International Journal Dental and Medical Sciences Research
Volume 8, Issue 1, Jan.-Feb. 2026 pp: 50-56 www.ijdmsrjournal.com ISSN: 2582-6018

Comprehensive Step-by-Step Guide to Designing a Removable Partial Denture Framework

Dr SuganyaS,Dr Varsha Murthy,Dr Lakshmi Devi M,Dr Balaji J,Dr Sadish M,Dr Akansha Kishen

Corresponding Author: Dr. Suganya S
Postgraduate (First Year), Department of Prosthodontics and Crown & Bridge
Sri Venkateshwaraa Dental College, Ariyur, Puducherry, India

Date of Submission: 13-01-2026 Date of Acceptance: 28-01-2026

Abstract
Removable Partial Denture (RPD) therapy is a widely adopted prosthodontic treatment due to its affordability and adaptability in managing partial edentulism. For postgraduate students, understanding the design of RPDs during the preclinical phase is essential, as it lays the foundation for effective clinical application. Despite its importance, structured literature on RPD design remains limited.

This guide presents a structured, step-by-step approach to designing RPD frameworks based on Kennedy Classifications I–IV. It covers key components, including major and minor connectors, rests, guide planes, direct and indirect retainers, and denture base design. Each classification is addressed with specific design considerations to enhance function, retention, and patient comfort. The guide serves as a practical resource for clinicians and students to ensure logical, efficient, and clinically sound RPD design.

Keywords
Removable Partial Denture, Kennedy Classification,Framework Design, Direct Retainers, Indirect Retainers.

I. Introduction:

A dental prosthesis is a replacement for one or more missing natural teeth and their supporting structures. When not all teeth in an arch are replaced, the prosthesis is classified as a partial denture. Depending on the design, it may be supported by natural teeth, oral mucosa, or both. Partial dentures may be fixed (e.g., bridges) or removable. A Removable Partial Denture (RPD) is a prosthesis that the patient can remove and reinsert independently. It restores function and aesthetics by utilizing the remaining teeth and/or soft tissues for support, stability, and retention.[1]

The proportion of partially dentate adults is steadily increasing due to greater life expectancy, an aging population, and the shift from complete edentulism to partial tooth loss.[2-4]In certain regions, the prevalence of partial edentulism exceeds 20%.[5]In the United States, the number of partially edentulous individuals is projected to surpass 200 million within the next 15 years.[6]Current data indicate that U.S. adults aged over 20 retain an average of 24.9 natural teeth, with 43.7% having experienced at least one extraction.[5]Among those aged 65 years and above, the average number of remaining teeth decreases to 18.9, and 43.1% have lost six or more teeth.[7,8]Similarly, the 2009 United Kingdom Adult Dental Health Survey reported that nearly one in five adults wore some form of removable denture—either partial or complete—with 6% completely edentulous and 13% using dentures in combination with natural teeth.[9]

As oral health standards continue to improve, complete edentulism is becoming less common, and the management of partial edentulism is increasingly emphasized.[3]The replacement of missing teeth and supporting structures is essential for improving aesthetics, mastication, phonetics, and maintaining arch integrity by preventing the drifting or overeruption of adjacent teeth.

RPDs remain a widely accepted treatment modality due to their clinical versatility, cost-effectiveness, and ability to accommodate various clinical and patient-specific conditions. They are indicated when implant-supported prostheses are contraindicated due to systemic, anatomical, or financial constraints, and they are often used as provisional or transitional prostheses[10]. Importantly, RPDs help preserve existing natural teeth by distributing occlusal forces and maintaining arch stability. The principal objectives of RPD therapy are to restore function and aesthetics, preserve remaining oral structures, and enhance patient comfort and quality of life[11,12]

Given these factors, emerging prosthodontists need to develop a comprehensive understanding of RPD design principles and fabrication techniques. However, current preclinical curricula often lack structured guidance for systematic RPD design. This review, therefore, aims

to bridge that gap by presenting a practical, step-by-step guide for designing removable partial dentures during preclinical training

Designing an RPD:

