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Original Research

Removable partial denture- Designs

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ABSTRACT:
Removable partial denture service is one of the most abused phases of practice of dentistry. It is small wonder that dental laboratory technicians feel capable of rendering this service when many times they receive artificial stone cast upon which to construct a RPD of their own design[9].Patient use of removable partial dentures has been high in the past and is expected to continue in the future as an aging population who retains more teeth will present with more partially edentulous conditions.The following review articlehighlights the importance of knowledge about designing principles of removable partial denture so that a proper treatment plan can be prescribed for the comfort of patient.
Key words: Removable partial denture, Mechanics

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INTRODUCTION

"Prosthodontics is the dental specialty pertaining to the diagnosis, treatment planning, rehabilitation and maintenance of the oral function, comfort, appearance and health of patients with clinical conditions associated with missing or deficient teeth and/or maxillofacial tissues using biocompatible substitutes.[1]"Despite evolution in treatment resources available for partially edentulous patients RPDs continues to be the treatment of choice for patients where technical and biological conditions that contraindicates the treatment with fixed prosthesis or implants[2].Removable partial prosthodontics is a versatile, cost effective, and reversible treatment method for partially edentulous patients at any age. With the changing trends in dental treatment that favor retention of natural teeth, a decline in the number of complete dentures with an increase in the number of removable partial dentures (RPDs) is anticipated[3].The objectives of RPD design have been well established. They include the restoration of function, enhancement of esthetic and, most importantly, the preservation of the remaining teeth and periodontal structures[4]. Over the years, the concepts of RPD design have been predicated on many factors such as clinical conditions, scientific research findings, social acceptance, dogmatic traditions, and philosophical axioms[5-7]. Often removable partial denture prosthesis falls short of objectives anticipated because of inadequate diagnosis and poor design. It is the responsibility of the dentist to design prosthesis that will be biomechanically sound while fulfilling functional and esthetic requirements[8]. Removable partial denture service is one of the most abused phases of practice of dentistry. It is small wonder that dental laboratory technicians feel capable of rendering this service when many times they receive artificial stone cast upon which to construct a RPD of their own design[9].Patient use of removable partial dentures has been high in the past and is expected to continue in the future as an aging population who retains more teeth will present with more partially edentulous conditions.[10]The following review articlehighlights the importance of knowledge about designing principles of removable partial denture so that a proper treatment plan can be prescribed for the comfort of patient.

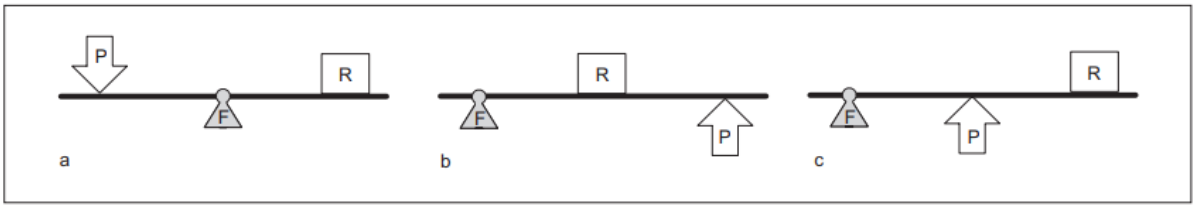
BIOMECHANICS OF REMOVABLE PARTIAL DENTURES

Removable partial dentures are not rigidly attached to teeth, the control of potential movement under functional load is critical to providing the best chance for stability and patient accommodation. The consequence of prosthesis movement under load is an application of stress to the teeth and tissue that are contacting the prosthesis. It is important that the stress not exceed the level of physiologic tolerance. Oral hygiene and appropriate prosthesis maintenance procedures are required for continued benefit of optimum biomechanical principles.[10]

LEVER AND INCLINED PLANE

When subjected to intraoral forces, a removable partial denture can perform the actions of two simple machines—the lever and the inclined plane. A lever consists of a rigid bar, a fulcrum, an object to be moved, and an applied force. There are three classes of levers: first, second, and third. A first-class lever has the potential to be very efficient, while a second-class lever is less efficient, and a third-class lever is the least efficient. During the design process, the practitioner must consider these three fulcrums and the movement that may take place around them. Components of the prosthesis may then be positioned to counteract or prevent each of the rotations.[65]

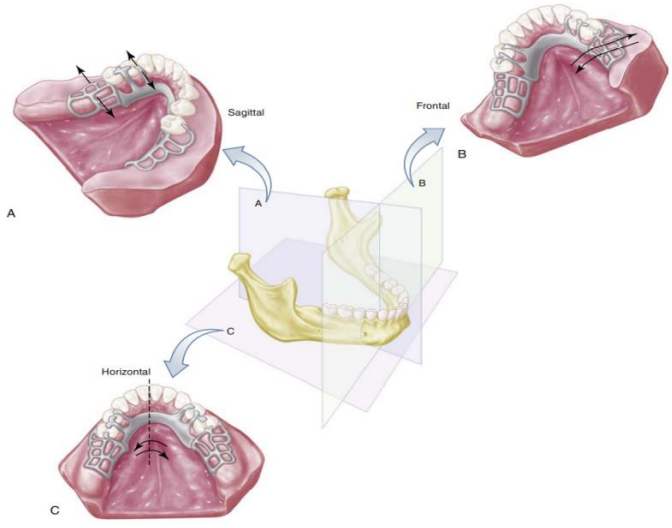
Fig. 1: Classes of levers: (a) Class I lever (b) Class II lever (c) Class III lever



FORCES ACTING ON THE REMOVABLE PARTIAL DENTURE

Removable partial dentures are subject to a composite of forces arising from three principal fulcrums. One fulcrum is on the horizontal plane that extends through two principal abutments, one on each side of the dental arch, and generally is termed the principal fulcrum line. This fulcrum controls the rotational movement of the denture in the sagittal plane (ie, denture movement toward or away from the supporting ridge). A second fulcrum line lies in the sagittal plane and extends through the occlusal rest on the terminal abutment and along the crest of the residual ridge on one side of the arch. In a Class I situation, there would be two such lines, one on each side of the arch. This fulcrum line controls the rotational movements of the denture in the frontal plane (ie, a rocking movement over the crest of the ridge). The third fulcrum is located in the vicinity of the mid-line, just lingual to the anterior teeth. This fulcrum line is oriented vertically and controls rotational movement in the horizontal plane (ie, the flat, arcuate movements of the prosthesis).[10,65]

Fig. 2: Forces acting on removable partial dentures



SURVEYING

The turning point in the change of partial denture construction from guesswork based on clinical experience to scientifically based procedure was the appearance of thedental surveyor in 1918.[51]

Dr. A.J. Fortunati is thought to be the first person to employ a mechanical device to determine the relative parallelism of tooth surfaces. At a clinic in Boston in 1918 he demonstrated a method for charting correct clasp placement by using a parallelometer. The first such device to be produced commercially the Ney

instrument, was made available in 1923. The Wills surveyor by Jelenko is second most widely used.A dental surveyor has been defined as a paralleling instrument used in the construction of prosthesis to locate and delineate the contours and relative positions of abutment tooth and associated structures.[1]

Primary purpose of surveying is to plan those modifications of oral structures necessary to fabricate a removable partial denture. Both Ney and Jelenko surveyors are precision made instruments. They differ principally in that the Jelenko arm swivels, whereas in Ney arm is fixed.

