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REVIEW

Attachment Systems in Implant-Supported Removable Dentures: Update for Clinicians

İmplant Destekli Hareketli Protezlerde Tutucu Sistemler: Klinisyenler için Güncelleme

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Abstract

Overdentures are tooth-supported complete or partial removable prostheses that are prepared on the remaining natural teeth, tooth roots, or implants in cases with maxillary constriction, vertical dimension loss, and traumatic or congenital jaw defects, whether the supporting teeth are prepared or not. In recent years, dental implants have become a highly successful and widespread treatment option for the prosthetic rehabilitation of completely edentulous patients. In the treatment of patients, fixed restorations can be carried out by placing a lot of implants; nevertheless, making implant-supported removable prostheses is also possible by placing a small number of implants due to existing systemic conditions of the patient, anatomical deficiencies in the jawbones, and high cost. In terms of patient satisfaction, prosthesis stability, retention, and chewing force, implant-supported removable prostheses are more successful when compared with traditional complete dentures. Numerous retentive systems with varying biomechanical characteristics have been developed for the connection of removable overdenture with implants. The study aims to guide clinicians with the current retentive systems and their indications.

Keywords: Dental implant; Removable prosthesis; Prosthodontics; Implant-supported prosthesis

In the glossary of prosthesis terms, complete edentulism is defined as the absence of natural teeth. Although trauma, oral tumors, pulp pathology, smoking, and so forth are risk factors that contribute to tooth loss, according to the World Health Organization, dental caries and severe periodontal diseases are the main causes of edentulism.[1] Complete edentulism can have adverse effects on individuals' oral function, psychosocial status, and quality of life.[2]

In implant-supported removable prostheses, which are commonly employed in the treatment of completely edentulous patients, numerous retentive systems with varying biomechanical characteristics have been developed for the connection between the implant and the removable superstructure.

The characteristics of ideal retentive systems can be listed as follows:[3]

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- Resistance to corrosion
- Sufficient retention
- Comfortable insertion and removal of the prosthesis
- Ease of clinical application
- Ease of repair
- Ease of laboratory procedures
- Cost-effectiveness

Retentive systems utilized in current treatments are classified in various ways. The most commonly employed classification is based on whether they are stud-retained (non-splinted) or bar-retained (splinted) retentive systems. Splinted retainers are formed by joining multiple implants with a connecting bar. Non-splinting retainers are retention systems that are supported by individual implants.[4]

In this study, studies that are related to retention systems were searched via Google Scholar, Pubmed, and Web of Science, and a literature review was carried out. The search strategy was limited to articles published in English or Turkish language appearing in peer-reviewed journals. No publication year limit was applied, so that the search could include the first available year of each particular database. In the selection of the retentive systems described in this study, being current and frequently used were accepted as the criteria. The study aims to guide clinicians regarding current retentive systems and their indications developed for implant-supported prostheses.

Stud Attachments (Non-splinted)

Ball Attachments

Ball attachment systems typically consist of a patrix (male part) connected to the implant, usually made of a metal alloy, in a spherical shape, with different heights and diameters, and a matrix (female part) located in the removable prosthesis (Fig. 1a). The matrix consists of silicone, nitrile fluoroelastomer, or ethylene–propylene parts located within a metal or metal housing. Among the various retentive systems utilized in clinical practice, ball attachment retainers are the simplest type.[5,6]

Advantages of ball attachments:[7,8]

- ease of providing hygiene around the implant area
- reduced time spent on fabricating the prosthesis superstructure
- availability of different retention levels with elastic components
- occupation of less space in comparison with bar-retained removable prostheses
- provision of hinge and rotational flexibility
- cost-effectiveness

Figure 1. (a) Different height ball attachment retainers and matrix components. **(b)** Locator attachments. **(c)** Elastic matrices that have different colors based on the retention levels. **(d)** Locator attachments that double retention.

The main disadvantage of the system is the wear that occurs over time in the matrix components. Particularly, in cases where the implant angles are not suitable, entry path problems, rapid wear of the matrices, and deformation of the ball attachments may take place.[9] Moreover, they necessitate a height of 8 mm or more within the prosthesis. In cases where the interarch distance is insufficient and the angle between implants is more than 15°, the use of ball attachment retainers is not recommended.[10]

O-Ring Attachment

O-ring attachment systems comprise a metal abutment, an O-ring, and metal housing. Metal abutments are composed of three parts: head, neck, and body. The head portion is wider than the neck. O-rings are ring-shaped synthetic polymer elastomers that sit on the undercut area of the abutment. The O-rings can be replaced when they become worn or lose retention.[10] O-ring retainers can tolerate angular differences of up to 10° between implants.[11] Loss of parallelism can lead to challenges when inserting or removing the prosthesis and may also contribute to abutment fracture.

