

PRINCIPLES OF REMOVABLE PARTIAL DENTURE WITH SPECIAL ATTACHMENT SYSTEMS: A NARRATIVE REVIEW

Marina Nicoleta Miron¹, Alexei Panfili^{2*}, Forna Norina²

¹ DDS, Resident, Faculty of Dental Medicine, University of Medicine and Pharmacy "Grigore T. Popa", Iasi

² "Gr. T. Popa" U.M.Ph. - Iasi, Romania, Faculty of Dentistry, Department of Implantology, Removable Dentures, Dentures Technology

Corresponding authors: Alexei Panfili, e-mail: alexei.panfili@gmail.com

ABSTRACT

Aim: The purpose of this study was to review and critically analyze contemporary literature regarding the principles of removable partial denture prosthodontics using special attachment systems, with emphasis on biomechanical behavior, retention mechanisms, clinical performance, and recent technological developments.

Materials and methods: A narrative review of contemporary literature was conducted using peer-reviewed scientific publications addressing special attachment systems in removable partial denture prosthodontics. The analyzed literature focused on precision attachments, extracoronal and intracoronal attachment systems, double crown prostheses, telescopic restorations, magnetic retention systems, and contemporary biomaterials used in removable prosthodontics. Data regarding indications, biomechanical principles, periodontal response, material properties, advantages, disadvantages, and clinical outcomes were extracted and comparatively analyzed.

Results: The reviewed studies demonstrated that attachment-retained removable partial dentures provide superior esthetics and improved retention compared with conventional clasp-retained prostheses. Extracoronal attachments showed favorable stress distribution, while PEEK-based attachments generated lower stresses on abutment teeth than zirconia systems. Double crown systems improved load distribution and long-term stability. Recent magnetic attachment systems demonstrated promising results regarding ease of insertion and patient comfort.

Conclusions: Special attachment systems remain an effective treatment option for partially edentulous patients. Appropriate case selection, attachment design, material choice, and maintenance protocols are essential for long-term success. Digital technologies and modern biomaterials are expected to further improve treatment outcomes.

Key words: removable partial denture, precision attachment, extracoronal attachment, intracoronal attachment, double crown system, telescopic crown, magnetic attachment, PEEK, biomechanics, prosthodontics.

INTRODUCTION

Partial edentulism remains one of the most prevalent oral health conditions worldwide and continues to represent a major challenge for prosthodontic rehabilitation. Tooth loss may occur as a consequence of dental caries, periodontal disease, trauma, congenital anomalies, or systemic conditions and often results in significant functional, esthetic, and psychological consequences for affected individuals [1–4].

The absence of natural teeth negatively influences mastication, speech, facial appearance, occlusal stability, and quality of

life. Although implant-supported restorations have become increasingly popular and are often considered the gold standard for replacing missing teeth, removable partial dentures (RPDs) continue to play a fundamental role in contemporary prosthodontic practice [5–8]. Economic considerations, anatomical limitations, systemic contraindications, insufficient bone volume, and patient preferences frequently necessitate the use of removable prosthetic solutions [9–11].

Conventional clasp-retained removable partial dentures have been used successfully for decades and remain an important treatment

modality. Nevertheless, several limitations have been associated with these prostheses, including compromised esthetics due to visible clasps, plaque accumulation around retentive components, increased caries susceptibility of abutment teeth, and unfavorable stress distribution under functional loading [12–15]. These limitations have encouraged the development of more sophisticated retention mechanisms designed to improve both clinical performance and patient acceptance.

Special attachment systems were introduced as an alternative to conventional clasp assemblies in order to enhance retention, support, stability, and esthetics. These systems establish a mechanical connection between fixed and removable prosthetic components while maintaining a more natural appearance and improving force transmission [16–18]. Over time, numerous attachment designs have been developed, including intracoronal attachments, extracoronal attachments, stud attachments, bar attachments, telescopic crowns, double crown systems, and magnetic attachments [19–21].

