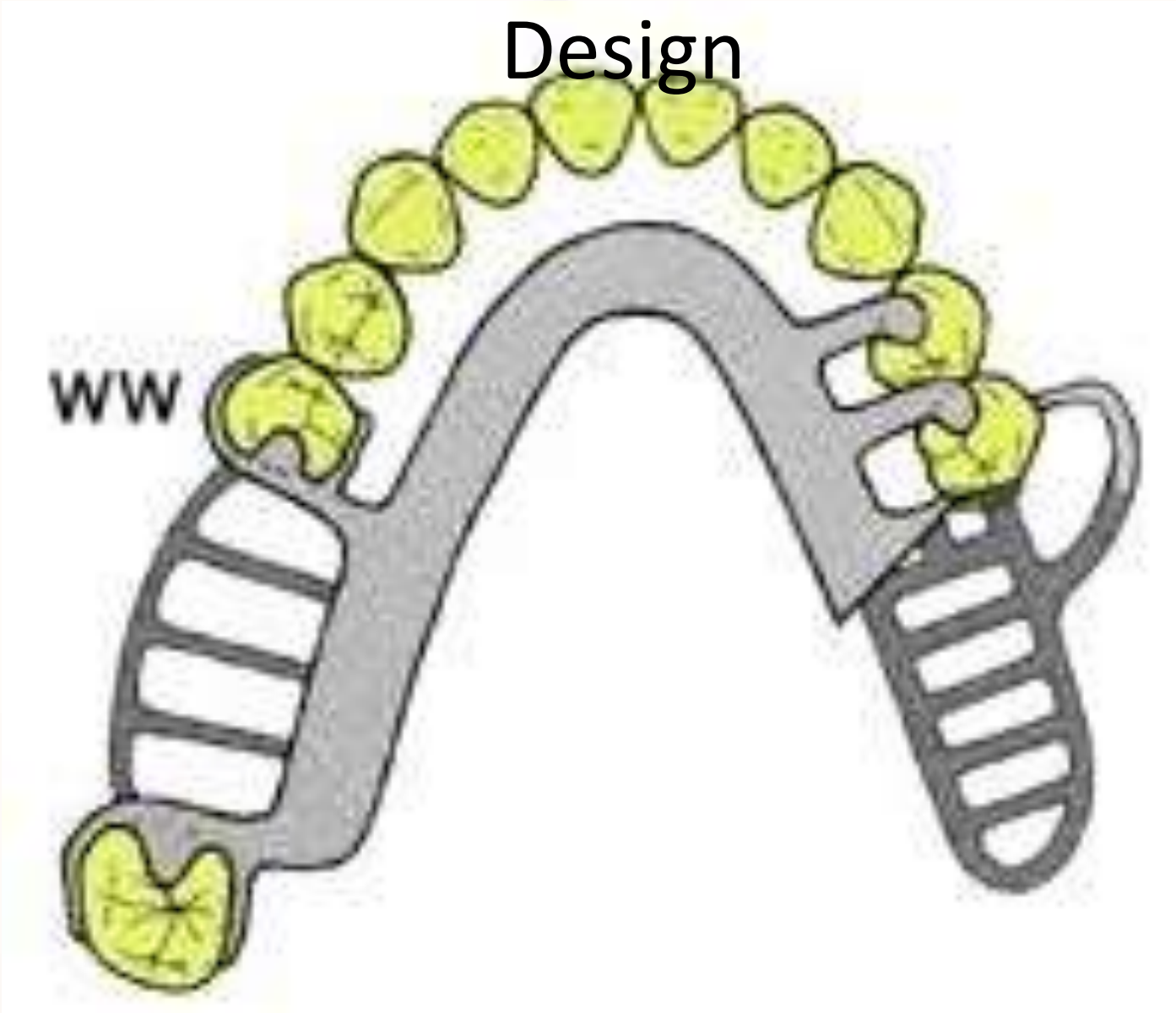


Kennedy Classification I Design

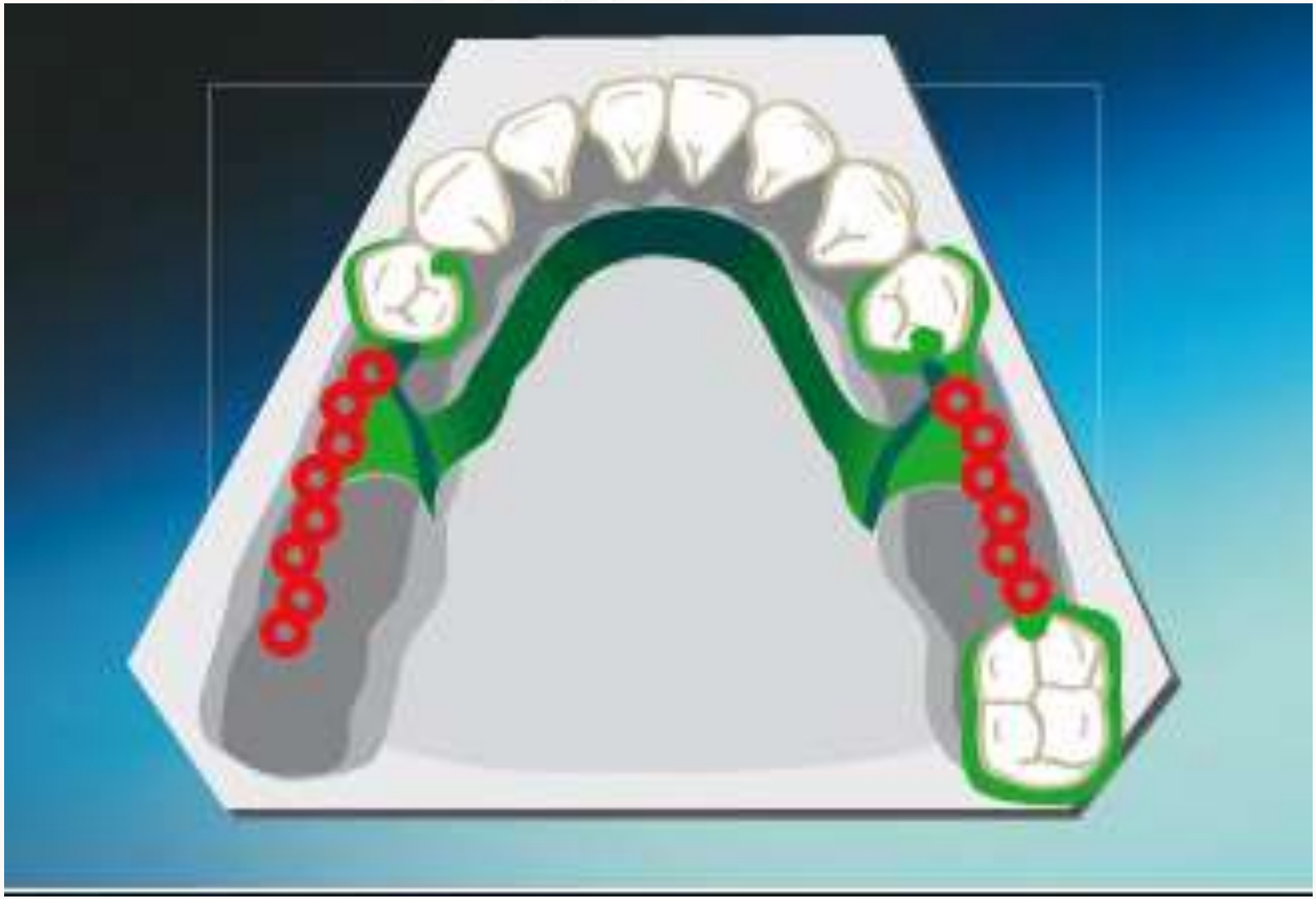
Kennedy Classification II

- **Direct retainer**: essential. The position of the undercut determines the type of retainer (i.e gingival/occlusal approach)
- **Clasp: 3 retentive clasps are required, 1 clasp on the edentulous side and 2 on the dentulous side. Should follow Tripod configuration**
- **Rest** should be placed on tooth with maximum support
- **Indirect retainer: 1 retainer on the dentulous side is sufficient**
- **Major connector**: horse shoe shaped palatal connector, antero-posterior palatal bar, lingual bar,