Proper framework design is crucial for long-term success. A well-designed framework restores function and aesthetics while minimizing harmful loads on abutment teeth. It must fit precisely to be comfortable and encourage patient compliance.[13]If a framework is poorly designed or ill-fitting, the RPD may cause soreness, accelerate ridge resorption, or transfer damaging forces to the remaining teeth. In short, meticulous framework design directly impacts the denture's stability, comfort, and longevity.[14]

Designing an effective RPD framework begins with a thorough clinical evaluation and case planning.[15]The sequence that follows is recommended as a starting point because it encourages a logical and systematic approach to designing removable partial dentures. 1. Surveying, 2. Selection of a major connector, 3. Selection of the direct retainers 4. Selection of an Indirect retainer 5. Location of rests, 6. Location of guide plates, 7. Placement of minor connectors, 8. Placement of denture base retentive elements, 9. Selection of replacement teeth.[16]

Surveying

A dental surveyor is a diagnostic and design instrument essential in the planning of Removable Partial Dentures (RPDs). It plays a critical role in determining the most favourable path of insertion and in the preparation of guiding planes on abutment teeth.[17] The process of using a surveyor is known as surveying. Proper surveying ensures optimal framework design, accurate prosthesis fit, and enhanced longevity of both the prosthesis and the supporting oral structures[18].

Functions and Uses of the Dental Surveyor

The dental surveyor serves several important diagnostic and laboratory functions in RPD design.[19-21]

1. Determining the path of insertion of the prosthesis by analyzing tooth and tissue contours. This allows for an optimal placement and removal path that minimizes stress on abutment teeth.
2. Locating soft tissue undercuts that may interfere with denture base extension or clasp design, thereby ensuring proper adaptation of the prosthesis to the supporting tissues.
3. Contouring wax patterns for fixed restorations that will serve as RPD abutments, ensuring that they are parallel to the planned path of insertion.
4. Machining parallel surfaces on cast restorations to accommodate retainers or attachments, improving mechanical retention and stability.
5. Blocking out undesirable undercuts on the master cast before framework fabrication to prevent distortion and enhance the fit of the metal framework.
6. Placing intracoronal attachments, such as precision retainers, accurately in relation to the chosen path of insertion for functional and esthetic success.
7. Tripoding, which involves recording and preserving the orientation of the diagnostic or master cast relative to the selected path of insertion for future reference.[22]

Components of a Dental Surveyor

A dental surveyor consists of several essential components that work together to achieve precision in RPD design.[23-25]

1. **Surveying Table (Cast Holder):** The surveying table is a movable platform on which the dental cast is mounted. It is equipped with a ball-and-socket joint that allows tilting and fixing of the cast in the desired position to determine the best path of insertion.
2. **Surveying Arm:** The surveying arm is a vertical column supporting an adjustable horizontal arm to which various surveying tools can be attached. It enables the evaluation of tooth surface parallelism and measurement of undercut depth.
3. **Surveying Tools:**
   a. Analysing Rod – a straight metal rod used to examine surface contours and axial inclinations of abutment teeth. It serves as the principal instrument for identifying the height of contour and locating undercuts.
   b. Carbon Marker – a pencil-like lead used to mark the height of contour on teeth and casts. It is often enclosed in a protective sheath to prevent breakage.
   c. Undercut Gauges – metal gauges with terminal lips, typically measuring 0.01" or 0.02", used to measure the depth of undercuts and identify suitable areas for clasp placement.
   d. Wax Trimmer – a sharp-edged tool used to trim wax patterns or apply blockout wax on casts, functioning by shaving or

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dragging along the surface to refine waxed areas.

RPD Design Framework for Mandibular Kennedy Class I

Definition

A Kennedy Class I arch is characterized by bilateral posterior edentulous spaces located behind the remaining natural teeth.

Steps in designing:

1.Major Connector:

a. **Lingual Bar:**The most frequently used major connector; it requires a minimum of 7 mm of functional depth in the floor of the mouth.
b. **Lingual Plate**: It is preferred when the lingual bar cannot be used due to inadequate functional depth of the floor of the mouth, compromised periodontal support of the remaining teeth, or the need for additional stabilization and indirect retention.