ERA Attachment (Extra-coronal Resilient Attachment)

ERA attachment systems comprise two components, namely, a metal matrix piece fixed inside the oral cavity and a nylon patrix piece with different retention levels placed in a metal housing on the prosthesis base. Various retention levels are provided based on the patient's requirements and the retentiveness of the ERA attachment integrated into the denture.

They are called extra-radicular retainers because the entry guide is positioned higher than the implant support and alveolar crest. This feature reduces resistance to forces. ERA retainers are resilient retainers and can be applied in numerous implant systems. They have angled abutments with angles of 5°, 11°, and 17° to ensure the parallelism of angled implants. Hence, they can compensate for implant angulations of up to 34.[10]

Locator Attachment

The locator attachment system provides dual retention and self-aligning features. The patrix pieces are manufactured from titanium alloy, and their outer surfaces are generally coated with titanium nitride (TiN). TiN material enhances surface hardness and fracture resistance.[12] Nevertheless, it has disadvantages such as causing allergic reactions and being prone to surface detachment.[13]

Locator attachments have varying gingival heights that range from 1 to 6 mm. The low-profile feature is particularly useful when there is limited inter-occlusal space.[14,15] A vertical clearance of 3 mm is sufficient for the matrix, metal cap, and acrylic of the retentive system.[16] Limited vertical height and the ability to compensate for divergent implant axes could have been cited as advantages of the locator system.[17,18]

Patrix pieces of the retainer system can tolerate angular differences of up to 40° between implants (Fig. 1b).[9,19–21]

The matrix piece comprises different retention level elastomers housed within a metal cap. Elastic matrices are manufactured in different colors based on the retention levels.[22,23] In elastic matrices, blue (6.8 N), pink (13.6 N), and transparent color (22.6) are employed in straight implants, and green (13.6–18.14 N) and red (6.8 N) are utilized in angled implants (Fig. 1c).[8]

The nylon locator holder inside the metal head is 0.4 mm longer and allows for hinge and vertical flexibility due to the resulting gap.[8]

Based on the problems encountered with locator holder systems, locator holders with different materials and geometric shapes have been developed over time. One of these is the titanium nitride-coated, tapered-shape abutments with external two protrusions, unlike locator abutments, which provide double retention only externally without providing retention from the inside (Fig. 1d). It can tolerate an angle difference of up to 60°. It has less food retention because of its smaller internal void. It can also be employed with bars to increase retention force.[16,24]

In the other system, the locator abutments have an uncoated surface and do not contain an internal void. They have a matrix made of polyetheretherketone (PEEK) with different retention values.[25]

In the latest holder system developed to prevent the wear problem encountered in locator systems, the patrix parts are coated with a material called amorphous diamond-like carbon (ADLC), which has high wear resistance. This coating technique is commonly employed in the medical field as well. There are options for both straight and 15° angled matrices (Fig. 2a). By using angled matrix holders, implant angles of up to 60° can be tolerated, and the entry path of the prosthesis can be corrected.

In the matrix part, PEEK material is employed, which has higher mechanical retention force and wear resistance than rubbers.[20,26] They have different color codes and different retention values. PEEK matrices in different color codes are in the form of a non-unified ring and allow flexibility during insertion and removal (Fig. 2b).[27]

Telescope Attachment

The telescope attachment system is a retainer system that is based on a dual crown system, which consists of an infrastructure (patrix, primer, and coping) screwed into the implant and an upper structure firmly attached to the prosthetic base. Retention is provided by the frictional force between the retention matrix and the patrix. This system is the only retainer system with a retention value

that increases over time. When failure is observed in any support, the prosthesis can be re-adjusted. Its cost is higher when compared with other independent systems.[28,29]

Magnet Attachment

Magnet attachment systems have two parts: a piece containing magnets inside the prosthetic base and a metal piece on the abutment or implant. Corrosion that occurs over time in these parts adversely affects retention. Compared with other independent retainer systems, plaque accumulation is higher and retention value is lower. Despite all these disadvantages, its use is recommended for individuals with a habit of clenching their teeth owing to the low transmission of force to implants. Moreover, it can be employed for patients with weak muscle diseases, including Parkinson's disease, who require less force to insert and remove an overdenture prosthesis.[30,31]