PARTS OF SURVEYOR IS SHOWN AS BELOW

Fig.3: Parts of surveyor[52]: A-surveying platform; B-vertical column; C-horizontal arm; D-surveying arm; E-mandrel; F-surveying tools; G-surveying table

Fig 4: Ney dental surveyor

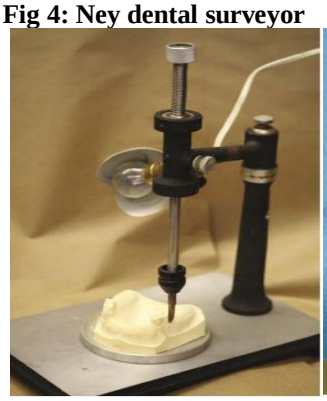
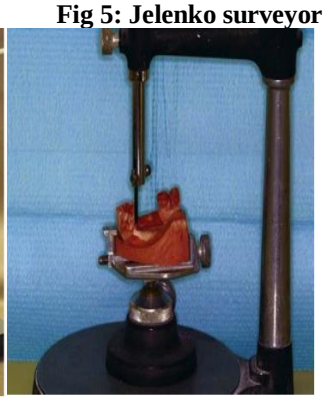


Fig 5: Jelenko surveyor



PURPOSES OF SURVEYOR

1. Surveying the diagnostic cast: Objectives of surveying the diagnostic cast are as follows.

a) To determine the most acceptable path of placement and removal
b) To identify proximal tooth surfaces that can act as guiding planes during placement and removal.
c) To locate and measure areas of the teeth that may be used for retention.
d) To determine whether tooth and bony areas of interference will need to be eliminated either by extraction or by selecting a different path of placement.
e) To determine the most suitable path of placement that will permit locating retainers and artificial teeth to the best esthetic advantage.
f) To delineate the height of contour on abutment teeth and to locate areas of undesirable tooth undercut those are to be avoided, eliminated, or blocked out.
g) To record the cast position in relation to the selected path of placement for future reference.

2. Contouring wax patterns: The surveyor blade is used as a wax carver
3. Placement of intra-coronal retainers (internal attachments): In the placement of intra-coronal retainers, the surveyor is used as follows

a) To select a path of placement in relation to the long axes of the abutment teeth that will avoid areas of interference elsewhere in the arch
b) To cut recesses in the stone teeth on the diagnostic cast for estimating the proximity of the recess to the pulp and to facilitate the fabrication of metal or resin jigs to guide the preparations of the recesses in the mouth
c) To carve recesses in wax patterns, to place internal attachment trays in wax patterns, or to cut recesses in castings with the hand-piece holder, whichever method is preferred.
d) To place the keyway portion of the attachment in

the casting before investing and soldering.[53]

4. Placement of internal rest seats: The surveyor may be used as a drill press, with a dental handpiece attached to the vertical arm by means of a handpiece holder. Internal rest seats may be carved in the wax patterns and further refined with handpiece after casting, or the entire rest seat may be cut in the cast restoration with the handpiece. It is best that the outline form of the rest seat be carved first in wax and merely refined on the casting with the handpiece.
5. Machining cast restorations: With handpiece holder attached axial surfaces of cast and ceramic restorations may be refined by machining with a suitable cylindrical carborundum point.
6. Surveying the master cast: To select the most suitable path of placement by following mouth preparations that satisfy the requirements of guiding planes, retention, noninterference, and esthetics. To permit measurement of retentive areas and to identify the location of clasp terminal in proportion to the flexibility of the clasp arm being used.To locate areas of undesirable remaining undercut that will be crossed by rigid parts of the restoration during placement and removal. These must he eliminated by block-out. To trim block-out material parallel to the path of placement prior to duplication.

Fig 6: Carbon rod or Marker **Fig 7: Analyzing rod** **Fig 8: Cast Holder**

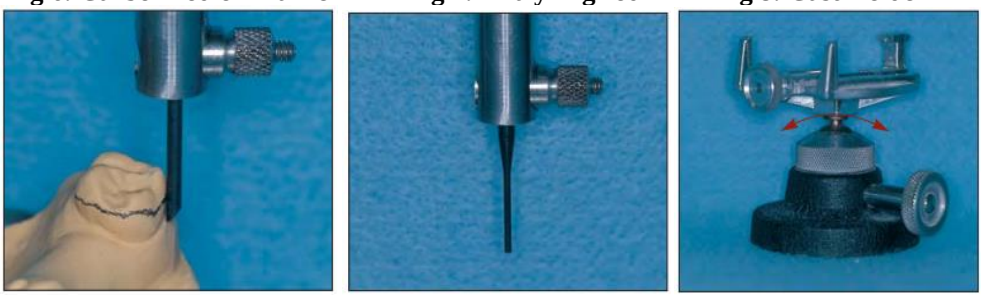
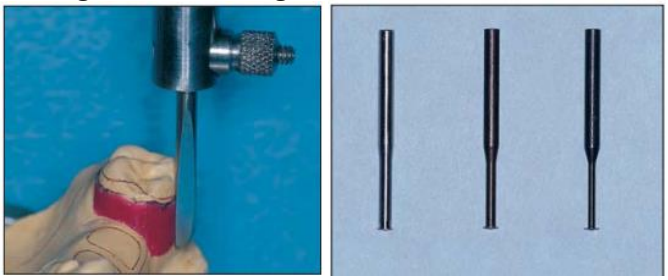


Fig 9: Wax knife Fig **10: Undercut gauges**

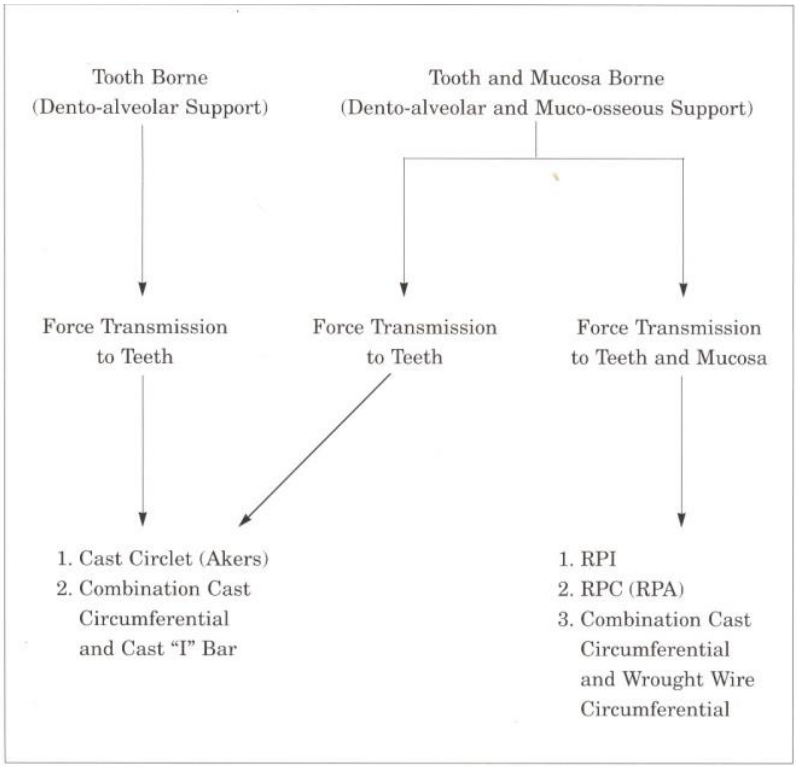


PROCEDURE FOR SURVEYING

1. Place the cast on the tilting table of the surveyor in a horizontal position. Tilt table antero-posteriorly at an angle which places the proximal surfaces of the abutment teeth parallel to the diagnostic rod which is in the spindle.
2. Tilt the table laterally guiding the lingual surfaces of the abutment teeth as nearly parallel as possible. No exaggerated tilt in any direction should be used. Tilting is not dictated by which teeth are missing. Instead, the health of the supporting structures of the remaining teeth, the character of the residual alveolar ridge present, the edentulous span, and masticatory requirements which the prosthesis must provide are among the primary critical factors to consider.
3. Securely tighten the set screw of the tilting table, and mark three orientation lines on the sides of the casts by placing the rod against the cast and scribing alongside it with a red pencil.
4. Remove the diagnostic rod from the spindle, and replace it with the metal shim and lead point, which has been altered by grinding the end at an angle on apiece of sandpaper.
5. Scribe the abutment teeth with the side of the lead point. This will indicate the survey line at the height of contour of the unaltered teeth.
6. Use a blue pencil to indicate alterations of the abutment tooth. Mark the areas indicated for placement of rest preparations. If a circumferential clasp is suggested, it should encircle the abutment tooth in a manner which will place only the terminal one third of the direct retainer portion into an undercut.[8]

PRINCIPLES OF DESIGN

The term design as used in RPD construction refers to the shape and structural details of the removable restoration. Over the years, the concepts of RPD design have been predicated on many factors such as clinical conditions, scientific research findings, social acceptance, dogmatic traditions, and philosophical axioms.The design principle is influenced by the force distribution purely of tooth borne and tooth-mucosa borne partial dentures.