2. Direct Retainers (Clasps):

a. Typically, two clasp assemblies are adequate—one on the terminal abutment tooth on each side of the arch.
b. Selection of clasp type depends on the position of the undercut:
   I. Disto-buccal undercut: Infrabulge clasp, such as a T-clasp or modified ½ T-clasp
   II. Mesio-buccal undercut: Wrought wire clasp
c. Clasps are commonly placed on premolars or canines adjacent to the edentulous areas.

3. Indirect Retainers:

a. Used to minimize rotational displacement around the fulcrum line
b. Design principles include:
   I. Placement as far from the fulcrum line as possible
   II. Avoid positioning anterior to the canine teeth
   III. Use of two indirect retainers for improved stability
c. A mesial occlusal rest on the first premolar frequently acts as the indirect retainer
d. Lingual plating may be incorporated to enhance indirect retention

4. Rest:

a. Positioned next to the edentulous areas
b. Primary rest:
   I. Located on the mesial occlusal surface of the first premolar
c. Supplementary rests:
   I. Placed on anterior teeth such as canines
   II. Function as indirect retainers

5. Guide Planes

a. Prepared on thedistal surfaces of abutment teeth adjacent to edentulous areas.
b. Recommended dimensions:
   I. Height: 2–3 mm
   II. Width: approximately one-third of the buccolingual width of the crown

6. Denture Base

a. The distal extension denture base should completely cover the retromolar pads
b. Functional impression techniques, such as the altered cast method, are recommended to achieve optimal support and adaptation

7. Minor Connectors

a. Must be rigid in design
b. Should cross gingival margins at right angles
c. Connect the major connector to rests, clasps, and the denture base framework

8. Denture Base Retention:

a. An open lattice framework is preferred over mesh, as it provides better mechanical retention for acrylic resin
b. In mandibular distal extension cases, the lattice should extend to approximately two-thirds of the distance toward the retromolar pad to ensure adequate support and stability. (Figure 1)

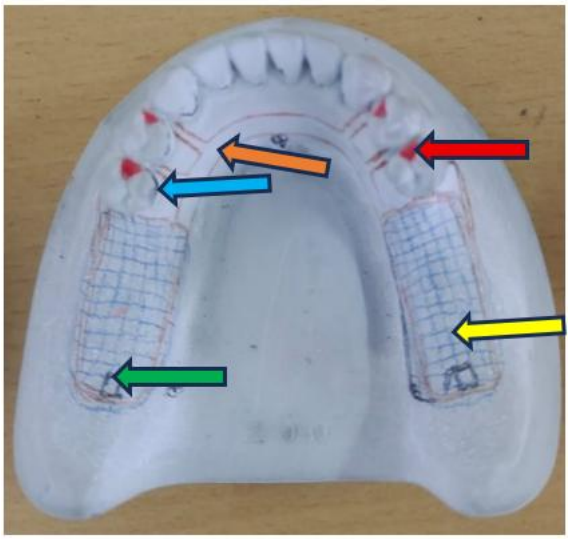

Figure 1. Removable partial denture Design Framework for Mandibular Kennedy Class I.

International Journal Dental and Medical Sciences Research
Volume 8, Issue 1, Jan.-Feb. 2026 pp: 50-56 www.ijdmsrjournal.com ISSN: 2582-6018

The orange arrow indicates the major connector; the blue arrow denotes the direct retainer (clasp assembly); the red arrow represents the rest; the yellow arrow indicates the denture base retention element; and the green arrow shows the cast stop (tissue stop).

RPD Design Framework for Mandibular Kennedy Class II

Definition:

In Kennedy Class II, the arch exhibits a single edentulous area on one side, situated posterior to all remaining natural teeth.

Steps in designing:

1.Major Connector

a. **Lingual bar** – if ≥7 mm functional depth available
b. **Lingual plate** – if depth is inadequate or additional stabilization is needed.

