Removable Partial Denture Design

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Introduction

Removable partial dentures (RPDs) remain an important and practical solution for replacing missing teeth, despite being associated with low patient acceptance, certain biological risks for remaining teeth and periodontal tissues[1]. While RPDs are sometimes viewed as a more economical but also less favourable solution compared to other prosthodontic options, they continue to play a significant role in dental care for many adults in the UK[2]. With careful patient assessment and planning, RPDs offer versatile and viable solutions for tooth loss.

The overview in the following highlights key factors influencing provision of RPDs and their implications for patients and dental professionals.

RPD Use in the UK

Prevalence: Data from the 2023 Adult Dental Health Survey (ADHS)[2] reveal that 11% of adults in the UK report wearing a denture, a significant decline from 20% in 2009[3]. While the survey does not distinguish between removable partial dentures (RPDs) and complete dentures (CDs), it highlights that 62% of denture wearers are aged 65 or older. This pattern reflects a higher prevalence of total tooth loss among older adults and is also detected amongst those with lower household incomes and those living in more deprived areas. These groups not only experience greater tooth loss but also face increased challenges in accessing dental care.

RPD-Specific Data: Focusing specifically on RPDs, a 2018 Oral Health Survey[4] of dental practice attendees found that 13.7% wore RPDs, with prevalence rising with age. Gender differences appear minimal, as a 2014 Oral Care Omnibus Study[5] reported similar rates of RPD use among males (14.6%) and females (12.9%).

Future Trends: There is evidence of a global shift from complete dentures to RPDs[5], likely reflecting improved tooth retention into older age. However, the 2023 ADHS findings suggest that older and more deprived patients - those most likely to need RPDs - are also those who may struggle most to access dental care. This underscores the ongoing need for accessible prosthodontic services and targeted support for vulnerable populations.

Patient Perspectives on RPDs

Psychological Impact: A 2021 study[6] found that 54% of RPD wearers struggled to accept tooth loss, 40% were concerned about appearance, and 32% felt embarrassed about wearing dentures.

Emotional Well-being: Over half (51%) reported reduced self-esteem, and 57% experienced anxiety about dental visits.[6]

Desire for Education: 62% wished they had received more oral care education earlier in life.[6]

Professional Awareness: The study concluded that dental professionals often lack sufficient understanding of the emotional and practical needs of RPD wearers.[6]

Dental Professionals' Views and Training

Professional Challenges: Dentists have traditionally found RPDs a challenging treatment option.[7,8,9,10,11]

Educational Trends: A 2025 survey[12] of 14 UK dental schools and 22 Foundation Trainees (FDs) found that clinical case numbers for RPDs have remained stable over the recent decades. FDs rated their undergraduate training in RPDs and CDs as 'good' or 'very good,' with further increased confidence in providing acrylic-based RPDs and CDs gained during foundation training. However, the number of dental technicians declined for the fifth year in a row, and almost 10% fewer dental technicians compared to 2020[13]. The Dental Technologists Association (DTA)[14] has expressed serious concern about the growing number of dental technology training programs facing closure or suspension, warning that these trends pose a critical threat to the future dental technology workforce and oral healthcare across the UK.

Confidence Gaps: Confidence in designing and providing cobalt-chrome RPDs varied[12], with some reporting reduced confidence after graduation. While CAD-CAM workflows increasingly present a reliable and efficient alternative to conventional fabrication methods[15], design software programs reportedly still have limitations[16]. Their role in overcoming gaps in design confidence is therefore likely more an aspiration than a reality.

Technical Complications and Outcomes

Repair and Replacement: In the 2018 Oral Health Survey[4], 18.1% of RPD wearers needed repairs or replacements.

Types of Complications: A 2023 systematic review[17] identified common issues such as loss of retention, decementation or loss of abutment crowns, and fractures of frameworks, denture teeth, or acrylic bases. Relining was also sometimes required.