Kennedy Classification II modification 1 Design



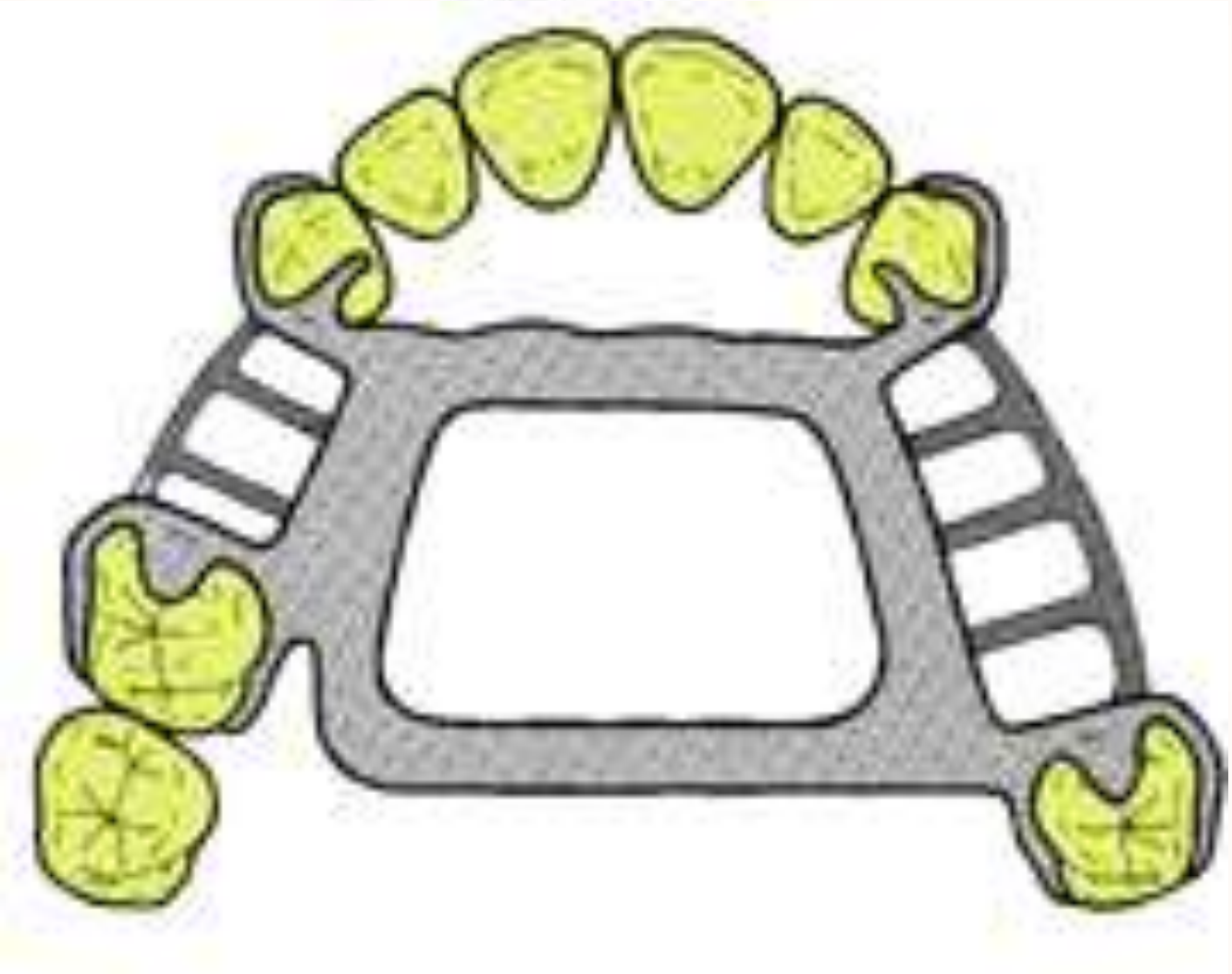
Kennedy Classification II modification 1 Design