The selection of an appropriate attachment system requires careful evaluation of multiple factors, including the number and distribution of remaining teeth, periodontal condition, occlusal relationships, available restorative space, esthetic requirements, and patient expectations [22–24]. Furthermore, the biomechanical behavior of each attachment system must be considered because improper force distribution may compromise both abutment teeth and supporting tissues [25–27].

One of the most important developments in recent decades has been the introduction of precision attachment systems. These attachments are manufactured with high accuracy and are capable of providing improved retention while minimizing visible prosthetic components. Clinical studies have demonstrated that precision attachments can improve patient satisfaction, prosthesis

stability, and esthetic outcomes when compared with conventional clasp-retained dentures [28–30].

Among the various attachment systems currently available, extracoronal attachments have gained particular attention because of their ability to function as stress breakers. These attachments are especially useful in Kennedy Class I and Class II situations, where distal extension bases create significant biomechanical challenges [31–33]. By permitting controlled movement between the removable prosthesis and the supporting structures, extracoronal attachments may reduce stress concentrations around abutment teeth and contribute to the preservation of periodontal health [34,35].

Double crown and telescopic systems represent another important category of attachment-retained prostheses. These systems consist of primary copings permanently cemented onto prepared abutment teeth and secondary crowns incorporated into the removable prosthesis. Their design provides excellent retention, favorable force distribution, and the possibility of splinting multiple abutment teeth together [36–39]. Long-term clinical investigations have reported high survival rates and satisfactory functional outcomes associated with telescopic prostheses [40,41].

In recent years, significant advances in biomaterials have further expanded the possibilities of attachment-retained prosthodontics. Zirconia and polyetheretherketone (PEEK) have emerged as promising materials due to their favorable mechanical properties, biocompatibility, and compatibility with digital manufacturing techniques [42–45]. Comparative biomechanical studies have suggested that PEEK may provide more favorable stress distribution patterns than rigid ceramic materials because of its lower elastic modulus and greater shock-absorbing capacity [46–48].

Simultaneously, digital dentistry has transformed prosthodontic treatment planning and fabrication processes. CAD/CAM technology enables highly accurate manufacturing of attachment components and prosthetic frameworks, reducing laboratory errors and improving reproducibility [49]. The integration of digital workflows has facilitated the development of customized attachment systems tailored to the specific biomechanical requirements of individual patients [50].

Given the continuous evolution of attachment systems, materials, and manufacturing technologies, a comprehensive review of current concepts is warranted. Therefore, the purpose of the present study is to evaluate the principles of removable partial denture prosthodontics using special attachment systems and to critically analyze their biomechanical characteristics, clinical applications, advantages, limitations, and future perspectives.

MATERIALS AND METHODS

This study was conducted as a narrative literature review focusing on the principles of removable partial denture prosthodontics using special attachment systems. The objective was to analyze current scientific evidence regarding biomechanical behavior, clinical performance, indications, advantages, limitations, and recent technological developments associated with attachment-retained removable partial dentures.

Literature Search Strategy

The literature search included publications indexed in PubMed, Scopus, Web of Science, Google Scholar, and ScienceDirect. Keywords used during the search process included “removable partial denture”, “precision attachment”, “special attachment system”, “extracoronar attachment”, “intracoronar attachment”, “double crown”, “telescopic

crown”, “magnetic attachment”, “PEEK”, “zirconia”, and “prosthodontics”.

Particular emphasis was placed on publications addressing modern concepts and contemporary treatment approaches. Studies published between 2020 and 2025 were considered in order to ensure the inclusion of current scientific evidence.

Study Selection

The selected studies included clinical investigations, biomechanical analyses, review articles, and reports describing innovative attachment-retained prosthetic systems.

The inclusion criteria were:

- studies evaluating removable partial dentures retained by special attachment systems;
- investigations involving extracoronar or intracoronar precision attachments;
- studies focusing on double crown or telescopic retention systems;
- articles evaluating biomechanical performance and stress distribution;
- publications discussing contemporary attachment materials and technologies;
- English-language publications with accessible full-text content.