Survival Rates: A 10-year retrospective analysis (2024)[18] reported median survival times of 6 years for metal-based RPDs and over 3 years for acrylic resin RPDs. Metal-based dentures, restoration of both arches, and ongoing maintenance improved survival rates. A different study[19] found that hygienic design principles increased mean survival to 8 years, with a 90% positive outcome after 5 years.

Biological Complications

Abutment Tooth Survival: Five-year survival rates for RPD abutment teeth are around 86.6%[20], with abutment tooth loss accounting for up to 40% of RPD failures.[21] Higher survival rates (94.2%) are reported with stringent attention to hygienic design and maintenance.[19]

Risk Factors: Significant risk factors[22] for abutment tooth loss include prior endodontic treatment, presence of prosthetic crowns and post-core, and tooth type. Pre-prosthesis bone support did not significantly affect prognosis[21].

Other Complications: Biological issues such as caries, tooth fracture, mobility, and gingival recession were noted[22], emphasising the importance of thorough pre- and post-treatment care to minimise complications.

In summary, RPDs remain a vital, adaptable solution for many patients, especially older adults. While challenges persist - ranging from technical failures to psychological impacts - ongoing education, careful design, and comprehensive patient support can significantly improve outcomes for both patients and dental professionals.

General Guidelines for Provision of RPDs

Patient Assessment

- Conduct a comprehensive and structured evaluation of each patient.
- Identify and document the patient's needs, wishes, and concerns in their records.
- Ensure that the recommendation for an RPD aligns with the patient's clinical indications to support informed consent and increase acceptance.

Treatment Planning

- Adopt a patient-centered approach, tailoring the treatment plan to individual requirements.
- Consider both oral and general health factors, including:
    - Specific challenges present in partially dentate patients.
    - Age-related factors, such as reduced saliva flow and decreased manual dexterity.
- Prefer minimally invasive designs and procedures whenever possible.
- Objectively assess case complexity and any modifying prosthodontic or RPD-specific factors[23,24] and record the rationale for chosen approaches.

RPD Design Considerations

- Design the RPD to minimise functional limitations and optimise aesthetics[25], addressing patient concerns about dental privacy[26].
- Incorporate hygienic design principles[27], especially for patients with higher risk of dental disease and specific or age-related challenges.
- Apply effective and hygienic design principles to RPDs with acrylic bases where possible.
- For long-term RPDs, include features that allow for future modifications, such as the addition of teeth with uncertain prognosis.

Maintenance and Support Care

- Educate both the patient and the dental team on the importance of daily oral hygiene and regular, supportive care.
- Emphasise that RPDs require intensive maintenance and ongoing professional follow-up to ensure long-term success.

Specific Guidelines for Provision of RPDs

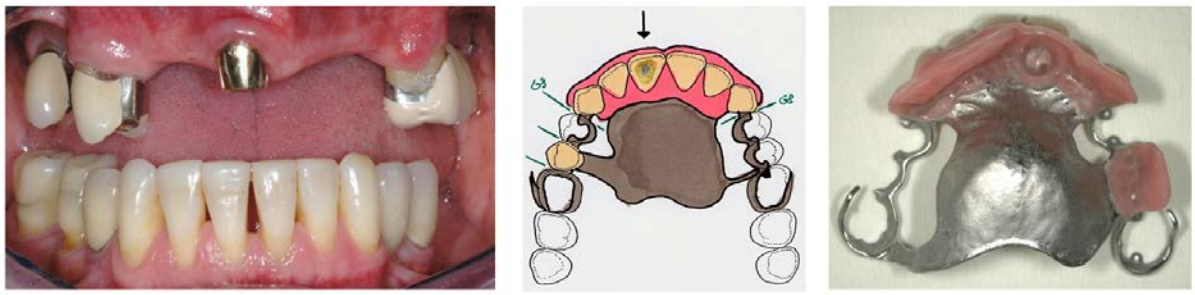
Indications for RPDs

The provision of a removable partial denture (RPD) must be based on justifiable, patient-centered indications, with the primary goal of restoring aesthetics and function. Consider the following principles:

- Shortened Dental Arch (SDA): An SDA is a functionally stable concept[28,29,30]. If an SDA exists or can be achieved with a fixed solution, an RPD is generally not indicated.

