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PRESERVING PERIODONTALLY COMPROMISED ABUTMENT TEETH: BIOLOGICAL AND BIOMECHANICAL CONSIDERATIONS FOR STRESS-RELEASING CLASP SELECTION IN DISTAL EXTENSION REMOVABLE PARTIAL DENTURES

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ABSTRACT

The preservation of periodontally compromised teeth has become a central objective in contemporary prosthodontic rehabilitation. Owing to advances in periodontal therapy, many teeth with reduced periodontal support can now be successfully maintained and incorporated into removable partial denture (RPD) treatment. Nevertheless, periodontal attachment loss, increased tooth mobility, and altered stress distribution may compromise the long-term prognosis of abutment teeth, particularly in distal extension situations. This narrative review evaluates the biological characteristics of periodontally compromised abutment teeth and examines the biomechanical principles underlying stress-releasing clasp designs in removable partial denture therapy. Special emphasis is placed on the biomechanical challenges associated with distal extension RPDs and on the role of wrought-wire clasps, Rest–Proximal Plate–I-bar (RPI) systems, and Rest–Proximal Plate–Akers (RPA) systems in controlling force transmission to the supporting dentition. The reviewed literature indicates that stress-releasing clasp assemblies may reduce torque, lateral loading, and stress concentration around terminal abutments by allowing controlled disengagement of retentive components during functional loading. Such biomechanical behavior appears particularly advantageous in patients with compromised periodontal support, where excessive forces may accelerate attachment loss and tooth mobility. However, prosthetic design alone cannot ensure favorable outcomes, as long-term success remains dependent on periodontal stability, effective plaque control, and regular maintenance care. Stress-releasing clasp designs should therefore be considered an important component of the interdisciplinary management of partially edentulous patients with a history of periodontitis. Emerging digital workflows, finite element analysis, and personalized prosthodontic approaches may further improve abutment preservation and optimize future RPD design.

Key words: removable partial denture, periodontal disease, stress-releasing clasp, RPI system, RPA system, wrought-wire clasp, distal extension denture

INTRODUCTION

The preservation of natural teeth has become a primary objective in contemporary dentistry, particularly in patients affected by periodontal disease. Advances in periodontal therapy have significantly improved the long-term prognosis of compromised dentitions, allowing many patients to retain teeth that would previously have been considered hopeless. Nevertheless, periodontal disease remains one of the leading causes of tooth loss worldwide, frequently resulting in partial edentulism and the need for prosthetic rehabilitation [1]. In these situations, treatment planning must focus not only on replacing missing teeth but also on maintaining the health and function of the remaining dentition [2,3].

Removable partial dentures (RPDs) continue to represent a valuable treatment option for partially edentulous patients due to their affordability, versatility, and ability to restore mastication, phonetics, and esthetics. Despite the increasing use of implant-

supported restorations, RPDs remain widely indicated, especially in patients with extensive tooth loss, systemic limitations, or financial constraints. Recent evidence has demonstrated satisfactory patient-reported outcomes and functional improvements following RPD therapy when appropriate prosthetic design and maintenance protocols are implemented. As a result, removable partial dentures continue to play an important role in the rehabilitation of periodontally compromised patients [1,4].

The use of periodontally compromised teeth as abutments presents unique biological and biomechanical challenges. Loss of periodontal attachment and alveolar bone support alters the ability of the periodontal tissues to withstand and distribute occlusal forces, often leading to increased tooth mobility and modified stress patterns. These changes may affect the long-term prognosis of abutment teeth and increase their susceptibility to mechanical and periodontal complications. Consequently, a thorough understanding of the relationship between prosthetic loading and periodontal support is essential when planning removable prosthodontic treatment [5].

Among the various components of removable partial dentures, clasp assemblies play a fundamental role in determining the magnitude and direction of forces transmitted to abutment teeth. The design of direct retainers influences not only denture retention and stability but also the distribution of functional loads within the supporting structures. For patients with reduced periodontal support, stress-releasing clasp designs have been proposed as a means of minimizing harmful forces and preserving the remaining periodontal tissues. Therefore, the aim of this review is to analyze the role of stress-releasing clasp designs in the preservation of periodontally compromised abutment teeth and to discuss their biological rationale, biomechanical behavior, and clinical implications [6].