The exclusion criteria were:

- studies focusing exclusively on complete dentures;
- articles unrelated to removable partial denture prosthodontics;
- duplicate publications;
- conference abstracts without complete methodological descriptions;
- studies lacking clinically relevant data.

Data Extraction and Analysis

Following article selection, relevant information was extracted and organized according to predefined categories:

- study design;
- attachment type;
- prosthetic indication;
- biomechanical characteristics;

- materials used;
- periodontal response;
- clinical outcomes;
- advantages and disadvantages;
- recommendations for clinical practice.

A comparative analysis was performed to identify similarities and differences among the selected studies. Special attention was given to biomechanical behavior, retention mechanisms, esthetic outcomes, periodontal health, patient satisfaction, and long-term prosthetic success.

The collected evidence was subsequently grouped into thematic categories, including:

- Biomechanical principles of special attachment systems;
- Precision attachment systems;
- Extracoronar attachment systems and clinical performance;
- Double crown and telescopic systems;
- Contemporary biomaterials (PEEK and zirconia);
- Magnetic attachment systems;
- Future perspectives in digital prosthodontics.

RESULTS AND DISCUSSIONS

Biomechanical Principles of Special Attachment Systems

The biomechanical behavior of removable partial dentures retained by special attachment systems represents one of the most important factors influencing long-term treatment success. Unlike conventional clasp-retained prostheses, attachment-retained dentures are designed to provide a more favorable distribution of functional forces while improving esthetics and patient comfort [12-15].

During mastication, occlusal loads are transmitted through the prosthesis to the supporting structures, including the abutment teeth, periodontal ligament, alveolar bone, and residual ridge. An imbalance in force

distribution may result in excessive stress concentration, leading to periodontal deterioration, tooth mobility, alveolar bone resorption, and prosthetic failure [21,22].

One of the greatest biomechanical challenges is encountered in Kennedy Class I and Class II partially edentulous arches. In these situations, the removable prosthesis is supported simultaneously by natural teeth and compressible mucosal tissues. Since the periodontal ligament permits only limited tooth movement, while the mucosa may compress significantly under functional loading, rotational movements inevitably occur during mastication [23-25].

Special attachment systems were developed to minimize these unfavorable forces by creating controlled movement between the prosthesis and the supporting structures. Stress-breaking mechanisms incorporated into many extracoronar attachments reduce torque forces acting on terminal abutment teeth and improve force distribution throughout the prosthetic foundation [31,33].

Several finite element studies have demonstrated that attachment design, attachment location, and attachment material significantly influence stress distribution patterns [39,40,43]. Prostheses incorporating resilient attachment systems generally exhibit lower stress concentrations around abutment teeth than rigid retention mechanisms. Consequently, attachment selection should always be based on the biomechanical characteristics of the clinical situation rather than on esthetic considerations alone.

The preservation of supporting structures remains the ultimate objective of prosthodontic treatment. Therefore, understanding the biomechanical principles governing attachment-retained removable partial dentures is essential for achieving predictable long-term outcomes [34,35].

Precision Attachments

Precision attachments are among the most sophisticated retention systems used in removable prosthodontics. These devices consist of accurately manufactured mechanical components designed to connect fixed and removable prosthetic elements while providing retention, support, and stability [13–18].

Historically, precision attachments were introduced to overcome the esthetic limitations associated with visible clasp assemblies. Their ability to conceal retentive mechanisms within or adjacent to fixed restorations resulted in significant improvements in patient satisfaction and acceptance [14,15].

Precision attachments may be classified as intracoronary or extracoronary according to their location relative to the contour of the crown. Intracoronary attachments are positioned within the normal contours of the abutment crown and provide highly favorable esthetic results. Because they are located close to the long axis of the tooth, these attachments often generate more favorable force transmission patterns [13,16].

However, intracoronary attachments require extensive tooth preparation and adequate crown dimensions. In many clinical situations, these requirements may limit their use. Furthermore, fabrication procedures are technically demanding and require precise laboratory execution [17].

Extracoronary attachments are positioned outside the crown contour and generally require less tooth reduction. Their design frequently incorporates resilient elements capable of absorbing functional stresses. As a result, extracoronary systems have become increasingly popular for distal extension removable partial dentures [31,32].