- Evidence and Clinical Experience: While the evidence base for RPD indications is limited, clinical experience supports several scenarios where RPDs are ideally suited. In most cases, more than one indication will apply, and the RPD design should reflect these combined requirements.

- Suggested Indications[23,24]:
  - Restoration of aesthetics and function when fixed prosthodontic solutions are not feasible or suitable.
  - Replacement of multiple missing teeth and missing hard and soft tissue volume, especially when other options are unsuitable.
  - Provision for future addition of individual teeth or modification of a bounded saddle to a free-end saddle.
  - Strategic support or preservation of remaining teeth. Examples are conversions to overdenture abutments or retaining teeth with residual mobility.
  - Patient preference, particularly when other solutions do not align with individual needs.
  - Note: tailor the RPD design to the specific clinical indications present in each case.



Patient indication example: *Restoration of aesthetics and function is required. Several teeth need to be replaced and there is significant loss of hard and soft tissue volume. The UR1 has been converted to an overdenture abutment. The post-retained cast root cap has a blank for a corresponding magnet inserted in the RPD base to provide strategic anterior retention. As a general rule, overdenture abutments need to be reduced to a low-level profile that is just supragingival, here dictated by the palatal gingival level. This reduction is needed to allow adequate room for the other RPD components Provision has been made for future addition of each of the remaining teeth. Based on an objective discussion of all applicable prosthodontic solutions with respective advantages /disadvantages, it is the patient's informed decision and preference to opt for the RPD solution.*

Assessment of Complexity

RPDs can be categorised as straightforward, advanced, or complex based on the clinical situation. This classification guides treatment planning and highlights areas requiring detailed attention.
Structured Assessment

A structured aide-memoire[23,24] (see next page) is recommended to assist clinicians in assessing RPD complexity at the outset of treatment. This aide-memoire, modeled on the SAC Classification in Implant Dentistry[31] and its risk assessment rubrics, lists prosthodontic and RPD-specific factors. For each factor, clinical scenarios are suggested that correspond to straightforward, advanced, or complex cases.

Purpose:

- Identify specific areas requiring in-depth planning and preparation.
- Ensure a systematic approach to RPD design and delivery.

Complexity Examples:

- Straightforward:
  - RPD with bounded saddles in a healthy, stable mouth with a functional occlusion (e.g., Kennedy Class III).
- Advanced:
  - Presence of one or more free-end saddles (e.g., Kennedy Class I and II).
  - Need for new cast restorations.
  - Replacement of anterior teeth and restoration of anterior guidance.
- Complex:
  - Full mouth rehabilitation, including changes in vertical dimension.
  - Periodontal concerns (e.g., splinting of mobile teeth).
  - Critical aesthetic requirements and/or use of precision attachments (e.g., Kennedy Class IV).

*This **straightforward** RPD situation has bounded saddles in a healthy remaining dentition with functional and stable occlusion. An existing indirect restoration on LL7 already has a milled rest seat for a ring rest. Note here that the LL7 crown preparation would have included specific reduction to accommodate the milled rest seat.*

*This **advanced** RPD for a remaining dentition with a guarded periodontal prognosis has provision for gradual addition of individual or all remaining teeth. The palatal semi-permanent splint provides anterior guidance and reduces loading of the individual canines and incisors.*

*This **complex** RPD situation requires a full mouth prosthodontic rehabilitation (including change in vertical dimension). The abutment teeth have been restored with indirect restorations and there is also a need for critical aesthetics of the replacement teeth and flange.*

Aide-memoire for Structured Assessment[23,24]: Determining Prosthodontic and RPD complexity and identifying modifying factors