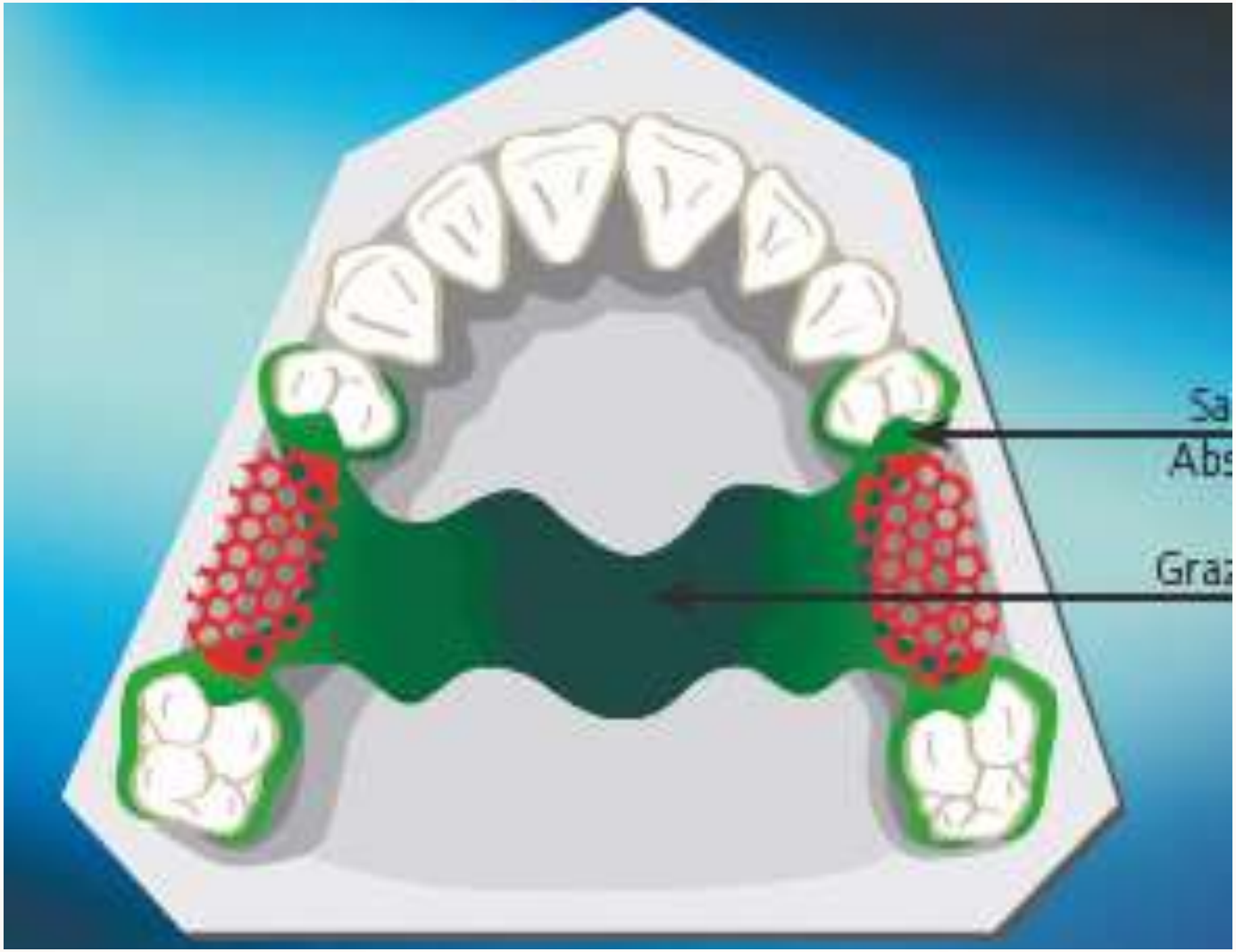
Kennedy Classification III

- **Direct retainer**: **position of undercut is NOT critical** in designing the prosthesis since damage to abutment is minimal
- **Clasp**: 4 clasps should be placed for **quadrilateral design** in case of modification of class III.
- **Indirect retainer**: **not needed**
- **Major connector**: single posterior palatal bar, palatal strap, lingual bar