1. The dentist must have a thorough knowledge of both the mechanical and biologic factors involved in removable partial denture design.
2. The treatment plan must be based on a complete examination and diagnosis of the individual patient.
3. The dentist must correlate the pertinent factors and determine a proper plan of treatment.
4. A removable partial denture should restore form and function without injury to the remaining oral structure.
5. A removable partial denture is a form of treatment and not a cure.[52]

Table 1: Factors which influence the principle of RPD design

Health of the patient	Condition of remaining natural teeth	Condition of osseous structures.	Number of remaining natural teeth	Distribution in the arch of remaining natural teeth
Probable retention period of remaining natural teeth	Distribution and extent of edentulous areas	Condition of mucosa throughout the mouth and especially over edentulous areas	Esthetics- The high and low lip lines or the extent to which teeth and gums show during function	Long axis inclination of abutment teeth in relation to other teeth in the same arch
Relation of opposing arches	Form of edentulous area	Nature of existing occlusion	Shape and contours of remaining natural teeth	Phonetics
Musculature of the human dental mechanism	Occlusal surface morphology of natural teeth	Extent of intermaxillary space at the	Total support available for the partial denture	Patient's care of his own mouth

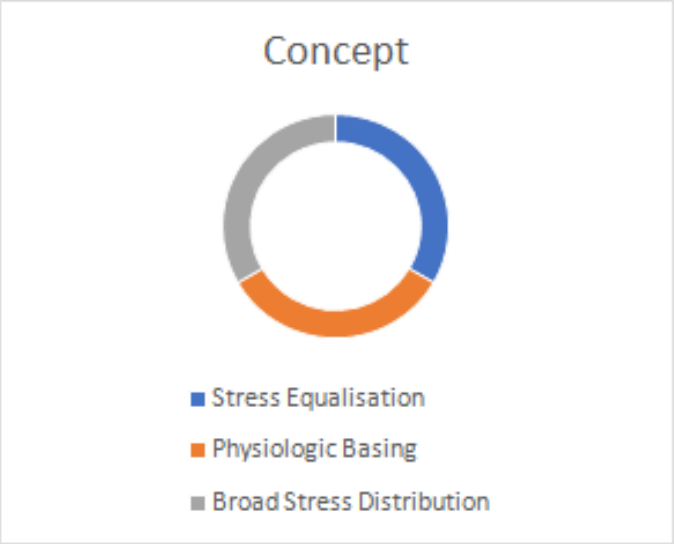
		accepted vertical dimension		
Materials used in construction- If for any reason the choice of a material is limited, the design must be influenced by the inherent property of material used			Economic factors may influence a choice of material therefore the design. The patient's ability to pay may not be in keeping with the design of choice	

PHILOSOPHY OF DESIGN

The objectives we should obtain in a partial denture prosthesis are support, stability, retention, function and esthetics.[57] A provisional RPD design, produced at the initial treatment planning stage, should be drawn on a proforma to provide easy reference while any other restorative treatment is being carried out. Once this treatment has been completed the provisional design should be reviewed and updated in the light of any changes in the treatment plan that proved to be necessary. In partial denture design, the main concern is for the tooth-borne and part soft-tissue-borne prosthesis. For the Class III arch the design is generally straightforward, because the denture will be all tooth supported. The challenge in design, then, lies primarily in Classes I and II arches and to some extent in the Class IV arch. The variations in the concept of design are multitudinous. There are three basic, underlying approaches to distributing the forces acting on a partial denture between the soft tissue and the teeth:

1. Stress equalization
2. Physiologic basing
3. Broad stress distribution

Fig. 11: Philosophy of design



STRESS EQUALIZATION

Resiliency of the tooth secured by the periodontal ligament in an apical direction is not comparable to the greater resiliency and displaceability of the mucosa covering the edentulous ridge. The most commonly used stress equalizers are composed of a hinge device interposed between the minor connector of the abutment tooth and the denture base. The hinge is designed to permit vertical movement of the denture base as occlusal forces are applied to the artificial teeth.

ADVANTAGES	DIADVANTAGES
1. Requires minimal direct retention 2. Eliminates tipping strain on abutment tooth, preventing bone resorption 3. Sum of resiliency of stress equalizer + periodontal ligament= Resiliency of mucosa 4. Minimizes tissue change and reduces the necessity of relining or rebasing	1. Comparatively fragile 2. Construction is complex and costly 3. Requires constant maintenance 4. Difficult or impossible to repair. 5. It can result in lateral movement of the denture base, and this will lead to rapid resorption of bone and settling of the denture.[52]

PHYSIOLOGIC BASING

This philosophy of design agrees in part with the first school about the relative lack of movement of the abutment teeth in an apical direction but denies the requirement of using stress directors to equalize the disparity of vertical movement between the tooth and mucosa.Equalization can best be accomplished by some form of physiologic basing or lining, of the denture base. The physiologic basing is produced either by displacing the ridge mucosa during the impression procedure or by relining the denture base after been constructed.

ADVANTAGES	DIADVANTAGES
Physiologically stimulating effect on the underlying bone and soft tissue	Denture is not well stabilized against lateral forces
Simplicity of design and construction, minimal maintenance and repair	Residual ridge receives greater forces
Minimal direct retention used	Difficult to produce effective indirect retention

BROAD STRESS DISTRIBUTION

Advocates of this school of partial denture design believe that excessive trauma to the remaining teeth and residual ridge can be prevented by distributing the forces of occlusion over as many teeth and as much of the available soft tissue area as possible. This is accomplished by the use of additional rests, indirect retainers, clasps, and broad coverage denture bases.

ADVANTAGES	DIADVANTAGES
Forces of occlusion are reduced	Increased bulk of denture
Prostheses are easier and less expensive to construct	Increased risk of dental caries
Lateral forces may be distributed widely	Difficult to produce effective indirect retention
Use of multiple clasps possible	Greater coverage of tooth and mucosa creates a feeling of insecurity to patients
No flexible or moving parts	Less acceptable to patients
Increased stability and decreased movement	Adaptability to speech considerations is less

DESIGN OF THE COMPONENT PARTS

For effectively managing the above factors, proper designing should be carried out. For the purpose of designing, components of RPD can be divided into:

1. Major connector
2. Minor connector
3. Direct retainer
4. Indirect retainer
5. Tooth replacements
6. Denture bases

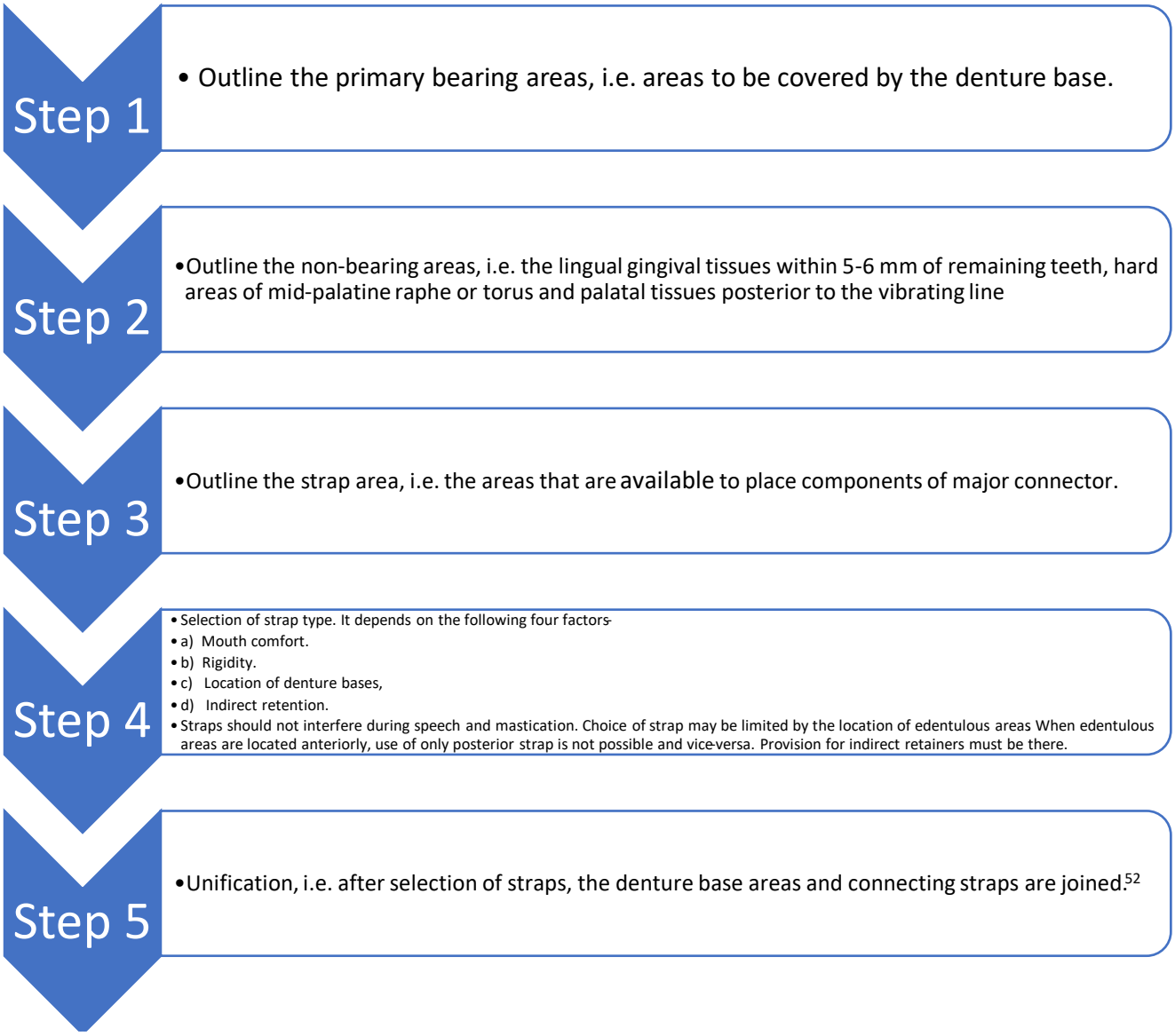
DESIGNING A MAJOR CONNECTOR

Major connector is the part of the partial removal dental prosthesis that joins the components on one side of the arch to those on the opposite side.[1]

Factors to consider for designing major connector

1. It should be rigid
2. It should not impinge the free gingival margins and should never terminate on the gingival tissue. In maxillary major connector it should be 6mm from the gingival margin and in mandibular 4mm from the gingival margins
3. The border of the major connector should parallel to the gingival margin of the tooth. Whenever it is crossing the gingival margin it should cross at right angles to the gingival margins.
4. The location and number of denture bases influence the type of major connector that must be used.
5. Anterior border should not end on the crest of rugae but end in the valley of the rugae
6. Borders of the major connector should be as inconspicuous as possible.
7. It is better to design a major connector so that its margin does not cross bony or soft tissue prominence[51]
8. It should not interfere with speech or phonetics. Attempt should be made not to cover the anterior portion of palate or rugae area.[52]

DESIGN APPROACH



MINOR CONNECTOR

Minor connector is the connecting link between the major connector or the base of the removable dental prosthesis and other units of the prosthesis, such as the clasp assembly, indirect retainers, occlusal rests or cingulum rests.[1]

There are four types of minor connectors,

1. Join the clasp assembly to the major connector,
2. Join indirect retainer or auxiliary' rest to the major connector,
3. Join the denture base to the major connector.
4. Serve as an approach arm for a vertical projection or bar-type clasp.

DIRECT RETAINERS

Direct retainers is that component of dental removable prosthesis used to retain and prevent dislodgement, consisting of clasp assembly or precision attachment.[1]Sufficient retention is provided by two means. Primary retention provided by retaining element (direct retainer) on the abutment tooth. Secondary retention is provided by intimate relationship of the minor connector with the guiding planes, denture bases, and major connectors with underlying tissue.[51,52,54]

There are two types of direct retainers: Intracoronal retainers and Extracoronal retainers. Two design strategies are adopted to either change the fulcrum location by use of mesial rest concept clasp assemblies or to minimize the effect of the lever by use of a flexible arm (wrought-wire retentive arm). Mesial rest clasp concept includes the RPI and RPA clasps.[52]

RPI CLASP SYSTEM

The RPI is a concept of bar clasp design, which refers to the rest, proximal plate, and I-bar component parts of the clasp assembly. Basically, this clasp assembly consists of a mesio-occlusal rest with the minor connector placed into the mesio-lingual embrasure,

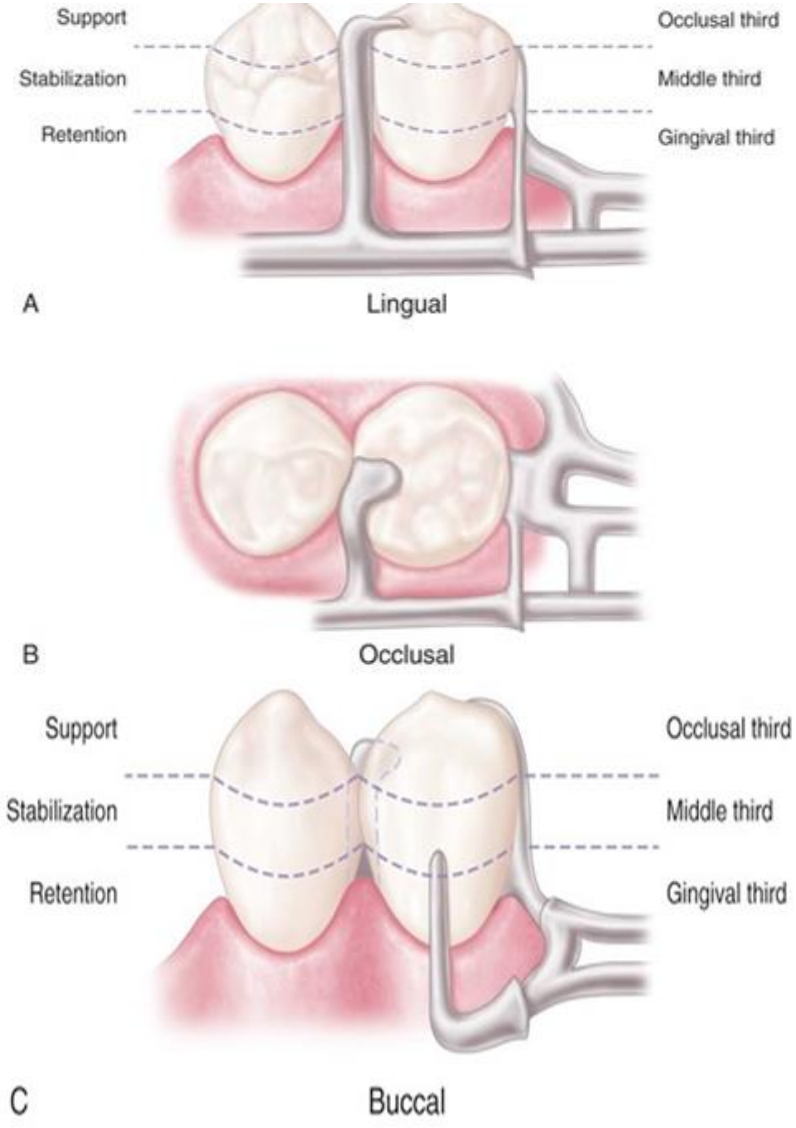
but not contacting the adjacent tooth .A distal guiding plane, extending from the marginal ridge to the junction of the middle and gingival thirds of the abutment tooth, is prepared to receive a proximal plate .The proximal plate, in conjunction with the minor connector supporting the rest, provides the stabilizing and reciprocal aspects of the clasp assembly. The I-bar, located in the gingival third of the buccal or labial surface of the abutment in an undercut provides retention.[51,52]