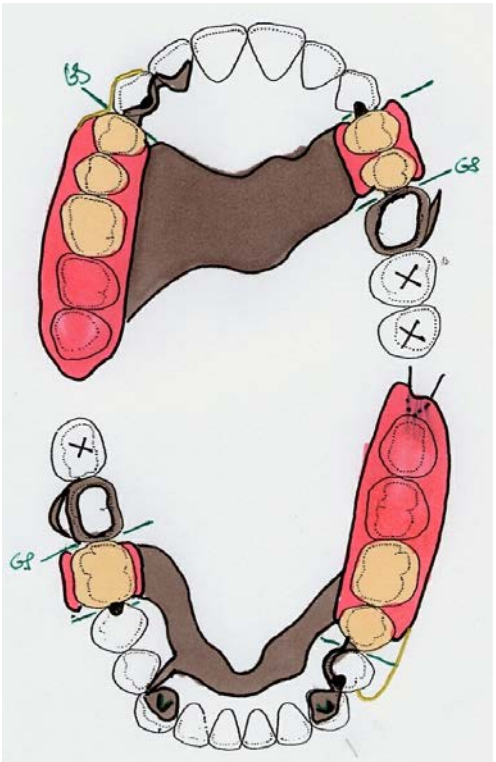
Prosthodontic Assessment	Straightforward	Advanced	Complex
Patient's needs and wishes	**Realistic**	**Specific aesthetic and functional expectations**	**Preference for fixed (Precision attachments?)**
Caries status	**None Controlled**	**At risk and/or active Failure of abutment teeth due to caries**	**High risk & active Shortened Dental Arch SDA alternative to reduce long-term maintenance burden?**
General restorative needs	**None or minor**	**Indirect/cast restorations in same arch as RPD**	**RPD as part of full mouth rehabilitation**
Specific restorative needs of abutment teeth	**None or minor**	**Structural strength and restorability?**	**Convert to ODAs? (Over Denture Abutment) Consider implant alternative?**
Periodontal status	**Healthy with no active disease past or present**	**Moderate disease (attachment loss 2-4mm) in the past but effectively treated and controlled**	**Unstable and/or past advanced disease (attachment loss > 4mm)**
Occlusion	**Conform**	**RPD making up missing criteria: Anterior guidance and/or Posterior support**	**In need of reorganisation incl. Change of vertical dimension And/or provisional phase**
TMD	**None**	**Myo-fascial symptoms**	**Internal derangement in TMJs**
RPD assessment			
Teeth to be replaced (SDA not possible)	**Posteriors only Bounded saddles**	**Some anteriors Unilateral free-end saddle**	**Most anteriors Bilateral free-end saddles**
Aesthetic needs	**Low lip line**	**Medium lip line Replacing anterior teeth**	**High lip line and no visible clasps: guide surfaces or precision attachments Visible anterior flange:tinting**
Residual ridge reduction	**Favourable (Cawood & Howell Class III-IV)**	**Advanced (Cawood & Howell Class V)**	**Severe (Cawood & Howell Class VI)**
Unwanted tooth movement	**None or minor**	**Twisted and/or tilted**	**Over-erupted:convert to ODA?**
Strategic abutments	**Present (Kennedy Class III)**	**One or two missing Kennedy Class I & II Convert to ODA?**	**Implants as ODAs? (Kennedy Class I,II & IV)**
Previous RPD experience	**None or good**	**None or difficulties**	**Failure and/or not used**
Cost band	**Standard fee**	**Subject to RPD design & laboratory estimate**	**Subject to full treatment plan, RPD design & laboratory estimate**

Effective and hygienic RPD Design[23,24]

Core elements

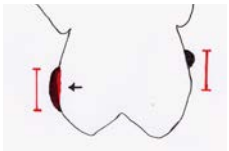
A logical sequence of six core elements, each incorporating hygienic principles, assists effective design:

1. Teeth to be replaced: Replace only those teeth necessary for aesthetics and function. Early try-ins of anterior teeth establish desired aesthetic outcome and help guide the path of insertion[32].
2. Support: Maximise stability by ensuring adequate support for each saddle and the overall design. Whenever possible, use sound teeth for support and prepare rest seats as needed. For heavily restored teeth, consider restorative options including conversion to overdenture abutment. Saddle extensions for soft tissue support should be optimised (e.g., extension of free-end saddles onto attached keratinised mucosa on retromolar pads).
3. Major Connector: As the backbone of the RPD, it must be strong and rigid. Designs should avoid unnecessary proximity to supporting teeth and their periodontal tissues to avoid trauma and as prevention against biological complications.
4. Retention: Strategic placement of clasps or precision attachments ensures effective retention with minimal components, ideally just two clasps forming an effective clasp axis.
5. Anti-Rotation (Indirect Retention): Assisting an effective clasp axis in minimising unwanted movement through strategic support (rests/mucosal extension) and or guide surfaces.
6. Reciprocation: Bracing against lateral forces from clasps prevents tooth movement and maintains stability.



Design example of application of six core elements:

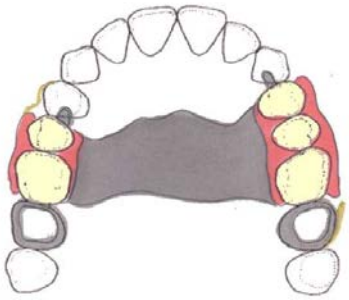
1. ***Teeth to be replaced:*** *Prior assessment has deemed a bilateral first molar occlusion adequate.*
2. ***Support:*** *Combination of rests (including ring-rests for the lone-standing molars) for each saddle and full extension of free-end saddles (around tuberosity and onto retro-molar pad).*
3. ***Major connectors*** *Upper strap design in palatal vault. Rigidity is gained from the 3D mucosal contour curvature. Lower sublingual bar gains rigidity from a tear-drop cross-section. Its upper border fits passively against attached, keratinised gingiva at least 3mm from the gingival margins for hygienic clearance [33].*
4. ***Retention*** *from 2 clasps placed strategically to form a clasp-axis. Here on diagonally opposite abutment teeth (UR3 & UL6 and LR7 and LL4).*
5. ***Anti-rotation*** *for preventing rotation around diagonal clasp-axis. Here by rest on UL3 and additional rest on LR3 and the full extension of the respective free-end saddles*
6. ***Reciprocation*** *components palatal/lingual design offer bracing of the clasped teeth during the deflection of the clasp in and out of the undercuts.*



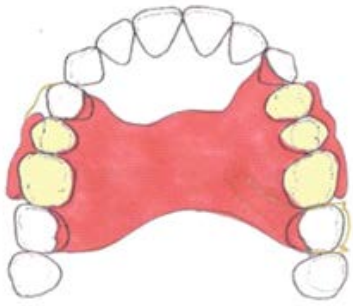
Hygienic Principles:

- Sometimes referred to as Scandinavian RPD design.
- Aimed at avoiding unnecessary coverage of gingival tissues. Where possible it is applicable to acrylic bases too.
- Ensure RPDs are easy to clean and maintain.
- Maintains clearance from gingival margins for all components (known as '3 mm rule')
- Design interproximal spaces for easy access and cleaning, balancing aesthetics, and hygiene.

Examples:

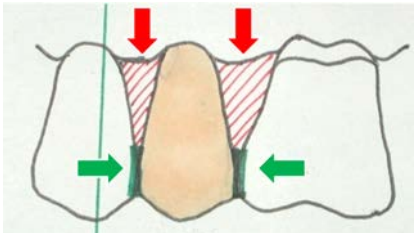


Major connector is designed to avoid unnecessary coverage of any gingival margins.



