OPEN ACCESS

Saudi Journal of Oral and Dental Research
Abbreviated Key Title: Saudi J Oral Dent Res
ISSN 2518-1300 (Print) | ISSN 2518-1297 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article **Overdenture**

Over-Denture Attachment Systems: Systematic Review with Meta-Analysis

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DOI: 10.36348/sjodr.2024.v09i02.002 | **Received:** 06.01.2024 | **Accepted:** 11.02.2024 | **Published:** 19.02.2024

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Abstract

Current scientific growths for implant over-denture attachments. We focused on the following topics: attachment systems, retention of various attachments, stress distribution with different attachments, the design and fabrication of attachments, digital techniques in over denture attachments, and the effects of attachments in two-implant health. We found that plastic resin is commonly used for ball and bar attachments, whereas nylon resin is commonly used in locator attachments. The locator system offers a valuable attachment option for implant-retained over denture. Attachment retention reduces while lateral force increases with implant inclination in over denture. The higher the retention of an over-denture attachment, the higher the transferred stresses. Additionally, clip loading produces more stress in implants and precision elements than bar-retained dentures.

Keywords: Dental implant, over denture, attachments, stress, retention.

INTRODUCTION

Edentulous patients with mandibular ridge atrophy frequently have difficulties in wearisome conventional dentures owing to absence of stability and retention, pain/discomfort during mastication, mucosal irritation, and poor patient tolerance few complications can be overcome by stabilization of dentures using dental implants to avoid complications and morbidity of other invasive surgical measures such as sulcus deepening and bone augmentation. It is healthy documented in the literature that 2-implant assisted mandibular over-dentures should be the smallest standard of care for edentulous patients as they are cost-effective, improve retention and stability of complete dentures, enhance chewing efficiency, and improve patient satisfaction.

There is now overwhelming evidence that a 2-implant over-denture should become the first choice of treatment for the edentulous mandible. (The McGill Consensus Statement on Over-dentures - 2002)

over-denture \o´var-dĕn´chur\ n: a dental prosthesis that covers and is partially supported by natural teeth, natural tooth roots, and/or dental implants; nonstand/syn, overlay denture, overlay prosthesis.

Dissimilar attachments can be used to recollect such over-dentures to the implants for instance bar, ball, and socket, magnetic, resilient stud (Locator), and resilient telescopic attachments. The choice of particular attachments depends on several factors such as the shape of the dental arch, the inter-ridge space, the amount of retention required, the cost, the degree of implant angulation, and the cost. Furthermore, the degree of ridge atrophy and prosthetic maintenance and complication is other important factors [10, 14].

