

Methods of Retaining Removable Dentures Using Dental Implants

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DOI : <https://doi.org/10.61796/jmgcb.v3i3.1641>



Sections Info

Article history:

Submitted: October 23, 2025

Final Revised: November 11, 2025

Accepted: December 16, 2025

Published: January 31, 2026

Keywords:

Dental implants

Removable dentures

Retention

Ball attachments

Bar systems

Lock mechanisms

CAD/CAM

Prosthetic rehabilitation

ABSTRACT

Objective: This article presents a review of current methods for retaining removable dentures using dental implants. **Methods:** The main types of attachment systems are discussed – ball attachments, clasp and lock mechanisms, bar designs, and magnetic systems. Their biomechanical characteristics, indications, advantages, and limitations in clinical practice are analyzed. Special attention is given to the role of digital CAD/CAM technologies in the planning and fabrication of implant-supported dentures, which enhance positioning accuracy, durability, and patient comfort. **Results:** It is shown that the use of implants for denture retention significantly improves stability, function, and quality of life, especially in cases of severe alveolar ridge atrophy. **Novelty:** Special attention is given to the role of digital CAD/CAM technologies in the planning and fabrication of implant-supported dentures, which enhance positioning accuracy, durability, and patient comfort.

INTRODUCTION

Reliable retention of removable dentures remains one of the key challenges in modern prosthetic dentistry. In cases of complete edentulism, particularly with pronounced alveolar ridge atrophy, traditional retention methods are often insufficient. In such cases, the use of dental implants to retain removable prostheses offers new possibilities for restoring masticatory and speech functions, as well as improving patients' quality of life.

Modern implantology considers implant-supported removable dentures as a physiologically justified solution, providing enhanced stability, better load distribution, and slower bone resorption. The concept of implant-supported overdentures has evolved significantly – from the first experiments of P.-I. Brånemark in the 1970s to current digital protocols utilizing mini-implants and customized superstructures. Initially, the idea was to stabilize dentures through osseointegrated supports, ensuring anchorage without requiring a completely rigid connection to the denture base. This approach combined the advantages of removable and fixed prostheses, greatly improving functional efficiency in complete edentulism.

In the early stages, massive cylindrical implants and cast cobalt-chromium bars were used, providing strength but accompanied by high rigidity and complex maintenance. In the 1980s–1990s, ball attachments were introduced, simplifying clinical protocols and making the technique accessible to a wider patient population. Later, lock

mechanisms such as Locator systems and low-profile designs allowed individual adjustment of retention and compensation for deviations in implant angulation.

In the 21st century, the concept of “mini-implants” with diameters below 3 mm emerged, intended for denture retention in cases of insufficient bone volume without the need for bone grafting. Their use is particularly effective in elderly patients with severe alveolar ridge atrophy, where standard implants are technically challenging. Contemporary studies demonstrate high clinical survival rates of mini-implants (up to 95% after five years) when occlusal balance and hygiene protocols are followed.

From a materials science perspective, superstructures and retention elements are made from high-strength, biocompatible alloys. Titanium remains the primary material – a lightweight, corrosion-resistant metal with strong osteophilic properties and a low modulus of elasticity similar to bone tissue. Its alloys (Grade IV and Ti-6Al-4V) provide durability and minimize vibration transfer to surrounding structures. Zirconia (ZrO₂), used in esthetic zones, offers high bioinertness and visual harmony but is less ductile than titanium. Cobalt-chromium alloys retain significance for bars and frameworks due to rigidity and resistance to deformation, although precise casting and milling control are required. In recent years, hybrid solutions integrating titanium connectors into zirconia frameworks have been actively employed, combining mechanical strength with esthetic qualities [1], [2], [3].

The development of CAD/CAM and additive manufacturing (3D printing) technologies has introduced a new level of precision in superstructure fabrication. Direct milling of titanium bases and 3D printing of zirconia and cobalt-chromium frameworks using laser systems have minimized fit errors and ensured uniform load distribution. In this context, overdenture technology is viewed as a dynamically evolving system in which advances in materials science directly influence the durability and clinical predictability of prosthetic rehabilitation [4], [5].