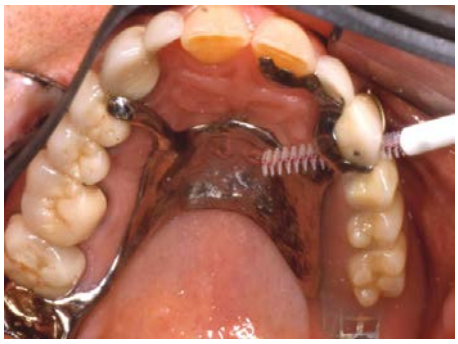
Schematic and clinical acrylic RPD examples with palatal support on the abutment teeth (base extended above abutment teeth survey lines) allowing other teeth to avoid unnecessary base coverage.

LL4+LL6 and UL4+UL6 denture teeth shaped as pontics, allowing full clearance of the proximal gingival margins apical to proximal contacts with adjacent natural teeth



Schematic example of an UL5 denture tooth pontic design with 3mm clearance apical to contact areas with adjacent natural teeth

Proximal gingival clearance can assist use of interdental brushes with RPD in situ, both for removal of food debris after meals and for removal of plaque on the often difficult to access proximal surfaces prior to removing RPD for general oral hygiene.

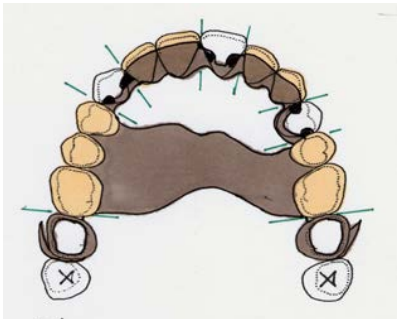


Palatal view of interdental brush inserted in hygienic space between abutment canine tooth and first premolar denture tooth

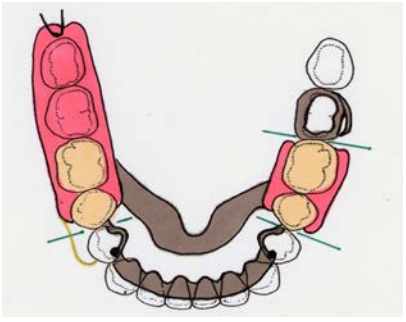
Additional Design Elements

- **Guide Surfaces:** Define the path of insertion and removal, providing a more secure fit.
- **Provision for Future Additions:** Design features that allow for the addition of teeth later.
- **Precision Attachments:** Offer retention without visible clasps, requiring careful planning.
- **Implant Abutments** Replacement of missing strategic tooth abutments in healthy and stable dentition[34,35] and contemporary alternative to precision attachments for support and retention.
- **Semi-Permanent Splints** Useful in compromised dentitions for tooth retention and distributing occlusal load.
- **Over-Denture Abutments:** Preserve strategic support, retention and proprioceptive feedback.
- **Note:** Strategically placed implants should aim to return a reduced dentition to a Kennedy Class III.

Examples:



In upper RPD, path-of-insertion defined by guide surfaces (green lines) allow clasps to be positioned more discreetly/out of sight on the posterior abutment teeth.



In lower RPD, custom attachments in LR4M and LL4M combined with guide surfaces defined the path of insertion and prevent distal movement of the free-end saddle.

Same patient, a single implant placed strategically lower right quadrant to provide a posterior abutment for improving RPD support and retention.

***Improvement:** Implant replacing missing UR3 provides strategic support and retention for long anterior RPD saddle.*

***Rescue:** Implant replacing recently removed LR6 as RPD abutment for restoring posterior support and retention in that quadrant for an existing lower RPD.*

***Forward planning:** Implants placed in both arches in anticipation of future failure/loss of long-serving tooth precision attachment abutments*