Optiloc Attachment

The Optiloc retention system features a low-profile design that is both smooth and wear-resistant (Fig. 2c). It includes matrix components made of PEEK, offering varying levels of retention force. This system is suitable for use with implant angulations of up to 40°.[10]

Bar-retained (Splinted)

In bar-retained systems, two or more implants are connected to each other via a bar. The system comprises implants that are connected to each other via the bar and clips inside the prosthetic base. Clips placed inside the prosthesis can be rigid (metal) or flexible (rubber). Replacement and repair of rigid clips are more difficult than flexible clips.[9,32] Bars can be custom-made by casting, or prefab bars can be employed.[1] Custom-made bars can be combined with ball abutments, locators, and O-ring retainers. The cost of cast bars is higher.[10]

Based on their cross-sectional shapes, there are four types of bars:

- Parallel (U-shaped) cross-section bar: rigid, suitable for four implant supports. Implants are joined in a straight baseline.
- Round cross-section bar: flexible, reduces forces on implants, allows for vertical movements at the distal end of the base.
- Oval cross-section (Dolder) bar: stress-resistant, advantageous in terms of flexibility and indirect retention.

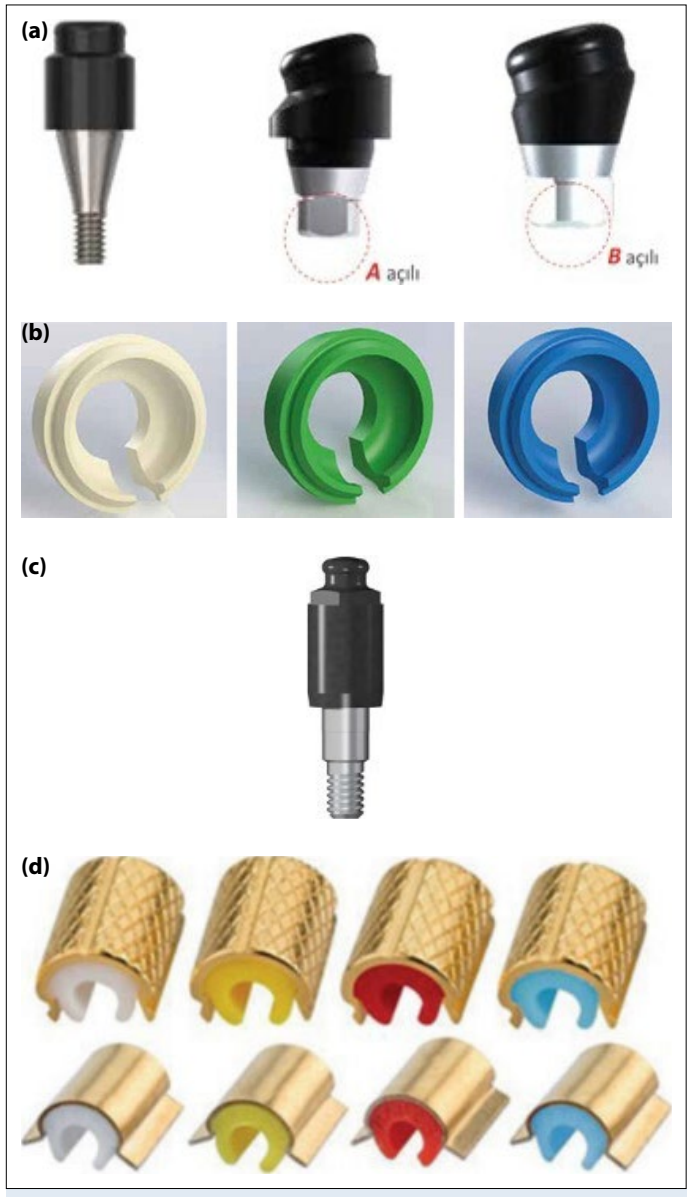

Figure 2. (a) ADLC-coated locator abutments with different angles. **(b)** PEEK matrix in different color codes. **(c)** Optiloc attachments. **(d)** Hader matrix with different retention values.