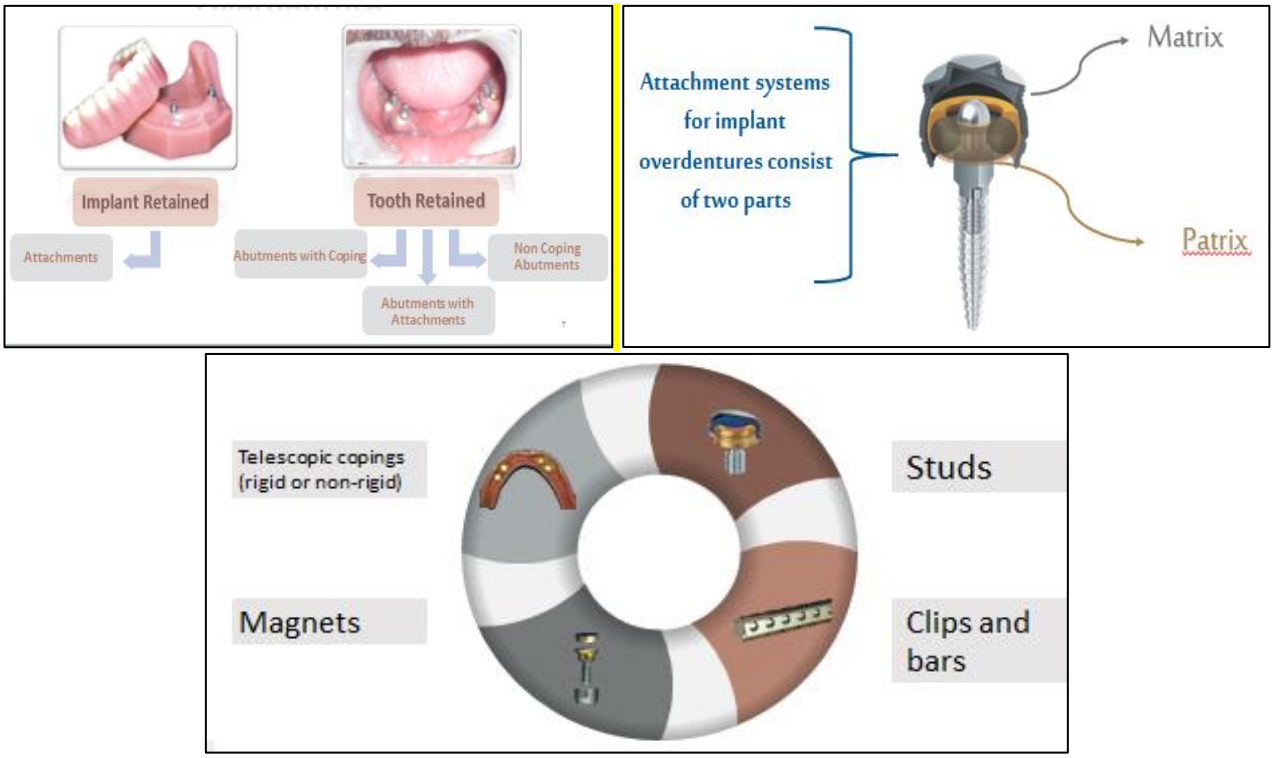
Bar attachment splints the implants together, distributes forces on the implants, inhibits horizontal displacing forces. Additionally, bars can compensate for mal-aligned implants by fabricating a custom substructure. Resilient telescopic attachments have primary and secondary crowns with intervening relieve spaces or retentive elements. It can be used to increase prosthesis stability for patients with resorbed ridges due to the friction between the primary and secondary crowns. Moreover, it facilitates hygiene and has a self-sealing mechanism that allows its use in patients with physical dexterity. Resilient stud (Locator) attachment has a low vertical height (can be used with limited restorative space), and can correct implant inclination up to 40. They provide a limited hinge movement and double retention by the incidence of internal and external

frictional flanges, thus increasing over-denture stability and decreasing horizontal engagements [18].

Extra improvement of the locators is the ability to adjust the retentive forces through the selection of different color coded nylon housings. In previous randomized controlled clinical trials, the authors compared clinical and radiographic outcomes, patient-based outcomes, electro-myographic activity, and denture base deformation of the bar, resilient telescopic and resilient stud attachments used to retain mandibular over-dentures in patients with atrophied mandibles. The prosthodontic maintenance for implant-assisted over-dentures has a clinical, laboratory, and economic implications which may affect the success of management and patient approval.

The prosthetic maintenance of implant over-dentures may be affected by several factors including retention and stability of the dentures, the degree of ridge atrophy and quality of denture base area, type of anchorage system (splined versus non splinted), and the patient's expectations. Reviewing the literature, several prospective or retrospective studies have investigated the prosthetic complications of mandibular 2-implant over-dentures retained by the bar, ball, telescopic, and Locator attachments. Other studies compared prosthetic complications of 2 attachments only, for example, ball versus bars, ball versus magnets, ball versus locators, bar versus locators, and ball versus telescopic. Nevertheless, there are a limited number of clinical trials comparing prosthetic complications of different attachments used for 2-implant over-dentures [9, 16].

These proceedings include ball, bar, and magnets, or ball, magnets, and Locators. Furthermore, most of the studies are short term, have insufficient patient numbers, and do not include patients with strictly atrophied mandibular ridges. This may not be sufficient to provide an evidence-based decision in the collection of suitable attachment concerning prosthetic maintenance and complication.



METHODS

This systematic review was performed according to the Preferred Reporting Items for the Systematic Review and Meta-Analysis guidelines. Randomized controlled clinical trials and crossover clinical trials with at least 1 year of follow-up on attachment systems for two or more implant-supported mandibular over-dentures, reporting various outcomes such as prosthodontic maintenance/complications, patient's satisfaction, prosthesis retention, and peri-implant tissue evaluation were included in this systematic review.