FEATURES

The design characteristics allow an RPI clasps to give good resistance to occlusal displacement, covers a minimum of tooth structure, and in most situations shows less metal than other clasps. An important but seldom mentioned advantage of the RPI clasp is its avoidance of contact with the lingual surface of the abutment tooth. Without a lingual arm, the high survey line on the lingual surface of many mandibular teeth is not a problem, making this design useful for tooth-supported as well as distal-extension removable partial dentures.[60]

Rests extend only into the triangular fossa, even in molar preparations, and canine rest seats are often circular, concave depressions prepared in mesial marginal ridges. The prepared guiding plane is 2 to 3 mm high occluso-gingivally, and the proximal plate contacts the apical 1 mm of the guiding plane.[65]

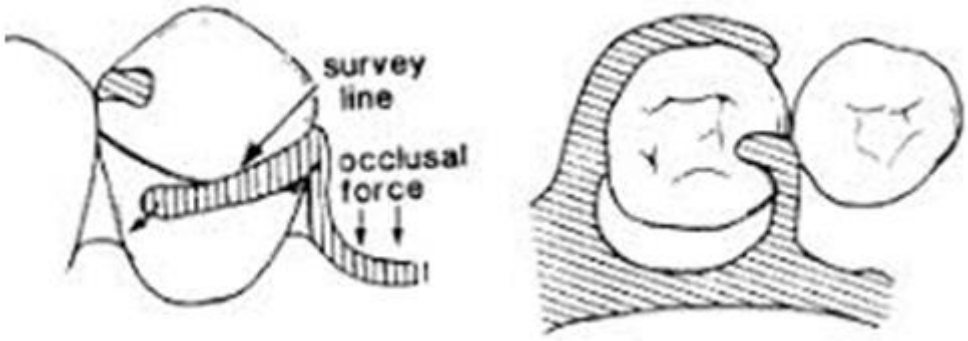
Fig. 12: RPI clasp system



RPA SYSTEM

If the abutment teeth demonstrate contraindications for a bar-type clasp (i.e., exaggerated buccal or lingual tilts, severe tissue undercut, or a shallow buccal vestibule) and the desirable undercut is located in the gingival third of the tooth away from the extension base area, a modification should be considered for the RPI system in the form of RPA clasp system.[51,52]

Fig. 13. RPA clasp assembly



COMBINATION CLASPS

Another strategy to reduce the effect of the Class I lever in distal extension situations is to use a flexible component in the "resistance arm," which is the strategy employed in the combination clasp. The combination clasp consists of a wrought-wire retentive clasp arm and a cast reciprocal clasp arm.[52]

CLASPS DESIGNED WITHOUT ACCOMMODATING FOR THE MOVEMENT OF THE PROSTHESIS

The circumferential clasp is usually most logical clasp to use with all tooth supported partial dentures where available retentive undercut permit its use because of its retentive and stabilizing ability.[51,52]

Different forms of circumferential clasp design are:

Ring clasp: It encircles nearly the entire tooth from its point of origin. For example, clasp originates from mesio-buccal surface and encircles the tooth to engage mesio-lingual undercut. It is used when proximal undercut can't be approached by other means as in case of tipped molar.

Embrasure clasp: It is designed in case of unmodified class II or class III situation where there are no edentulous spaces on the opposite side of the arch to aid in clasping. It consists of two retentive and two stabilizing arms either bilaterally or diagonally opposed with minor connector placed in the embrasure space.

Reverse clasp: It is designed when the retentive undercut is located on the abutment tooth adjacent to the edentulous space and in case of distal extension RPDs where it helps to control stresses transmitted to the terminal abutment tooth on the edentulous side. It is exact opposite of the simple circulate clasp. Simple circlet clasp usually engages the mesial undercut on an abutment tooth, reverse circulate usually engages distal undercut.

Multiple circulate clasp: It is essentially two opposing simple circlet clasp joined at the terminal end of the two reciprocal arms. It is designed where retention has to be shared among different abutment teeth on one side of the arch and principal abutment tooth has lost some of its periodontal support.

Hairpin clasp: It is a simple circlet clasp in which the retentive arms after crossing the facial surface of the tooth from its point of origin, loops back in a hairpin turn to engage proximal undercut below its point of origin. It is designed when retentive clasp must engage undercut adjacent to occlusal rest or edentulous space and a soft tissue undercut precludes the use of bar clasp.

RESTS

Rest is that component of the RPD that serves primarily to transfer forces occurring against the prosthesis down the long axis of the abutment tooth.[1]

Three different types of rests are

- Occlusal rests
- Lingual or cingulam rests
- Incisal rests

Primary rest is the component of the direct retainer unit, whereas auxiliary or secondary rest is the part of the indirect retainer.[51,52,54]

OCCLUSAL RESTS AND REST SEATS

1. 'The outline form of an occlusal rest should be a 'rounded' triangular shape with the apex towards the center of the occlusal surface. The shape should follow-as closely as possible the outline of the mesial or distal fossa of the occlusal surface. It should have smooth, gentle curves. All angles, walls or ledges should be avoided.
2. It should be as long as it is wide, and the base of the triangular shape at the marginal ridge should be at least 2.5 mm. The size of the rest varies from l/3rd to1/4th the mesio-distal width and about 1/2 the buccolingual width of the tooth measured from cusp tip to cusp tip.
3. The marginal ridge at the site of the rest seat should be lowered to permit sufficient bulk of metal for the rest and minor connector. A reduction of the marginal ridge of about 1.5 mm is necessary.
4. The floor of the occlusal rest seat should be apical to the marginal ridge and occlusal surface. It should be concave or 'spoon-shaped'. The deepest part of the seat should be in the center of the preparation, with the base of the preparation

rising gradually to join the enamel of the occlusal surface in a smooth, curving junction. Sharp edges or line-angles should be avoided.

5. The angle formed by the rest and the vertical minor connector from which it originates should be less than 90 degrees so that the transmitted occlusal forces can be directed along the long axis of the abutment tooth.
6. As far as possible, the rests should be placed on the proximal surfaces of all teeth adjacent to edentulous spaces; otherwise food may be impacted between the minor connector and the tooth if a rest is not used on the proximal-occlusal surface.[51-52]

LINGUAL OR CINGULUM REST

When only anterior teeth are remaining and are to be used for occlusal support or to support an indirect retainer, lingual or cingulum rest is used. It is used primarily on maxillary canines. The normal morphology of the tooth is such that a satisfactory rest seat can be formed with a minimum of tooth preparation[45]**.** It has a gradual lingual incline and a prominent cingulum. The thickness of enamel on the lingual surface of mandibular canine rarely allows a lingual rest seat to be placed. Also, the lingual slope of mandibular canine is too steep for an adequate lingual rest seat to be placed in the enamel.

INCISAL REST

Incisal rests are used mostly as an auxiliary rests or indirect retainers. They are frequently used for mandibular canines, but can also be used on maxillary canines.