- Hader bar: semi-flexible. Its upper part has a round cross-section, and its lower part extends toward the tissue. The part extending toward the tissue increases the durability of the bar and reduces its flexibility. Its cross-section resembles a keyhole.[21] It has plastic matrix parts called Rider with different retention values (Fig. 2d). It allows for hinge movement.[11]

Bar-retained systems can be preferred in cases where there is excessive resorption in the mandible, where there is a need for retention and stabilization, and where partial resection is performed in the bone and/or soft tissue.

Table 1. Attachment selection for implant-supported removable prostheses

	Ball/ O-ring	Locator	Bar retained
Insufficient interarch space	✓✓	✓✓✓	✓
Alveolar crest is "V-shaped"	✓✓	✓✓✓	✓
High angulation of implants	✓	✓✓	✓✓✓
High retention requirement	✓	✓✓	✓✓✓
Post-treatment low complication rate	✓✓	✓✓✓	✓
Low treatment cost	✓✓	✓✓✓	✓
Low hygiene motivation	✓✓	✓✓✓	✓

✓: Least preferred; ✓✓: Preferred; ✓✓✓: Most preferred.

Advantages include the following

- They can be used in the presence of angled implants.
- They are more retentive than non-splinting retention systems.
- They distribute forces to implants, which results in less force transmission.

Disadvantages include the following:

- They have difficult and complicated construction.
- Providing hygiene is more difficult when compared with independent retainer systems; hence, it is not recommended for use in elderly/disabled patients.
- There is a possibility of gingival hyperplasia under the bar.
- They can be used only in cases where the interocclusal distance is at least 14–15 mm.
- Their manufacturing cost is high.[10,33]

Attachment Selection for Implant-Supported Removable Prostheses

Selection of the correct retentive system is one of the crucial stages in implant-supported removable denture cases. Choosing the appropriate retentive system not only increases implant survival but also minimizes bone loss and other prosthetic complications.[34] Factors including residual ridge volume and quality, angulation of implants, retention, and stability requirements, as well as the experience of the dentist and technician has a role in the selection of the retentive system (Table 1).[15,35–37]

Residual Ridge Volume and Quality

In cases where alveolar bone loss is minimal and the interarch space does not allow for the healthy placement of splinted systems, independent retentive systems including ball attachments, O-rings, and locators should be preferred.[11]

For bar-retained systems, the distance from the crest of the alveolar ridge to the incisal edge should be at least 12 mm, comprising a 4-mm bar height, 1-mm gap between the bar and the gingiva, and 7 mm for the prosthesis. For ball attachments, 5–6 mm is adequate, whereas for locator attachments, 3–4 mm of space is sufficient.[5,16]

In cases where the mandibular alveolar crest is narrow and V-shaped, the use of bar-retained systems should be avoided as they may restrict tongue movement and adversely affect phonation. Moreover, positioning the bar more labially can cause discomfort to the lip, impacting both aesthetics and the retention of the prosthesis. Hence, in such cases, non-splinted retentive systems should be preferred.

In situations with a U-shaped residual ridge and sufficient bone support, a removable prosthesis can be fabricated over four implants splinted with three bars.[5]

Angulation of Implants

To minimize matrix wear and ensure stable retention force, it is recommended to place implants parallel to each other. However, when anatomical limitations prevent parallel placement of implants, bar-retained attachments should be preferred to ensure that the path of insertion is parallel to the prosthesis.[30,38,39] When stud attachments must be used, ball attachments experience less retention loss.[40]

Retention Requirement

For patient satisfaction and prosthesis health, the retention value of the chosen retentive system must be known.[41,42] In atrophic jaws where bone volume is reduced, the use of bar or telescopic systems will enhance prosthesis retention and stability.[43–45] In cases where independent retentive systems are needed, locator attachments provide greater initial retention when compared with ball attachments.[40,46]

Treatment Cost

Bar-retained and telescopic attachments tend to be costlier. Other independent retentive systems (ball, locator, and magnet attachments) require less technical precision and are more economical.[47,48]

Oral Hygiene and Soft Tissue Condition

Independent retentive systems should be preferred for patient groups, such as the elderly or individuals with disabilities, who may have difficulty maintaining oral hygiene.[49] In cases where bar-retained systems are utilized, there should be a gap between the bar and the tissue to facilitate oral hygiene and reduce plaque accumulation.[33]

Conclusion

Each clinical situation is unique, so attachment selection should be made on the basis of a detailed assessment of the patient and expert opinions provided by the dentist. For the long-term success of the prosthesis and overall patient satisfaction, the most suitable attachment type for each patient must be determined.

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