LITERATURE REVIEW

► Biological Characteristics of Periodontally Compromised Abutment Teeth

Periodontally compromised teeth are frequently encountered in contemporary prosthodontic practice due to the increasing success of periodontal therapies aimed at preserving the natural dentition. Although periodontal disease remains a major cause of tooth loss, advances in diagnosis, treatment, and maintenance have improved the long-term survival of many compromised teeth, allowing them to serve as potential abutments for prosthetic rehabilitation [7]. As a result, clinicians are increasingly required to evaluate teeth with reduced periodontal support and determine their suitability for removable partial denture therapy [8]. This decision requires a thorough understanding of the biological changes associated with periodontal breakdown and their potential influence on prosthetic outcomes [9].

One of the most significant consequences of periodontal attachment loss is increased tooth mobility. The reduction of periodontal ligament support and alveolar bone height diminishes the capacity of the supporting tissues to absorb and distribute functional forces, resulting in altered tooth movement under loading conditions. Mobility may be further influenced by inflammation, occlusal trauma, and the extent of periodontal destruction [10]. Recent evidence suggests that increased tooth mobility is associated with a less favorable long-term prognosis and may represent an important risk factor for future tooth loss. Consequently, mobility assessment remains a critical component in the evaluation of abutment teeth intended for removable partial denture support [11,12].

Periodontal attachment loss is also accompanied by structural changes that affect the mechanical behavior of the tooth, including alterations in crown-root ratio and reductions in the amount of supporting alveolar bone. As periodontal support decreases, the tooth becomes more susceptible to leverage forces and stress concentration during function. Furthermore, residual periodontal pockets and persistent

inflammatory activity may continue to compromise periodontal stability even after active treatment has been completed [13]. These biological alterations not only influence the prognosis of abutment teeth but also modify the manner in which functional loads are transmitted to the supporting structures during removable partial denture function. Consequently, understanding the biomechanical challenges associated with periodontally compromised abutments is essential for appropriate prosthodontic design and long-term treatment success [14,15].

► Biomechanical Challenges in Distal Extension Removable Partial Dentures

Distal extension removable partial dentures represent one of the most challenging clinical situations in removable prosthodontics due to the absence of posterior tooth support. In Kennedy Class I and Class II edentulous arches, the prosthesis is supported simultaneously by the residual ridge and the remaining dentition. Because the periodontal ligament and the mucosa exhibit different levels of resiliency under functional loading, the denture base tends to undergo displacement during mastication [16]. This unequal support creates a complex biomechanical environment in which functional forces are distributed between the edentulous ridge and the terminal abutment teeth [17,18].

As the denture base moves toward the edentulous ridge during function, rotational movements may occur around the terminal abutments [19]. These movements generate a combination of vertical, horizontal, and torsional forces that can increase stress concentration within the supporting periodontal structures. The resulting torque may be particularly detrimental in patients with reduced periodontal support, where the ability of the periodontium to absorb and dissipate functional loads is already compromised. Consequently, excessive loading of terminal abutment teeth has long been considered one of the principal biomechanical concerns associated with distal extension removable partial dentures [20,21].

Numerous experimental and finite element studies have demonstrated that prosthetic design can significantly influence stress distribution within distal extension prostheses. Factors such as support configuration, retainer design, reciprocation, and denture base extension may affect the magnitude and direction of forces transmitted to the abutment teeth. Therefore, successful treatment depends not only on achieving adequate retention and stability but also on minimizing harmful leverage forces that could accelerate periodontal breakdown. These biomechanical considerations have led to the development of retention systems specifically designed to reduce torque and improve force distribution, particularly in situations involving periodontally compromised abutment teeth [19,21].

3.1 Wrought-Wire Clasps

Wrought-wire clasps are among the most commonly recommended direct retainers for removable partial dentures supported by periodontally compromised abutment teeth. Unlike cast circumferential clasps, wrought-wire retainers exhibit greater flexibility due to their manufacturing process and material properties. This increased flexibility allows the clasp arm to deform more readily under functional loading, thereby reducing the magnitude of stresses transmitted to the supporting tooth [22]. As a result, wrought-wire clasps are capable of engaging deeper undercuts while generating lower lateral forces, an important consideration when periodontal support has been reduced. Their biomechanical characteristics have led many authors to consider them a favorable option for distal extension removable partial dentures in which protection of the terminal abutment is a primary concern [23].