INDIRECT RETAINERS

It is the component of a partial removable dental prosthesis that assists the direct retainer in preventing displacement of the distal extension denture base by functioning through the lever action on the opposite side of the fulcrum line when denture base moves away from the tissue in pure rotation around the fulcrum line. The type of clasp used has the greatest influence on the amount of denture base displacement and the indirect retainers have little effect on retention of distal extension partial dentures. The guiding planes on the distal surface of abutment are important in preventing denture base lifting. The use of mesial instead of a distal rest on the terminal abutment tooth doesn't decrease indirect retention.[31]

FORMS OF INDIRECT RETAINERS

The indirect retainer may take any one of the several forms. All are effective in proportion to their support and the distance from the fulcrum line.[52]

AUXILIARY OCCLUSAL REST

It is the most frequently used form of indirect retainer. It should be located on an occlusal surface as far from the distal extension base as possible. In a Class I arch, the most favorable location would be on an incisor, but it is judicious to use bilateral rest on the first premolars. They are effective without jeopardizing the weaker single-rooted teeth and also, the interference with the tongue is far less when the minor connector can be placed in the embrasure between the canine and premolar instead of placing it anterior to the canine.

In class II cases, indirect retainer can be placed on the mesio-occlusal surface of the first premolar on the opposite side of the arch from the distal extension base. In Class IV cases, it will be the occlusal rests of the posterior most direct retainers.

CANINE EXTENSIONS FROM OCCLUSAL RESTS

Occasionally a finger extension from a first premolar rest is placed on the prepared lingual surface of the adjacent canine. It is used to affect the indirect retention by increasing the distance of a resisting element from the fulcrum line. This is important when the first premolar is used as a primary abutment. By using a canine extension with a mesio-occlusal rest on a premolar, the tipping leverage on the canine is avoided.

CANINE RESTS

They are also auxiliary rests used for indirect retention. When the most favorable location for placing indirect retainer comes on an incisor tooth, it is judicious to use a canine rest rather than using the incisor tooth with a lingual or incisal rest.

LINGUAL PLATE OR CONTINUOUS BAR RETAINER

Technically they are not indirect retainers as they rest on unprepared lingual inclines of anterior teeth. The indirect retainers are actually the terminal rests at either ends of these major connectors, which are in the form of auxiliary occlusal or canine rests. Lingual plate or continuous bar retainer extends the effectiveness of the indirect retainers, when they are used with a terminal rest at each end.

DENTURE BASE

It is the part of the denture that rests on the foundation tissue and to which teeth are attached.[51-52]

Two types of denture bases are used they are metals or resin bases. Support should be a primary consideration in designing a distal extension denture base.Metal denture bases are preferred in the region where relining is not required and resin bases should be used where it requires frequent relining. Metal base is more indicated for tooth supported edentulous areas whereas resin base is indicated for distal extension partial dentures where frequent relining is required.

TOOTH REPLACEMENTS

Tooth replacements are classified into anterior and posterior teeth selection

ANTERIOR TEETH

1. Porcelain and acrylic Resin tooth on denture base
2. Facings
3. Tube teeth
4. Reinforced acrylic pontics

POSTERIOR TEETH REPLACEMENTS

1. Acrylic resin tooth
2. Porcelain teeth
3. Metal pontics
4. Metal pontics with acrylic windows
5. Tube teeth

STEPWISE PROCEDURES FOR DESIGNING

General procedural sequence for designing a partial denture include[61]:

- Examination of patient
- Diagnosis of patient
- Formulating a treatment plan
- Mount diagnostic casts
- Survey diagnostic casts
- Design diagnostic casts
- Verify mouth preparation
- Survey master cast
- Design master cast
- Designing sequence
- Secure the cast at a zero-degree tilt
- Identify proximal surfaces for guiding planes
- Adjust lateral tilt to redistribute undercuts
- Index cast
- Draw survey lines(black)
- Mark depth of undercuts(2mm red lines)
- Indicate tooth modification areas(green)
- Draw design(blue)
- Highlight subtle features(red)
- Drawing the design on the cast

ARMAMENTARIUM

Following equipments are required for designing a RPD

1. Surveyor.
2. Cast holder.
3. Analyzing rod.
4. Carbon marker.
5. Undercut gauges (0.010, 0.020, and 0.030 inches).
6. Plaster-less type of Articulator[51]

COLOR CODING

Brown color	Outline the metallic portion of the partial denture
Blue color	Outline the acrylic resin portion of the prosthesis
Red colour	Indicate areas on the teeth that will be prepared, relieved, or contoured
Solid red colour	Rest seats
Black	survey lines, tripod marks, soft tissue undercuts

STEP-BY-STEP PROCEDURE OF DESIGN

1. Examine the occluded diagnostic casts. Indicate the proposed rest areas by a short vertical line on the cast below the tooth with the black pencil. Indicate by outlining in red any cuspal relief that will be needed to provide adequate occlusal clearance for rest spaces. Examine the lingual aspect of the occluded casts for adequate space for cingulum rests, indirect retainers, and so on. Using the black pencil from the rear of the casts, draw a line on the lingual surfaces of the maxillary anterior teeth using the incisal edges of the mandibular teeth as a guide. This line shows the incisal limit of proposed metal extensions (rests or lingual plating) onto those teeth
2. Indicate with a pencil, using the following symbols, the type of tooth replacement desired. Artificial teeth on a denture base — no symbol. Tube tooth—T. Facing—F. Metal pontic—M. Reinforced acrylic pontic—RAP. Place these symbols on the soft tissue portion of the cast, adjacent to the edentulous area. One symbol

should be used for each tooth replacement.

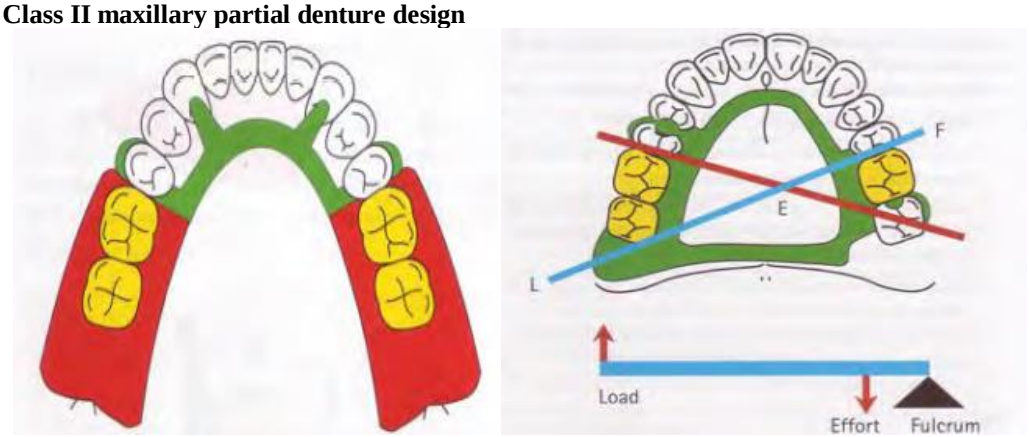
3. Place the cast on the cast holder at a horizontal tilt. Examine the teeth to be clasped for favorable retentive undercuts. Examine anterior edentulous areas for esthetic considerations. Examine proximal and lingual tooth surfaces for guiding planes. Be aware of soft tissue undercuts that may interfere with the placement of the partial denture. After considering these factors, select the best tilt, or path of insertion. Outline in red pencil those surfaces that will require recontouring or reshaping to produce the desired result.
4. Tripod the cast.
5. Place a carbon marker in the vertical arm of the surveyor and scribe the survey line on the teeth that will be contacted by the partial denture.
6. With a red pencil draw in the extent of rest areas to be prepared in the mouth
7. Outline the exact position and extent of the denture base area Blue pencil indicates acrylic resin denture base; brown indicates a metal denture base.
8. With a brown pencil outline the framework design to harmonize and join the major connectors, rest areas, indirect retainers, minor connectors, denture bases, and replacement teeth. Use the carbon marker to outline soft tissue undercuts that will influence the design.
9. Replace the carbon marker with the appropriate undercut gauge. (For most clasps of chrome cobalt alloy, a 0.010-inch undercut is adequate. In unusual cases, large molars or long canines, I 015 inch may be used. For wrought wire retentive clasps 0.020 inch is usually indicated. If gold is used, the amount of undercut should increase slightly.) Place the gauge on the desired retentive undercut area so that the head and shank of the gauge touch the tooth simultaneously. With the red pencil mark the spot that the head touches the tooth. This mark represents the gingival edge of the clasp tip in the desired retentive undercut.
10. With the brown pencil draw the clasp arms to the actual shape, size, and location desired. If wrought wire clasps are to be used, place the symbol WW on the soft tissue below the tooth.
11. The design should now be complete Reexamine for accuracy and clarity.[52]