Preparation

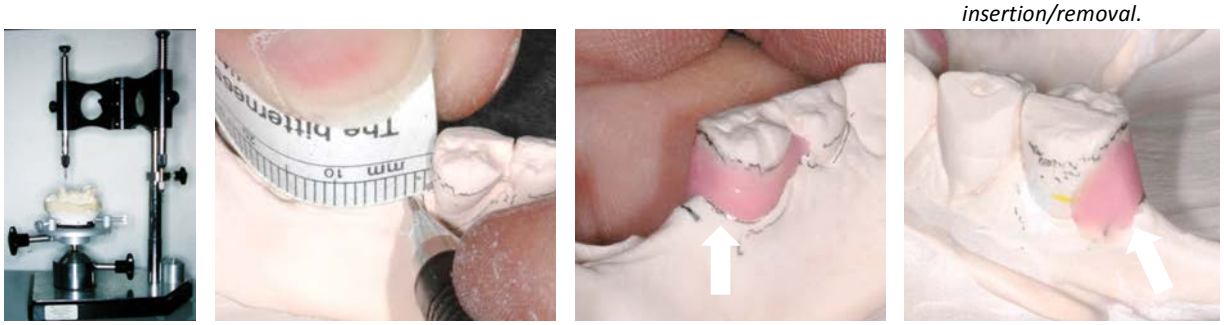
- The workflow stages would typically include:
  - Primary impressions for study casts/IO-scans for set-up and try-in of replacement of any missing anterior teeth and record of jaw relationship for articulation.
  - Preliminary design as basis for discussion with patient and dental technician.
  - Survey of casts/scans with technician input to confirm feasibility of design, determine the path of insertion and identify necessary tooth modifications.
  - Add or prepare rest seats and guide surfaces for optimal force transmission followed by master impression in special tray/master scan.
  - Request hygienic clearance on the master cast/scan and hand-finish of critical fitting surfaces of the cast/milled/printed metal framework for preserving accuracy.
  - Try-in of metal framework by itself or with tooth set-up in wax as appropriate.
  - Finish, fit and review

Examples:

A 2mm tall guide surface is usually adequate for defining RPD path-of insertion/removal.

Rest seats are needed to ensure axial transmission of load to and abutment tooth stability for preventing unwanted movement. The rest seats design should reflect this, and the preparation should allow adequate dimensions for strength of the rests and clearance of occlusion.

Composite rest seats added to lower incisors for providing RPD support and stability. The vertical aspect of the composite rests is aligned with the overall RPD path-of-insertion/removal.



In addition to surveying for confirming path-of-insertion and undercuts to be used for clasps and others to be blocked out, the hygienic gingival clearance requires additional blocking out as seen in the above three images. First 3mm is marked away from the gingival margin of the abutment tooth. Secondly, a triangular blocking-out is added, creating a slope apically from the future contact surface to the mark on the edentulous ridge.

Note: Composite rest seats added to sound enamel surfaces, using appropriate resin bonding technique are predictable and durable[22,24,36]

Maintenance

- Educate patients on daily maintenance and schedule regular professional follow-up, especially during the first year for assessment of adherence to compliance.
- Ensure dental hygienists/therapist are also checking and reinforcing oral hygiene of both tooth surfaces with RPD proximity as well as of the RPDs themselves.
- Assess RPDs at every patient visit, checking for continued satisfactory aesthetics, functions, signs of complications and need for update or repairs.

Examples:

Reinforce RPD specific oral hygiene including use of interdental brushes in proximal spaces for removal of food debris after meals and plaque prior to general tooth brushing.

Suggest both patient and dental hygienist/therapist undertake regular disclosure of RPD to assess presence and subsequent removal by patient of biofilm.

Artificial Intelligence aided denture design software tools are making their way into the market, which can help to both initiate and optimise design for RPDs. Design software programs are reported to still be limited and professional critique and review of any generated RPD designs also continue to apply. [37, 38]

Conclusion

RPDs remain a vital prosthodontic solution. Success depends on a systematic, patient-centered approach and a thorough understanding of effective design and incorporation of hygienic design principles. Each RPD – with cast framework or acrylic base - should be tailored to the individual, with ongoing assessment and maintenance to ensure long-term oral health.