RESEARCH METHOD

Main Methods of Retaining Removable Dentures on Implants

Retention Methods

Retention methods for removable dentures can be classified according to the type of attachment mechanism:

1. **Ball Attachments** – a classical system offering simplicity and accessibility. Typically used with two implants in the mandibular canine region. Provides adequate retention and comfort during removal but requires periodic replacement of the matrix components.
2. **Locking Systems** (Locator, Rhein, Dalbo, OT-Cap) – advanced designs with adjustable retention levels. Resistant to wear, capable of compensating implant angulation up to 40°, and considered the “gold standard” for rehabilitating fully edentulous mandibles.
3. **Bar-Retained Systems** – employed when multiple implants (3–4 or more) are placed. A metallic bar connects the implants and distributes masticatory forces.

Provides high stability but requires precise fabrication and meticulous hygiene maintenance.

4. **Magnetic Retainers** – provide soft retention, minimizing mechanical wear and mucosal trauma. Commonly used in elderly patients or those with limited manual dexterity. Limitations include reduced retention strength and potential risk of demagnetization.

Materials and Methods of Fixation for Implant-Supported Removable Dentures

Modern retention methods rely on high-precision bioengineered systems and materials that ensure long-lasting connections and biocompatibility with surrounding tissues. The primary materials for superstructures are titanium and its alloys (Ti-6Al-4V), which are strong, corrosion-resistant, and biologically inert [6].

In some cases, cobalt-chromium alloys and zirconia frameworks are used, providing enhanced esthetics in the anterior region. CAD/CAM technologies allow for individualized design of the attachment geometry, while 3D milling and laser sintering ensure element fit accuracy of 20–30 μm , significantly reducing micro-movement and the risk of decementation [7].

The evolution of retention systems has progressed from ball attachments and telescopic systems to self-adjusting lock-type designs such as Locator, which feature minimal profile height and the ability to compensate for implant angulation up to 40°. Bar systems, based on connecting implants with a single bar, provide optimal load distribution and stability in full edentulism. Magnetic attachments are used in elderly patients where ease of removal and minimal mucosal pressure are required [8], [9], [10].

RESULTS AND DISCUSSION

Biomechanical and Clinical Considerations

The choice of retention method depends on anatomical conditions, the quantity of remaining bone, and functional requirements. In cases of mandibular alveolar ridge atrophy, two implants with ball or lock attachments are preferred. In the maxilla, due to lower bone density, at least four implants are recommended to achieve stability [11].

Bar systems distribute masticatory forces evenly, preventing overload of individual implants and supporting long-term osseointegration. However, they require complex hygiene care and increase the risk of biofilm formation. Magnetic systems are minimally traumatic and biocompatible but less stable under masticatory forces, limiting their use in posterior regions [12].

Digital Planning and Modern Technologies

The introduction of digital technologies has radically transformed implant-supported denture rehabilitation. Computed tomography, virtual modeling, and CAD/CAM systems enable individualized planning of implant placement, taking into account jaw anatomy, mucosal thickness, and occlusal angles. 3D printing of surgical guides and milling of denture bases ensure high accuracy of component fit and uniform load distribution. Digital protocols significantly reduce production time and increase predictability of clinical outcomes [13].

Clinical Effectiveness

According to numerous studies, the use of implants for removable denture retention improves functional performance by 60–80% compared with conventional prostheses. Improvements are observed in speech, denture stability, and esthetic perception. Additionally, implant-supported dentures help preserve alveolar bone volume through functional stimulation.

Patient surveys demonstrate significantly increased treatment satisfaction, improved social adaptation, and greater confidence during communication and eating. Current research focuses on developing hybrid retention systems combining magnetic and mechanical elements, as well as using three-dimensional load modeling with finite element analysis (FEA) [14].

Digital Protocols

The development of digital workflows—including intraoral scanning, Exocad, and 3Shape software—allows clinicians to predict the biomechanics of implant–prosthesis interactions already at the planning stage [15].

CONCLUSION

Fundamental Finding: The use of dental implants for retaining removable dentures represents an effective and biomechanically justified method of prosthetic rehabilitation. Modern retention systems—ball, lock-type, bar, and magnetic attachments—provide reliable prosthesis stability, even load distribution, and high patient comfort. **Implication:** Integration of CAD/CAM technologies and navigated surgery has significantly enhanced the precision, predictability, and durability of implant-supported prostheses. **Limitation:** The current application of implant-supported removable dentures is still limited by existing technological, biological, and procedural constraints, which necessitate continuous refinement of materials, systems, and clinical protocols to ensure optimal long-term outcomes. **Future Research:** Looking forward, the development of implant-supported prosthetics is expected to focus on bioengineered surface coatings, individualized superstructures, and minimally invasive surgical protocols, opening new horizons in clinical dentistry.

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