Kennedy Classification III, Modification 1 Design



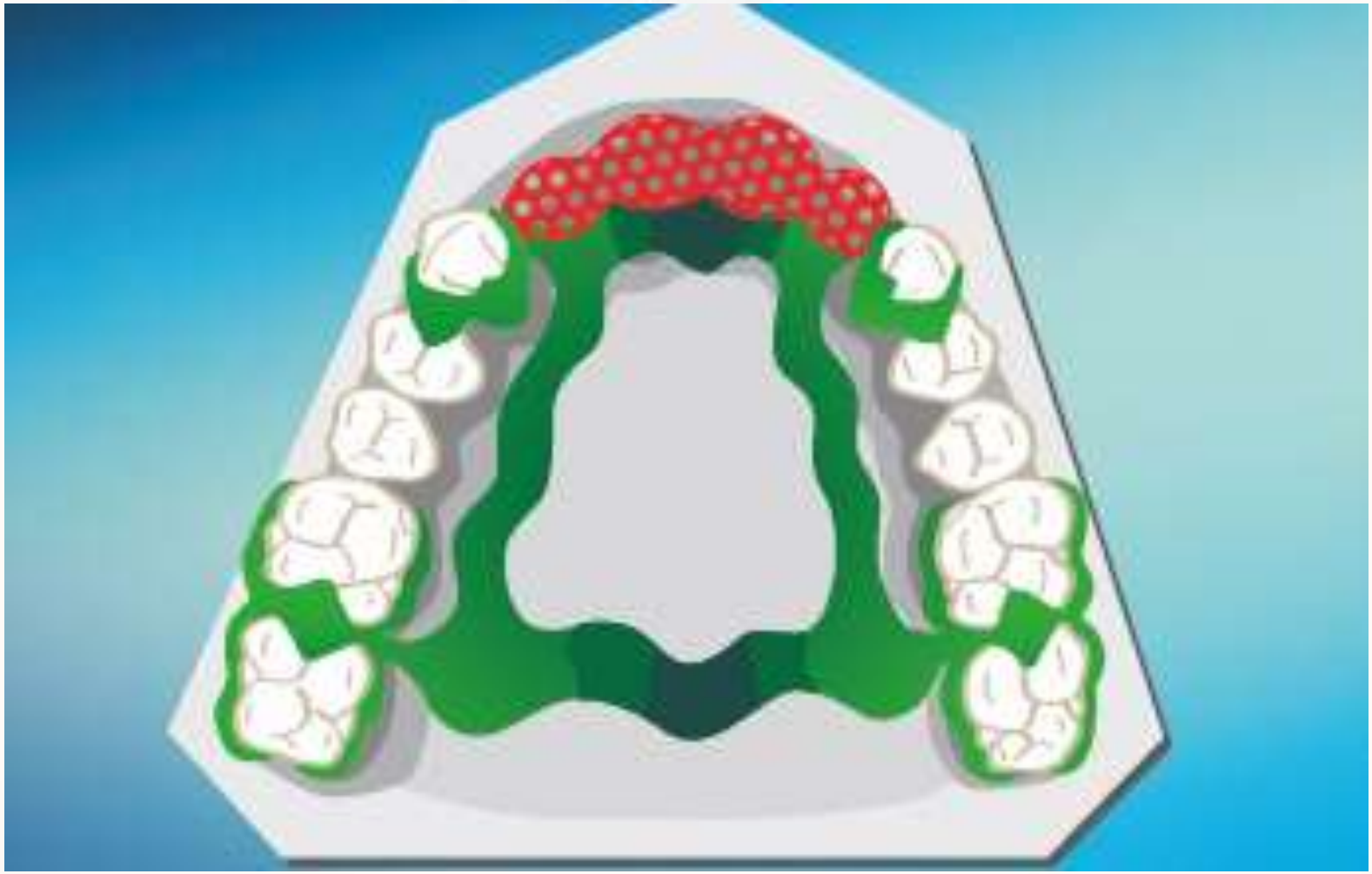
Kennedy Classification III, Modification 1 Design



Kennedy Classification IV

- In case of short edentulous spans, the need for retainers and clasps are very limited.
- In case of long span edentulous areas,
  - 4 clasps can be placed for quadrilateral configuration
  - Indirect retainer to be placed posterior to the fulcrum line

Kennedy Classification IV Design



Reference

- A textbook of prosthodontics, *Deepak Nallaswamy, reprint 2005.*
- McCracken's removable partial Prosthodontics, *11th edition.*
- Principles of designing in Removable partial denture, *Shebin Abraham, online presentation, uploaded on 11/2/2016, slideshare.net.*
- Designing removable partial dentures, *Dr Ting Ling Chang, UCLA, online presentation, ffofr.org.*
- Presentations by Indian dental academy
- Pictures from the internet

THANK YOU

Taseef