2. Direct Retainers (Clasps)

Tripodal clasp distribution is commonly used in Kennedy Class II arches.

a. One clasp assembly is placed on the abutment tooth adjacent to the distal extension area.
b. If no modification space is present:
   I. One clasp is positioned as posteriorly as possible.
   II. The second clasp is placed as far anteriorly as permitted by esthetics, available space, and tooth contour.
c. Circumferential clasp is preferred in most situations.

3. Indirect Retainers:

a. Indirect retention is less critical than in Class I, but still required.
b. Helps in resisting rotational movement of the prosthesis.
c. An embrasure rest between the first and second premolars on the opposite side of the distal extension is commonly used.
d. The rest is positioned sufficiently anterior to the fulcrum line to function effectively as an indirect retainer.

4. Rest:

a. Mesial rest on abutment adjacent to the extension base
b. Auxiliary rests on the opposite side for indirect retention

5. Guide Planes

- Prepare guide planes on:
  a. Distal surface of abutment tooth adjacent to the edentulous area
  b. Proximal surfaces of key teeth on the tooth-supported side

6. Denture Base

a. Extension based on the edentulous side, extending to the retromolar pad.
b. Record impression using altered cast technique for accurate adaptation.
c. Tooth-supported base on the other side.

7. Minor Connectors

a. Rigidly connect all components (rests, clasps, mesh) to the major connector
b. Cross the gingival margin at 90°

8.Denture Base Retention

a. Open lattice or meshwork on extension side
b. Ensure mechanical and chemical retention of the acrylic base. (Figure 2)

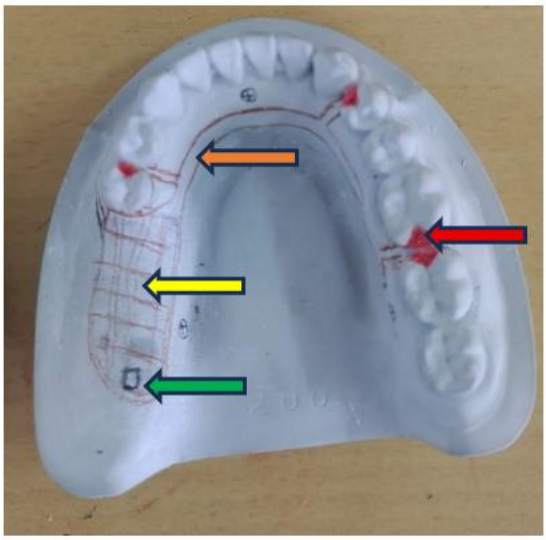

Figure 2. Removable partial denture Design Framework for Mandibular Kennedy Class II.

The orange arrow indicates the major connector; the red arrow denotes the rest; the yellow arrow shows the denture base retention component; and the green arrow represents the cast stop (tissue stop).

RPD Design Framework for Maxillary Kennedy Class III

Definition:

A Kennedy Class III arch is characterized by a single unilateral edentulous space that is bounded by natural teeth both anteriorly and posteriorly.

1. Support Type:

a. Tooth-supported → more favourable prognosis.
b. No need for tissue support or extension base
c. No rotational forces like in Class I/II

2. Major Connector

a. **Palatal strap**: most commonly used (especially for short-span Class III)

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b. **Anteroposterior palatal strap**: for longer edentulous spans or when more rigidity is needed.

3. Direct Retainers (Clasps)

a. Quadrilateral clasp positioning of direct retainers is considered ideal.

b. Simple circlet clasps are chosen.

4. Indirect Retainers

a. Not essential in Class III since the base is tooth-supported and doesn't rotate.

b. May include auxiliary rests for stabilization if needed.

5. Rest

a. Should be positioned adjacent to the edentulous space.

b. Provide vertical support and prevent tissue-ward movement of the framework.

6. Guide Planes

a. On the proximal surfaces of abutment teeth

b. Help in the path of insertion and frictional retention.

c. Height: 2–3 mm, width: ~1/3 buccolingual width

7. Minor Connectors

a. Rigidly connect the clasp assemblies and rest seats to the major connector

b. Should cross the gingiva at a 90° angle.