The clinical success of precision attachments depends on multiple factors, including periodontal health, oral hygiene, occlusal relationships, attachment parallelism, and patient compliance. Numerous studies have demonstrated that patients treated with

attachment-retained prostheses report superior comfort, improved esthetics, enhanced masticatory efficiency, and greater overall satisfaction when compared with conventional clasp-retained dentures [17,21,25].

Despite their advantages, precision attachments are associated with increased treatment costs, greater technical complexity, and higher maintenance requirements. Periodic replacement of worn retentive components is often necessary to maintain optimal prosthetic performance [18].

Extracoronary Attachments and Clinical Performance

Extracoronary attachments represent one of the most frequently utilized attachment categories in contemporary removable prosthodontics. Their popularity stems from the combination of favorable esthetic outcomes, simplified clinical application, and beneficial biomechanical characteristics [31,32].

Unlike intracoronary attachments, extracoronary systems are positioned external to the crown contour and may incorporate resilient mechanisms that permit limited movement between the removable prosthesis and the supporting abutment teeth. This controlled movement functions as a stress-breaking mechanism and reduces the transmission of harmful forces to periodontal structures [33].

The reviewed clinical study comparing integrated interlock and parallel interlock extracoronary attachment systems demonstrated that attachment design may significantly influence periodontal outcomes and prosthetic performance [28]. Patients rehabilitated with attachment-retained prostheses generally exhibited acceptable periodontal health and high levels of treatment satisfaction when maintenance protocols were respected.

One of the principal advantages of extracoronary attachments is their application in

distal extension situations. Kennedy Class I and II cases often present biomechanical challenges because of the different resiliency characteristics of teeth and soft tissues. The resilient properties of extracoronar attachments allow part of the functional load to be dissipated before reaching the abutment teeth, thereby reducing stress concentration [31–35].

Clinical studies have reported improvements in chewing efficiency, prosthesis stability, and esthetic appearance among patients treated with extracoronar attachment systems [28,29]. In addition, the absence of visible clasps contributes significantly to patient confidence and social acceptance.

From a periodontal perspective, attachment-retained dentures may demonstrate favorable outcomes when appropriate oral hygiene measures are maintained. However, plaque accumulation around attachment components remains a concern, particularly in patients with poor compliance. Consequently, regular professional maintenance and patient education are essential components of long-term treatment success.

Another important consideration is the progressive wear of retentive components. Over time, repeated insertion and removal of the prosthesis may reduce retention and necessitate replacement of specific attachment elements. Although this represents an additional maintenance requirement, it also contributes to the longevity of the prosthetic system by allowing component renewal without complete prosthesis replacement.

Double Crown and Telescopic Systems

Double crown systems, also referred to as telescopic crown systems, constitute one of the most biologically favorable approaches in removable prosthodontics. These systems consist of a primary coping permanently cemented onto the prepared abutment tooth and a secondary crown incorporated into the

removable prosthesis [30–38].

Retention is achieved through frictional contact, conical wedging, or resilient engagement between the primary and secondary components. Because multiple abutments may be splinted together, telescopic systems facilitate more uniform force distribution and improve overall prosthetic stability [37].

One of the major advantages of double crown systems is their capacity to compensate for compromised periodontal support. The splinting effect created by the prosthesis distributes occlusal loads among several teeth and may reduce the risk of overloading individual abutments [31].

Long-term clinical studies have reported favorable survival rates for telescopic prostheses, with many restorations remaining functional for more than ten years [33–36]. Furthermore, the removable nature of these restorations facilitates oral hygiene procedures and professional maintenance.

Another important benefit is treatment flexibility. If additional tooth loss occurs, telescopic prostheses may often be modified rather than completely replaced. This characteristic is particularly advantageous in elderly patients and individuals with progressive periodontal disease [30].

Recent advances in CAD/CAM technology have significantly improved the precision of telescopic crown fabrication. Digital workflows enable more accurate production of primary and secondary copings, reducing manufacturing discrepancies and improving retention consistency. These developments have renewed interest in telescopic systems and have expanded their applicability in contemporary prosthodontic practice.