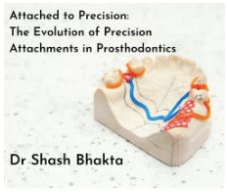
National guidelines for RPDs:

1. Standards in Dentistry – College of General Dentistry, Third Edition, CGDent 2025. 2.12 Removable Partial Dentures Page 28
2. Adult oral health survey 2021: self-reported health of teeth and gums - GOV.UK
3. Medical Devices Directive 2007, CL1993L0042EN0050010.0001.3bi_cp 1..1
   Article 1 Page 21: 'custom-made device'
4. SAC Classification in implant dentistry 2021, SAC Assessment Tool - Home - ITI
   Assess case complexity and identify modifying factors for use of implants in connection with removable partial dentures.

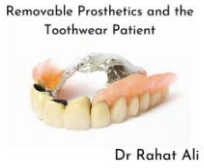
Links to BSSPD webinars on RPDs:

How to do Scandinavian RPD designs on demand webinar by Charlotte Stilwell
https://www.bsspd.org/CPD%20Movie.aspx?prodid=1029

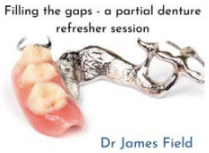
INSERT HERE Strategic use of implants for RPDs on demand webinar by Charlotte Stilwell



Attached to Precision: the evolution of precision attachments in prosthodontics webinar by Shash Bhakta
https://www.bsspd.org/CPD%20Movie.aspx?prodid=847



Removable Prosthetics and the Toothwear Patient by Mr Rahat Ali
https://www.bsspd.org/CPD%20Movie.aspx?prodid=602



Filling the gaps - a partial denture refresher session by Dr James Field
https://www.bsspd.org/CPD%20Movie.aspx?prodid=598

Links to EJPRD articles on RPD*s*:

Cambiaghi L, de Azevedo-Silva LJ, Campos Costa MS, da Silva Costa SM, de Almeida ALPF. Is Periodontal and Peri- Implant Disease Associated with Fixed Partial Denture Use? A 25-year Prospective Case Series. Eur J Prosthodont Restor Dent. 2024 Feb 29;32(1):56-64. doi: 10.1922/EJPRD_2542Cambiaghi09. PMID: 37721553.
https://www.ejprd.org/view.php?journal_id=145&article_id=1158&search_terms=partial%20dentures

Muehlemann E, Al-Haj Husain N, Özcan M. Patient Satisfaction and Accuracy of Partial Denture Frameworks Fabricated using Conventional and Digital Techniques. Eur J Prosthodont Restor Dent. 2024 Feb 29;32(1):65-74. doi: 10.1922/EJPRD_2554Muehlemann10. PMID: 37812515.
https://www.ejprd.org/view.php?journal_id=145&article_id=1144&search_terms=partial%20dentures

Al-Dwairi ZN, Taani DS, Naseeb AZ, Al-Haj Husain N, Özcan M, Lynch E. Evaluation of Clinical Periodontal Parameters of Abutment Teeth Supporting Distal-Extension Base Removable Partial Dentures: A Cross-sectional Study. Eur J Prosthodont Restor Dent. 2023 Nov 30;31(4):424-431. doi: 10.1922/EJPRD_2500AlDwairi09. PMID: 37318323.
https://www.ejprd.org/view.php?journal_id=144&article_id=1135&search_terms=partial%20dentures

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2. Adult oral health survey 2023 - GOV.UK
3. Steele JG, Treasure ET, O'Sullivan I, Morris J, Murray JJ. Adult Dental Health Survey 2009: transformations in British oral health 1968-2009. Br Dent J. 2012 Nov;213(10):523-7. doi: 10.1038/sj.bdj.2012.1067. PMID: 23175081.
4. Oral health survey of adults attending general dental practices 2018
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