8. Denture Base

a. Since it is a tooth-supported metal base or acrylic base, a mesh or lattice for acrylic retention may be used.

b. For aesthetic and tissue adaptation purposes, acrylic is preferred in the anterior region. (Figure 3)

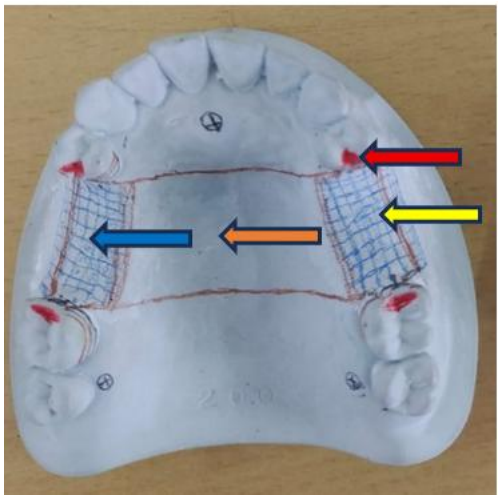

Figure 3. Removable partial denture Design Framework for Mandibular Kennedy Class III.

The orange arrow indicates the major connector; the blue arrow denotes the direct retainer (clasp assembly); the red ar
row represents the rest; and the yellow arrow shows the denture base retention component.

RPD Design Framework for Maxillary Kennedy Class IV

Definition:

Kennedy Class IV involves a **single, bilateral anterior edentulous area** crossing the midline, with remaining natural teeth only in the posterior regions.

1. Support Type:

a. Tooth-tissue supported.

b. Challenging due to esthetics, lack of anterior abutments, and long edentulous span

2. Major Connector

a. Anteroposterior palatal strap is most recommended, provides rigidity, and leaves the anterior palate uncovered for phonetics and comfort.

3. Direct Retainers (Clasps)

a. Quadrilateral configuration of direct retainers is considered ideal.

b. The Fout clasp assembly should be used. The two clasp assemblies should be placed as far anterior as possible. Remanning clasp assemblies have to be placed as far posterior as possible.

c. Use an Akers (circumferential) clasp or an embrasure clasp if two adjacent molars are used.

4. Indirect Retainers

a. The forces acting to move the denture's base away from the edentulous ridge, in class four RPD, must be resisted by the indirect retainer positioned posterior to the fulcrum.

b. Embrasure rest provides effective indirect retention.

5.. Rest

a. Rest for the embrasure clasp should be placed on the first and second molars.

6. Denture Base

a. Use an open lattice or meshwork for acrylic retention.

b. Aesthetics is key: consider a metal-free zone in the aestheticarea. (Figure 4)

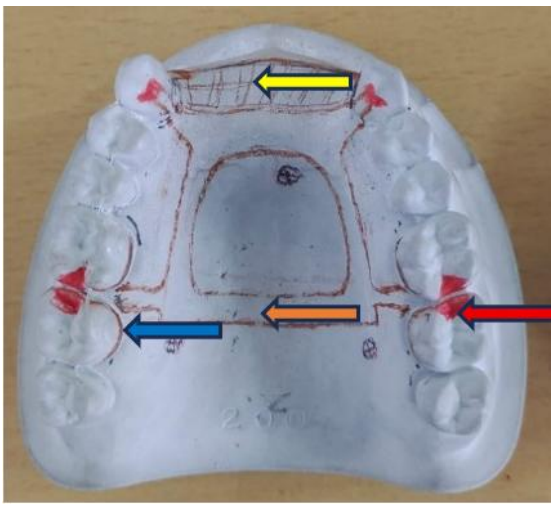

Figure 4. Removable partial denture Design Framework for Mandibular Kennedy Class IV.

The orange arrow indicates the major connector; the blue arrow denotes the direct retainer (clasp assembly); the red arrow represents the rest; and the yellow arrow shows the denture base retention component.

II. Conclusion:

A systematic, classification-based approach to RPD design ensures optimal function, retention, and patient comfort. By carefully selecting and positioning each component according to the specific Kennedy class, clinicians can create effective, stable, and patient-friendly prostheses. This guide serves as a practical tool for achieving predictable and successful RPD outcomes.

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