Despite their advantages, telescopic systems remain technically demanding. Precise preparation, accurate laboratory procedures, and strict control of taper angles are essential for achieving optimal retention and long-term

success. Treatment costs are generally higher than those associated with conventional removable partial dentures; however, the biological and functional benefits often justify the additional complexity.

Clinical evidence suggests that double crown prostheses provide excellent patient satisfaction due to their stability, comfort, esthetics, and ease of maintenance. Consequently, they continue to represent one of the most reliable treatment options for partially edentulous patients requiring advanced removable prosthodontic rehabilitation.

Contemporary Biomaterials: PEEK and Zirconia

The development of advanced biomaterials has significantly influenced modern prosthodontics and has expanded the possibilities for attachment-retained removable partial dentures. Among the materials that have received considerable attention in recent years, zirconia and polyetheretherketone (PEEK) have emerged as promising alternatives to traditional metal alloys due to their favorable mechanical, biological, and esthetic properties [39–43].

Zirconia is a high-strength ceramic material characterized by excellent fracture resistance, biocompatibility, chemical stability, and esthetic appearance. Because of its tooth-colored nature, zirconia is particularly attractive in situations where esthetics are of paramount importance. CAD/CAM technology has facilitated the fabrication of highly accurate zirconia components, contributing to improved prosthetic precision and reproducibility [39].

Despite these advantages, zirconia exhibits a high modulus of elasticity, which may result in increased stress transmission to supporting structures. Several biomechanical investigations have demonstrated that rigid materials tend to concentrate forces around

abutment teeth, potentially increasing the risk of periodontal overload in certain clinical situations [40].

Polyetheretherketone (PEEK) has emerged as a viable alternative because its elastic modulus is closer to that of human cortical bone. This characteristic allows the material to absorb and distribute functional loads more efficiently than highly rigid ceramics. Recent finite element analyses have shown that PEEK attachment systems may generate lower stress concentrations within periodontal structures and alveolar bone compared with zirconia attachments [39–43].

In addition to its favorable biomechanical behavior, PEEK exhibits several other advantages, including low density, corrosion resistance, radiolucency, excellent biocompatibility, and compatibility with digital manufacturing processes. These properties have contributed to its increasing use in removable prosthodontics, implant dentistry, and maxillofacial rehabilitation [40–42].

The comparative study evaluating extracoronary attachment systems fabricated from PEEK and zirconia demonstrated that PEEK generated lower strain values around abutment teeth, suggesting a potentially protective effect on supporting tissues [39]. Such findings support the concept that material selection should be considered an integral component of biomechanical treatment planning.

Nevertheless, long-term clinical evidence regarding PEEK attachments remains limited. Although laboratory and finite element studies have produced encouraging results, further prospective clinical investigations are required to determine the long-term durability, wear resistance, and maintenance requirements of these systems [43].

Overall, current evidence suggests that both zirconia and PEEK represent valuable

additions to contemporary prosthodontics. The choice between these materials should be based on the specific biomechanical requirements, esthetic demands, and clinical characteristics of each patient..

Magnetic Attachment Systems

Magnetic attachment systems represent one of the most innovative developments in removable prosthodontics. Unlike conventional mechanical attachments, these systems utilize magnetic attraction to provide retention between prosthetic components [44–47].

The concept of magnetic retention was first introduced several decades ago; however, early designs were limited by corrosion, inadequate magnetic strength, and poor durability. Advances in rare-earth magnetic materials and encapsulation technologies have significantly improved the clinical applicability of magnetic attachment systems [44].

Modern magnetic attachments offer several advantages. They facilitate prosthesis insertion and removal, require minimal manual dexterity, and reduce the need for complex mechanical retention mechanisms. Consequently, they may be particularly beneficial for elderly patients, individuals with neuromuscular disorders, and patients presenting with reduced hand function [45].