The clinical rationale for using wrought-wire clasps in periodontally compromised patients is based on their ability to reduce torque and dissipate functional stresses more effectively than rigid cast retainers. Since excessive lateral loading may accelerate periodontal breakdown and compromise the long-term prognosis of abutment teeth, the

use of a more flexible retentive element may contribute to a more favorable biomechanical environment. Clinical and experimental studies have demonstrated that clasp design plays a significant role in force transmission and stress distribution within distal extension prostheses, emphasizing the importance of selecting retainers that minimize harmful loading patterns. Although wrought-wire clasps may present certain disadvantages, including reduced rigidity and potential deformation over time, their stress-releasing behavior remains one of their most valuable characteristics. This principle of minimizing torque on terminal abutments subsequently formed the foundation for the development of dedicated stress-releasing clasp assemblies such as the RPI system [23,24].

3.2 RPI System

The RPI (Rest–Proximal Plate–I-bar) system is considered the classic stress-releasing clasp assembly for distal extension removable partial dentures. Introduced to address the biomechanical limitations associated with conventional clasp designs, the RPI concept incorporates a mesial occlusal rest, a proximal plate, and an I-bar retainer approaching the undercut from the gingival direction. This configuration alters the rotational behavior of the prosthesis during function and allows the retainer to disengage from the tooth surface as the denture base moves toward the edentulous ridge. Consequently, the magnitude of distal tipping forces and torque transmitted to the terminal abutment is reduced, creating a more favorable biomechanical environment for teeth with diminished periodontal support [25,26].

The biomechanical rationale of the RPI system is particularly relevant in periodontally compromised patients, where the preservation of the remaining supporting tissues is a primary treatment objective. Experimental, analytical, and finite element studies have demonstrated that the I-bar clasp contributes to a more favorable stress distribution by reducing lateral loading and minimizing stress concentration around the abutment tooth [27].Furthermore, because the retentive arm contacts a relatively small portion of the tooth surface, plaque-retentive areas may be reduced when compared with conventional circumferential clasp designs. These characteristics have made the RPI system one of the most frequently recommended designs for Kennedy Class I and Class II situations involving reduced periodontal support. However, anatomical limitations such as shallow vestibules, soft tissue undercuts, or unfavorable tooth morphology may restrict the use of an I-bar retainer, requiring alternative stress-releasing approaches. In such circumstances, the RPA system has been proposed as a practical modification capable of providing similar biomechanical advantages while overcoming some of the clinical limitations of the traditional RPI design [28,29].

3.3 RPA System

The RPA (Rest–Proximal Plate–Akers) system was introduced as a modification of the traditional RPI concept for clinical situations in which the use of an I-bar retainer is not feasible. Anatomical factors such as shallow vestibules, pronounced soft tissue undercuts, high frenum attachments, or unfavorable gingival contours may limit the application of gingivally approaching clasps [30]. In these circumstances, the RPA design preserves the mesial rest and proximal plate components of the RPI system while replacing the I-bar with a circumferential Akers clasp. By maintaining the mesial rest position and allowing controlled movement of the clasp assembly during function, the RPA system seeks to reduce the transmission of harmful torque to the terminal abutment while providing adequate retention and stability. Consequently, it has become one of the most widely accepted alternatives to the conventional RPI design in distal extension removable partial dentures [31].

The biomechanical rationale of the RPA system is based on the same stress-releasing principles that govern other designs intended for distal extension situations. During functional loading, the denture base tends to rotate toward the edentulous ridge, while the retentive arm is expected to disengage from

the tooth surface and minimize the development of damaging lateral forces. This mechanism may be particularly beneficial in periodontally compromised abutment teeth, where excessive torque and stress concentration can negatively influence long-term prognosis [31,32]. Although the retentive behavior of circumferential clasps may be affected by clasp geometry, material characteristics, and intraoral conditions, the RPA design remains an important option when stress control and periodontal preservation are priorities. Together with wrought-wire and RPI clasp assemblies, the RPA concept reflects the ongoing effort to optimize force distribution and protect the supporting structures of distal extension abutments. The potential periodontal benefits associated with these stress-releasing designs are discussed in the following section [32].