RPD DESIGN IN TOOTH-MUCOSA BORNE RPD
KENNEDY'S CLASS I & II SITUATIONS

The following design considerations are kept in mind while designing the component parts:

Fig 14: Class I mandibular partial denture design

Fig 15: Class II maxillary partial denture design



RPD DESIGN IN TOOTH BORNE RPD
KENNEDY'S CLASS III SITUATIONS
DESIGN CONSIDERATIONS

1. Major and minor connectors

- The major connector must be rigid.
- It must not impinge on gingival tissue.
- If oral hygiene is adequate, a cast metal connector is to be preferred. Support from the hard palate like complete palate design are not necessary in the design of the maxillary major connector because major aim is to gain support.[59]
- Best support for lower denture is that of the functional sulcus depth and on the retromolar pad and buccal shelf of mandible using lingual bar or lingual plate designs.
- Major connector should be extended onto the lingual surfaces of the teeth may be employed to increase rigidity, distribute lateral stresses, improve indirect retention, or eliminate potential food impaction areas. Lingual plating should always be supported by adequate rest seats.

2. Direct retention

- For bounded saddles, retention principally depends on direct retainers.[59]
- Retention can be achieved with much less potential harmful effect on the abutment teeth than with the Class I or II arch.
- Close adaptation and proper contour of an adequately extended denture base and accurate fit of the framework against multiple properly prepared guide planes should be used to help the

retentive clasp arms retain the prosthesis.[52]

- The position of the retentive undercut on abutment teeth is not critical.

3. Clasps

- The quadrilateral positioning of direct retainers is ideal.
- The type of clasp selected is not critical.
- Tooth and tissue contours and esthetics should be considered, and the simplest clasp possible selected.
- If restorations are required to correct tooth contours, the wax patterns must be shaped with the surveyor.
- Bracing arms must be rigid.

4. Rests

- Rest seats should be prepared next to the edentulous space when possible.
- Rests should be used to support the major connector and lingual plating.

5. Indirect retention

- Indirect retention is usually not required.
- If one or both of the posterior abutment teeth are used for vertical support alone without retentive clasp arms, the entire design must follow the requirements of a Class I or II design.

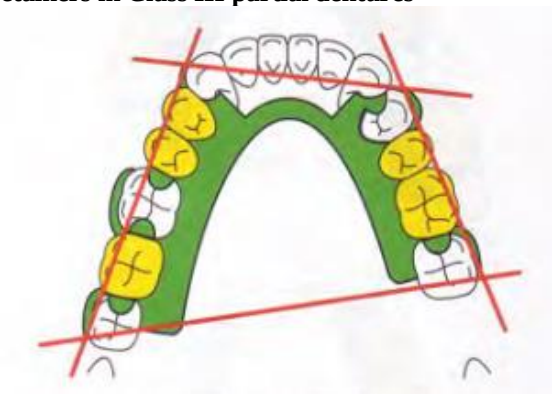
6. Occlusion

- The requirements for occlusion are the same as for a Class I or II design.

7. Denture base

- A functional type impression is not required.
- The extent of coverage of the residual ridge areas should be determined by appearance, comfort, and the avoidance of food impaction areas.
- First, support should be provided entirely by the abutment teeth. Due to the favorable distribution of abutments, Class III removable partial dentures often function like fixed prostheses. Residual ridges should be used for support only when edentulous spans are long or abutments display decreased periodontal support.

Fig. 16: Position of indirect retainers in Class III partial dentures



KENNEDY'S CLASS IV SITUATION

Design considerations:

1. Major and minor connectors

- The major connector must be rigid.
- It must not impinge on gingival tissue.
- The options for maxillary major connector include two cast bar (antero-posterior bar) connectors, horse-shoe connectors (less preferred) or palatal plate connectors (most preferrable).
- The lower major connector could be the best support like lingual bar connectors, sublingual bar or lingual plate connector.[59]
- Extension of the major connector onto the lingual surfaces of the teeth may be employed to increase rigidity, distribute lateral stresses, improve indirect retention, or eliminate potential food impaction areas. Lingual plating should always be supported by adequate rest seats.

2. Direct retention

- Retention can be achieved with much less potential harmful effect on the abutment teeth than with the Class I or II arch.
- Close adaptation and proper contour of an adequately extended denture base and accurate fit of the framework against multiple properly prepared guide planes should be used to help the retentive clasp arms retain the prosthesis.[52]
- The position of the retentive undercut on abutment teeth is not critical.

3. Clasps

- The anterior short saddle requires clasps to be positioned as far as possible because of esthetical considerations.
- Tooth and tissue contours and esthetics should be considered, and the simplest clasp possible selected.
- If restorations are required to correct tooth contours, the wax patterns must be shaped with the surveyor.
- The occlusally approaching clasps provide retention. The anterior clasps provide retention for the saddle while the posterior clasps provide indirect support.
- The anterior rests provide support for the saddle while the posterior rests provide indirect retention.

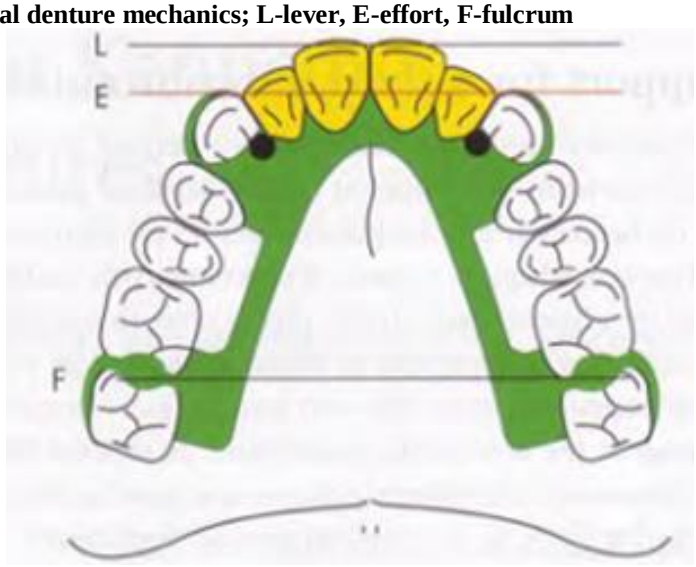
4. **Rests**
- Rest seats should be prepared next to the edentulous space when possible.
- Rests should be used to support the major connector and lingual plating.

5. **Indirect retention**
- Indirect retention is usually not required.
- If one or both of the posterior abutment teeth are used for vertical support alone without retentive clasp arms, the entire design must follow the requirements of a Class I or II design.

6. **Occlusion**
- The requirements for occlusion are the same as for a Class I or II design.

7. **Denture base**
- The longer the saddle, the shorter the denture base and the less scope for avoiding gingival margin coverage. The extent of coverage of the residual ridge areas should be determined by appearance, comfort, and the avoidance of food impaction areas.[59]
- First, support should be provided entirely by the abutment teeth. Due to the favorable distribution of abutments, Class III removable partial dentures often function like fixed prostheses. Residual ridges should be used for support only when edentulous spans are long or abutments display decreased periodontal support.