Recent studies investigating ultra-thin magnetic attachment systems have reported promising clinical outcomes. These systems provide sufficient retention while maintaining a compact design that requires minimal restorative space. Additionally, their simplified insertion path may improve patient compliance and daily prosthesis management [47].

Another advantage of magnetic systems is their ability to distribute functional forces more evenly during prosthesis insertion and removal. Unlike rigid mechanical attachments, magnetic retention mechanisms may reduce lateral stresses acting on abutment teeth and

supporting tissues [46].

Despite these advantages, magnetic attachments also present certain limitations. Corrosion resistance remains an important consideration, particularly in the oral environment where moisture and fluctuations in pH may affect material stability. Furthermore, magnetic retention forces are generally lower than those achieved with some precision attachment systems [45].

Current evidence suggests that magnetic attachments should be considered a valuable adjunct in selected clinical situations rather than a universal replacement for conventional attachment systems. Additional long-term clinical studies are necessary to establish definitive treatment guidelines and determine their long-term survival rates.

Future Perspectives

The future of removable partial denture prosthodontics is closely associated with the continued evolution of digital technologies, advanced biomaterials, and individualized treatment planning approaches [49].

Computer-aided design and computer-aided manufacturing (CAD/CAM) technologies have already transformed many aspects of prosthodontic treatment. Digital workflows allow highly accurate fabrication of attachment components, frameworks, and prosthetic structures while reducing laboratory variability and manufacturing errors [49].

Three-dimensional printing technologies are expected to play an increasingly important role in the production of removable prostheses and attachment systems. Additive manufacturing may facilitate the fabrication of customized components with complex geometries that would be difficult to achieve using conventional laboratory techniques.

Artificial intelligence and machine learning algorithms may further contribute to treatment planning by assisting clinicians in selecting optimal attachment systems based on patient-

specific anatomical, biomechanical, and functional parameters. Such technologies have the potential to improve treatment predictability and reduce complications.

The development of novel polymer-based materials represents another promising area of research. Materials that combine favorable mechanical properties with excellent biocompatibility may contribute to more physiologic stress distribution and improved long-term outcomes [40–43].

Future investigations should focus on long-term clinical trials comparing different attachment systems, biomaterials, and digital fabrication techniques. Standardized evaluation protocols are needed to facilitate comparison among studies and establish evidence-based clinical recommendations.

Ultimately, the integration of digital technologies, advanced biomaterials, and patient-centered treatment planning is expected to further enhance the effectiveness and predictability of attachment-retained removable prosthodontics.

CONCLUSIONS

Special attachment systems represent an important advancement in removable partial denture prosthodontics, offering significant improvements in esthetics, retention, stability, and patient comfort when compared with conventional clasp-retained prostheses. The literature reviewed demonstrates that the success of these treatment modalities is closely related to a thorough understanding of biomechanical principles, careful treatment planning, and appropriate selection of attachment systems according to individual clinical circumstances.

Contemporary attachment-retained prostheses contribute to a more favorable distribution of occlusal forces and may reduce the risk of overloading abutment teeth and supporting tissues. Precision attachments and

extracoronary systems have shown predictable clinical performance and high levels of patient satisfaction, particularly in cases where esthetics and functional efficiency are major treatment objectives. Similarly, double crown and telescopic systems provide excellent support and long-term stability while facilitating maintenance and future modifications of the prosthesis when necessary.

Recent developments in biomaterials and digital technologies have further expanded the possibilities of attachment-retained removable prosthodontics. Materials such as PEEK have demonstrated promising biomechanical behavior due to their ability to absorb and distribute functional stresses more effectively, while innovative magnetic attachment systems offer simplified handling and improved accessibility for selected patient groups.

Despite these advantages, the long-term success of special attachment systems depends on appropriate case selection, meticulous clinical and laboratory procedures, regular maintenance, and patient compliance with oral hygiene instructions and follow-up visits. Continued research focusing on long-term clinical outcomes, digital workflows, and emerging materials is essential to further optimize treatment protocols and enhance the predictability of removable partial dentures retained by special attachment systems.