► Periodontal Implications of Stress-Releasing Designs

The periodontal effects of removable partial dentures have been a subject of debate for many decades. Early investigations frequently associated removable prostheses with increased plaque accumulation, gingival inflammation, and deterioration of periodontal parameters around abutment teeth. The presence of clasp assemblies and denture components may create plaque-retentive areas that facilitate bacterial colonization and complicate oral hygiene procedures. However, more recent evidence suggests that periodontal outcomes are influenced by a combination of factors, including prosthetic design, oral hygiene practices, maintenance protocols, and the initial periodontal condition of the patient. Therefore, the impact of removable partial dentures on periodontal health should not be evaluated solely on the basis of prosthesis wear but also in relation to the biological and biomechanical characteristics of the prosthetic design [33].

From a biomechanical perspective, the preservation of periodontal support depends largely on the ability of the prosthesis to control the forces transmitted to the abutment teeth. In distal extension situations, excessive torque and lateral loading have the potential to increase stress concentration within the periodontal ligament and supporting alveolar bone. Stress-releasing clasp assemblies were developed specifically to reduce these unfavorable loading patterns. By incorporating flexible retentive elements and designs that permit disengagement during function, systems such as wrought-wire clasps, RPI, and RPA assemblies seek to minimize mechanical overload while maintaining adequate retention and stability. These characteristics are particularly important in periodontally compromised patients, where the supporting tissues possess a reduced capacity to tolerate excessive functional stress [34].

Clinical evidence indicates that periodontally compromised teeth can remain functional for extended periods when periodontal disease is adequately controlled and prosthetic treatment is planned according to sound biomechanical principles. Long-term observational studies have demonstrated that the prognosis of abutment teeth is strongly influenced by maintenance care, plaque control, and force management. In this context, stress-releasing clasp designs should be viewed as protective biomechanical strategies rather than simply retentive components. Their ability to reduce torque and distribute functional loads more favorably may contribute to the preservation of attachment levels and support the long-term survival of abutment teeth [35,36].

Despite these potential advantages, no clasp design can fully compensate for inadequate periodontal maintenance or poor oral hygiene. Persistent inflammation, residual periodontal pockets, smoking habits, and other patient-related risk factors may continue to influence periodontal outcomes regardless of prosthetic design. Consequently, successful rehabilitation of periodontally compromised patients requires a multidisciplinary approach that combines periodontal stability, effective plaque control, and biomechanically favorable prosthetic planning. The contribution of stress-releasing clasp assemblies should therefore be

considered as one component of a broader strategy aimed at preserving the remaining dentition [36,37].

Overall, the available literature supports the concept that stress-releasing clasp designs may create a more favorable biomechanical environment for periodontally compromised abutment teeth by reducing harmful force transmission during function. Although long-term success remains dependent on multiple biological and behavioral factors, these designs represent an important tool in the effort to preserve periodontal support and maintain removable partial denture abutments over time. Based on these considerations, practical clinical guidelines are necessary to assist clinicians in selecting the most appropriate retentive strategies for abutment preservation [38].

► Clinical Recommendations for Abutment Preservation

The selection of clasp assemblies in distal extension removable partial dentures should be guided by both periodontal and biomechanical considerations. In patients with reduced periodontal support, the primary objective is to minimize torque and lateral loading while maintaining adequate retention and stability. Although no single clasp design is universally applicable, stress-releasing concepts are generally preferred because they promote a more favorable distribution of functional forces. The clinician must also consider periodontal stability, tooth mobility, anatomical limitations, and the patient's ability to maintain adequate oral hygiene when designing the prosthesis. The recommendations summarized in **Table 1** may assist clinicians in selecting appropriate retentive strategies for the preservation of periodontally compromised abutment teeth [36,38].