Fig. 17: Class IV partial denture mechanics; L-lever, E-effort, F-fulcrum

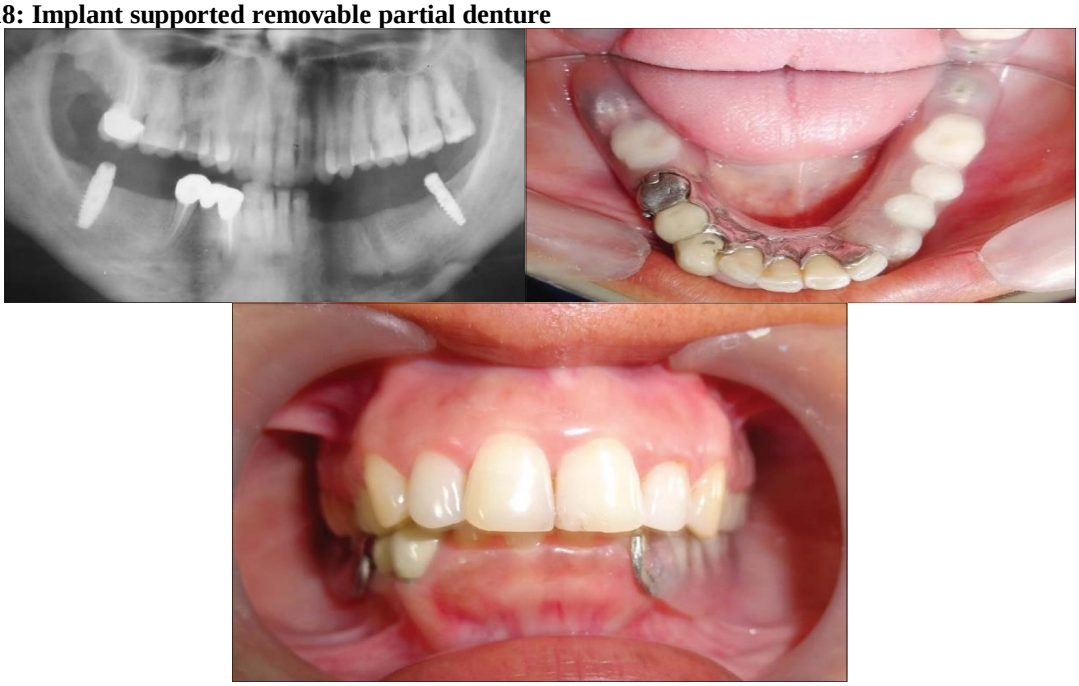


IMPLANTS IN REMOVABLE PARTIAL PROSTHODONTICS

When the root form osseointegration concept of Brånemark for full arch edentulous fixed prostheses became more dominant in the mid-1980s, these implants came to be used in partially edentulous arches. There are more partially edentulous patients missing posterior teeth than anterior teeth. As a result, the most common scenario for which a root form implant may be joined to a natural tooth is in the posterior regions. Of these cases, the most common scenario is as a terminal abutment in a patient missing the molars.[62]Placement of osseo-integrated dental implants in the posterior edentulous regions, distal to the terminal abutment provides improved vertical support to the distal extension removable partial denture, effectively converting its intraoral performance from a Kennedy Class I to a Class III situation, thereby resulting in improved stability of the prosthesis and consequently, enhanced patient satisfaction.[50]The case report published by Ramchandran A et al, showed conversion of distal extension tooth-mucosa supported partially edentulous arches to purely tooth supported partially edentulous arch using the root form osseo-integrated implants. The following pictures depicts the above-mentioned circumstances and resulted in good stability, retention and good patient satisfaction.

The systematic review conducted by de Freitas R F, de Carvalho D K, da Fonte P C A, Barbosa G A, Ferreira M A showed increase in patient satisfaction and high survival rates of implants associated with mandibular removable partial dentures with distal extensions. However, some complications and need of prosthetic repair were reported. Although this treatment approach could represent a low-cost and beneficial rehabilitation for free-end mandibular ridges.[47]There are generally three terms used by various authors to describe the use of implants in removable partial prosthesis. The three terms include: Implant supported removable partial dentures, Implant retained partial overdentures and Implant assisted removable partial dentures.

Fig. 18: Implant supported removable partial denture



IMPLANT SUPPORTED REMOVABLE PARTIAL DENTURES (ISRPD)

Implant supported Removable Partial Denture is the one in which implant serves as an abutment for support over which removable partial denture fabrication is done due to inadequate natural teeth as an abutment. A case report presented by Kumar L, Sehgal K showed the fabrication and advantages of removable partial denture supported by teeth and implants for a patient with long edentulous span. Patients were satisfied with their dentures in terms of function and aesthetics and regular follow-up visits over a period of three years revealed that the periodontal condition of remaining natural dentition and peri-implant conditions were stable and that there were no evidence of excessive residual ridge resorption or mobility of the teeth, nor were any visible changes in the bone levels of the natural teeth or implants noted on radiographs.[63]

IMPLANT RETAINED PARTIAL OVERDENTURES (IRPOD)

The article published by Chikunov I, Doan P, Vahidi F discusses the implant-retained partial overdenture (IRPOD) with resilient attachments as a predictable and cost-effective treatment for partially edentulous patients. The rationale for the IRPOD involves placement of a limited number of implants that are capable of providing adequate retention for implant- and tooth-supported RPDs and offer a functional restoration without visible retentive elements; however, additional thoughts should be given to the locations of the implants to allow for future conversion of the IRPOD to implant-supported FPDs or to implant-supported overdentures, because the remaining natural teeth may be compromised or have questionable prognosis.[64]

IMPLANT ASSISTED REMOVABLE PARTIAL DENTURES (IARPD)

Implant-assisted removable partial dentures are the one supported by natural teeth and/or soft tissues; retention also may involve conventional clasping systems. Implants can offer many benefits for removable dental prostheses, including improved support, retention, comfort, and esthetics. Implants also can result in increased patient satisfaction and therapeutic success. Removable partial denture patients can be assisted in many ways when implants are incorporated into comprehensive treatment plans. The term implant-assisted is preferred by many authors because it best describes what implants can do for patients treated with removable partial dentures.[65]

In general, implants are an adjunct to removable and fixed partial prosthesis fabrication. So the controversies in the nomenclature exists. Implants in partial edentulous patients can be used with predictable long-term results in carefully selected and well-maintained population. Patients should be advised of their role in maintenance, and a comprehensive recall system is mandatory to obtain satisfactory long-term results.[49] It may be expected that the future of removable partial prosthesis desiging may be dependent on implant supported prosthesis designing since the implants provide almost above 90% success rates when planned and placed properly.

CONCLUSION

Goal of the preventive prosthodontics is to provide useful functional removable partial dentures with preservation of remaining soft and hard tissues. To achieve this one should understand how to maximize every opportunity for providing and maintaining a sable prosthesis. Since removable partial denture is not rigidly attached to teeth, the control of potential

movement under functional load is critical to providing the best chance for stability. AsMaxfield states “common observation clearly indicates that the ability of living things to tolerate force is largely dependent upon the magnitude or intensity of force. The supporting structures of removable partial dentures are living things and are subjected to forces. The design principles should reduce these deleterious forces which are acted upon on the tissues. It should be known that which component could generate what type of forces, tentative degree of force so applied and the direction of the force transmission. Each component must be selected and designed to complement the esthetics. At the same time, not compromising on the functional aspect of the denture, as the property of function is of prime importance. A harmonious balance between function and esthetics has to be maintained to fabricate a removable partial denture that will serve optimally.It will be the responsibility of the dentist to excuse the shortcomings of the commercial dental laboratory because dentist directly involves for planning biologic partial denture design and frequently fails to provide the laboratory technician with casts of properly prepared mouths and adequate prescriptions.To achieve success in removable partial denture therapy, nothing can replace good judgment coupled with the knowledge of the fundamental principles of partial denture design. the practitioner must display a thorough understanding of those factors that will impact the design process. It must be remembered that any of the philosophies which were mentioned can be successful if applied under the appropriate circumstances.Certain principles are applicable for the solution of given conditions, which will be the same principles that will operate in another instance showing repetition of those conditions.The rationale for design should logically develop from analysis of the unique oral condition of each mouth under consideration. However, it is possible that alternative design “solutions” could be applied, and it is the evaluation of perceived merits of these various designs that seems most confusing to clinicians.

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