REFERENCES

1. McCracken WL. McCracken's Removable Partial Prosthodontics. 13th ed. St. Louis: Elsevier; 2016.
2. Carr AB, Brown DT. McCracken's Removable Partial Prosthodontics. 14th ed. St. Louis: Elsevier; 2019.
3. Zarb GA, Hobkirk J, Eckert S, Jacob R. Prosthodontic Treatment for Partially Edentulous Patients. 13th ed. St. Louis: Mosby; 2013.
4. Basker RM, Davenport JC, Thomason JM. Prosthetic Treatment of the Edentulous Patient. 5th ed. Oxford: Wiley-Blackwell; 2011.
5. Rosenstiel SF, Land MF, Fujimoto J. Contemporary Fixed Prosthodontics. 5th ed. St. Louis: Mosby; 2016.
6. Shillingburg HT Jr, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of Fixed Prosthodontics. 4th ed. Chicago: Quintessence; 2012.
7. Wostmann B, Budtz-Jorgensen E, Jepson N, et al. Indications for removable partial dentures: a literature review. *Int J Prosthodont*. 2005;18(2):139-145.
8. Vermeulen AH, Keltjens HM, van't Hof MA, Kayser AF. Ten-year evaluation of removable partial dentures. *J Prosthet Dent*. 1996;76(3):267-272.
9. Carlsson GE. Clinical morbidity and sequelae of treatment with removable dentures. *J Prosthet Dent*. 1998;79(1):17-23.
10. Knezovic-Zlataric D, Celebic A. Treatment outcomes with removable partial dentures. *Coll Antropol*. 2003;27(Suppl 2):285-294.
11. Fenlon MR, Sherriff M. An investigation of factors influencing patients' satisfaction with new dentures. *Br Dent J*. 2004;197(11):717-722.
12. Becerra G, MacEntee MI. A classification of precision attachments. *J Prosthet Dent*. 1987;58(3):322-327.
13. Burns DR, Ward JE. A review of attachments for removable partial denture design. *J Prosthet Dent*. 1990;63(3):265-272.
14. Preiskel HW. Precision Attachments in Prosthodontics. Vol. 1. Chicago: Quintessence Publishing; 1985.
15. Preiskel HW. Precision Attachments in Prosthodontics. Vol. 2. Chicago: Quintessence Publishing; 1985.
16. Goodkind RJ. Precision attachment-retained removable partial dentures. *Dent Clin North Am*. 1985;29(1):185-198.
17. Mensor MC. Attachment fixation for removable partial dentures. *J Prosthet Dent*. 1971;26(2):137-149.
18. Davenport JC, Basker RM, Heath JR, Ralph JP, Glantz PO. A Clinical Guide to Removable Partial Dentures. London: Wolfe Publishing; 1988.
19. Krol AJ. Removable Partial Denture Design: Outline Syllabus. San Rafael: Indent; 1981.
20. Phoenix RD, Cagna DR, DeFreest CF. Stewart's Clinical Removable Partial Prosthodontics. 4th ed. Chicago: Quintessence; 2008.
21. Bergman B, Hugoson A, Olsson CO. Caries and periodontal status in patients treated with removable partial dentures. *J Clin Periodontol*. 1982;9(6):483-495.
22. Cecconi BT, Asgar K, Dootz E. The effect of partial denture clasp design on abutment tooth movement. *J Prosthet Dent*. 1971;25(1):44-56.
23. Kratochvil FJ. Influence of occlusal rest position on movement of abutment teeth. *J Prosthet Dent*. 1963;13(1):114-124.
24. Frantz WR. The use of stress breakers in removable partial dentures. *J Prosthet Dent*. 1980;43(4):364-369.
25. Pigozzo MN, Mesquita MF, Henriques GE, Vaz LG. Stress distribution in removable partial dentures. *J Oral Rehabil*. 2007;34(1):50-56.