Table 1. Clinical recommendations for clasp selection and preservation of periodontally compromised abutment teeth.

Clinical condition	Preferred design approach	Clinical rationale
Mild to moderate periodontal attachment loss	RPI clasp assembly	Reduces torque and lateral forces through stress release during functional loading [25,26].
Reduced periodontal support with anatomical limitations for I-bar placement	RPA clasp assembly	Preserves stress-releasing principles when an I-bar is contraindicated [30,31].
Increased tooth mobility	Wrought-wire clasp	Greater flexibility may decrease stress concentration on abutment teeth [22,23].
Kennedy Class I and II distal extension situations	Mesial rest design	Reduces distal tipping forces and improves biomechanical behavior of the terminal abutment [25,34].
Periodontally compromised terminal abutments	Avoid rigid retentive components whenever possible	Minimizes unfavorable leverage forces and stress concentration [20,21].
History of treated periodontitis	Supportive periodontal therapy before and after	Long-term tooth survival depends on periodontal stability and maintenance

Clinical condition	Preferred design approach	Clinical rationale
	prosthetic rehabilitation	[7,8].
Persistent inflammation or residual periodontal pockets	Delay definitive prosthetic treatment until disease control is achieved	Active inflammation may compromise abutment prognosis [13,36].
Long-term maintenance phase	Periodic periodontal and prosthetic follow-up	Early detection of mobility changes, plaque accumulation, and prosthetic complications improves long-term outcomes [33,38].

3. FUTURE PERSPECTIVES

Digital technologies are progressively transforming the planning and fabrication of removable partial dentures. CAD/CAM workflows enable greater control over framework design, clasp geometry, and guiding plane preparation while improving the standardization of laboratory procedures. The integration of digital design and manufacturing techniques may facilitate the development of removable partial dentures that are more precisely adapted to the biomechanical requirements of individual patients. As these technologies continue to evolve, they may contribute to more predictable prosthetic outcomes and improved preservation of periodontally compromised abutment teeth [39,40].

Finite element analysis (FEA) is expected to play an increasingly important role in removable partial denture research and design. By simulating functional loading conditions, FEA allows detailed evaluation of stress distribution within clasp assemblies, supporting structures, and abutment teeth [41]. These computational models may help identify biomechanically favorable designs capable of reducing torque and minimizing stress concentration around periodontally compromised abutments. Future studies combining clinical outcomes with biomechanical simulations could support the development of evidence-based protocols for the selection and optimization of stress-releasing clasp systems [42].

The future of removable partial denture therapy is likely to move toward personalized prosthodontics, where treatment decisions are guided by patient-specific biological and biomechanical characteristics. Advances in digital impressions, intraoral scanning, artificial intelligence, and data-driven treatment planning may enable clinicians to incorporate periodontal status, tooth mobility, anatomical features, and functional loading patterns into the design process. Such individualized approaches have the potential to improve force distribution, enhance periodontal preservation, and increase the long-term survival of abutment teeth [43,44]. The integration of digital technologies, biomechanical modeling, and personalized treatment planning may therefore represent the next step in the management of periodontally compromised patients requiring removable partial denture therapy [44].

CONCLUSIONS

1. Periodontally compromised teeth may successfully function as removable partial denture abutments when periodontal stability is achieved and maintained through appropriate supportive care.
2. Distal extension removable partial dentures generate complex biomechanical forces that may increase torque and stress concentration around terminal abutment teeth, particularly in the

presence of reduced periodontal support.
3. Stress-releasing clasp assemblies, including wrought-wire clasps, RPI systems, and RPA systems, are designed to minimize harmful force transmission and promote a more favorable biomechanical environment for periodontally compromised abutments.
4. The preservation of periodontal support depends on the combined effect of prosthetic design, periodontal maintenance, and effective plaque control, emphasizing the need for an interdisciplinary treatment approach.
5. Selection of clasp assemblies should be individualized according to periodontal status, tooth mobility, anatomical characteristics, and the biomechanical requirements of each clinical situation.
6. Emerging digital technologies, finite element analysis, and personalized prosthodontic approaches may improve future removable partial denture design and contribute to the long-term preservation of periodontally compromised abutment teeth.

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