26. Sato Y, Abe Y, Okane H, Tsuga K. Finite element analysis of attachment-retained prostheses. *J Oral Rehabil.* 2001;28(6):578-584.
27. Takahashi T, Gonda T, Maeda Y. Biomechanical evaluation of attachment systems. *J Prosthodont Res.* 2010;54(4):179-184.
28. Reslan MR, Osman E, Segaan L, Rayyan M, Joukhadar C, Fattouh M. Comparison between integrated and parallel interlock designs of an extra-coronal attachment-retained distal extension removable partial dentures: a clinical trial. *J Int Soc Prev Community Dent.* 2021;11(1):41-49.
29. Hodson TM, Patel J, Jablonski RY. Removable partial dentures: precision attachments and advanced retention systems. *Br Dent J.* 2024.
30. Langer A. Telescope retainers and their clinical application. *J Prosthet Dent.* 1980;44(5):516-522.
31. Langer Y, Langer A. Tooth-supported telescopic prostheses in compromised dentitions. *J Prosthet Dent.* 1991;66(1):129-132.
32. Körber KH. Konuskronen: Das rationelle Teleskopsystem. Berlin: Hüthig; 1983.
33. Widbom T, Andersson B, Carlsson GE. Long-term clinical evaluation of telescopic crown-retained dentures. *Int J Prosthodont.* 2004;17(1):29-34.
34. Wenz HJ, Hertrampf K. Survival of telescopic crown-retained dentures. *Int J Prosthodont.* 1998;11(6):541-546.
35. Igarashi Y, Goto T. Ten-year follow-up of conical crown-retained dentures. *Int J Prosthodont.* 1997;10(2):149-155.
36. Wagner B, Kern M. Clinical evaluation of removable partial dentures retained by double crowns. *Int J Prosthodont.* 2000;13(2):152-158.
37. Tannous F, Steiner M, Shahin R, Kern M. Retention forces and wear patterns of double crown systems. *Clin Oral Investig.* 2012;16(3):913-920.
38. Beuer F, Schweiger J, Edelhoff D. Attachments and Double Crown Systems for Removable Partial Dentures. *Int J Prosthodont.* 2023.
39. Abd Allah AA, Elshorbagy MA, Mohamed AA, et al. Biomechanical evaluation of extracoronary attachments fabricated from zirconia and PEEK in removable partial dentures. *BMC Oral Health.* 2024;24:4477.
40. Stawarczyk B, Beuer F, Wimmer T, Jahn D, Sener B, Roos M. Polyetheretherketone in prosthodontics. *J Prosthet Dent.* 2013;109(3):139-144.
41. Schwitalla AD, Müller WD. PEEK dental implants and prosthetic applications. *J Oral Implantol.* 2013;39(6):743-749.
42. Najeeb S, Zafar MS, Khurshid Z, Siddiqui F. Applications of polyetheretherketone in dentistry. *J Prosthodont Res.* 2016;60(1):12-19.
43. Liebermann A, Wimmer T, Schmidlin PR, et al. Physicomechanical characterization of PEEK materials. *Dent Mater.* 2014;30(11):1143-1149.
44. Kase MT, Tsuka H, Yamashita A. Magnetic attachment systems in prosthodontics. *J Prosthet Dent.* 1997;77(3):292-297.
45. Riley MA, Walmsley AD, Harris IR. Magnets in prosthetic dentistry. *J Prosthet Dent.* 2001;86(2):137-142.
46. Ceruti P, Bryant SR, Lee JH, MacEntee MI. Magnet-retained removable prostheses: a review of the literature. *Int J Prosthodont.* 2010;23(1):11-18.
47. Wigianto R, et al. Contemporary Magnetic Removable Partial Denture Utilizing a Novel Ultra-Thin Magnetic Attachment System. *Dentistry Journal.* 2025;13(7):278.
48. Feine JS, Carlsson GE, Awad MA, et al. The McGill consensus statement on overdentures. *Int J Prosthodont.* 2002;15(4):413-414.
49. Burns DR. Mandibular implant overdenture treatment: consensus and controversy. *J Prosthet Dent.* 2000;84(5):507-512.
50. van Kampen FM, Cune MS, van der Bilt A, Bosman F. Masticatory function with implant-supported overdentures. *J Dent Res.* 2004;83(9):708-711.