Search Strategy

An electronic literature search was independently conducted by two investigators (PS, PM) from January 2010 to December 2020, using MEDLINE (PubMed), the Cochrane central register of controlled trials (central) and Science direct databases for articles in English language published in journals of dentistry using following search terms: implant over-denture and

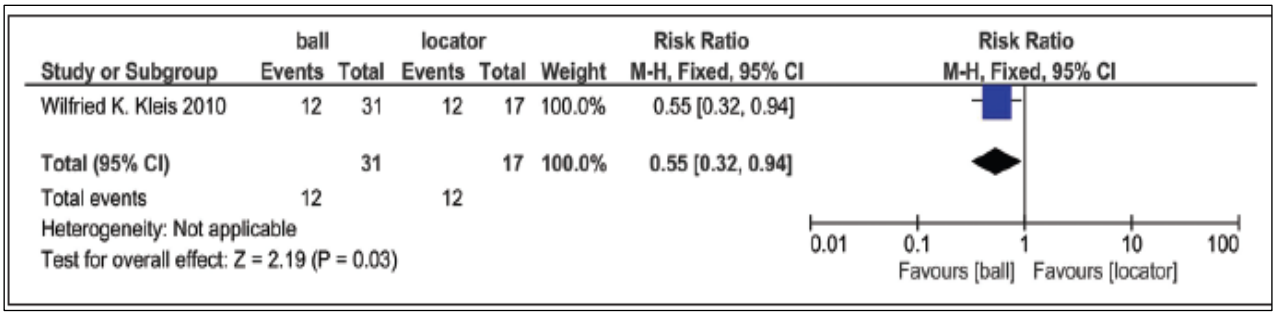
mandibular arch, mandibular implant over-denture and over-denture attachment systems, implant over-denture attachments not maxillary implant over-denture, implant over-denture attachment systems not single implant over-denture, mandibular implant over-denture and implant over-denture attachment systems not maxillary implant over-denture not single implant over-denture, mandibular implant over-denture attachments and prosthodontic complication/maintenance, mandibular implant over-denture attachments and retention, mandibular implant over-denture attachments and patient's satisfaction, mandibular implant over-denture attachments and peri-implant tissue condition.

Meta-analysis

A RCT compared ball attachment and locator attachment for prosthodontic maintenance, patient's preference, biologic complications, and oral health-related quality of life. This study provided data for analysis only about prosthodontic maintenance. Upon pooling the data obtained from this single trial regarding the outcome prosthodontics success, it was identified that ball attachment reported fewer complications compared to the locator attachment (RR = 0.55, CI = 95%, *P* = 0.03, Heterogenecity = not applicable, single study, 40 Patients, 23 events of prosthodontic complications).

Number	Author	Year	Study design	Follow-up (year)	Number of patients	Type of attachment
1	Albuquerque *et al*.[15]	2019	RCT (cross over clinical trial)	1	24	Cylindrical, ball attachment
2	Burns[16]	2011	Prospective RCT	1	30	2 implant supported bar, 4 implant supported bar, ball attachment
3	Cepa *et al*.[17]	2017	Prospective RCT	3	25	Ball attachment, telescopic attachment
4	Cristache *et al*.[18]	2014	Prospective RCT	5	69	Ball, magnet, locator attachment
5	Kleis *et al*.[19]	2010	Prospective RCT	1	60	Locator, 2 types of ball attachment
6	Krennmair *et al*.[20]	2012	Prospective RCT	3	51	Telescopic crown, milled bar attachment

This meta-analysis included a RCT and crossover clinical trial with follow-up of more than 1 year, showing a low risk of bias published in MEDLINE (PubMed), Cochrane, Science direct databases. The attachment systems utilized by the included studies were, locator, telescopic and magnet over-denture attachments.



Analysis - Comparison of Ball and Locator attachment for Prosthodontic complication and maintenance

Stud attachment

It is the simplest of all types of attachments. Stud attachments can be divided into two groups:

1. The Extra Radicular:

"The Stud" (Male part) usually attached to metal coping cemented over the prepared abutment and it projects from the root surface of the preparation. The female part is attached to the denture. Attachment of male component to female component provides retention.

The male parts are available as:

a. Prefabricated Metal Posts-Cemented Directly To The Root.

b. Prefabricated Resin Patterns- Which Is Cast And Cemented To The Root.

The female component is also termed as retentive anchor and made in metal or plastic and is in the form of an o ring or matrix. Eg-CEKA, ORS-OD, DALBOS, SERIES, GERBER, LOCATOR ATTACHMENT AND ROTHERMAN.

The Intra Radicular Attachment:

The Stud (Male element) forms part of the denture base and engages a specially produced depression (housing or female part) within the root contour. This attachment is indicated in situations with reduced interocclusal space. Eg-Logic, Zest attachment, ERA attachment Zest Anchor System: The female sleeve is cemented in the post space. Male portion consists of nylon.

ERA system:

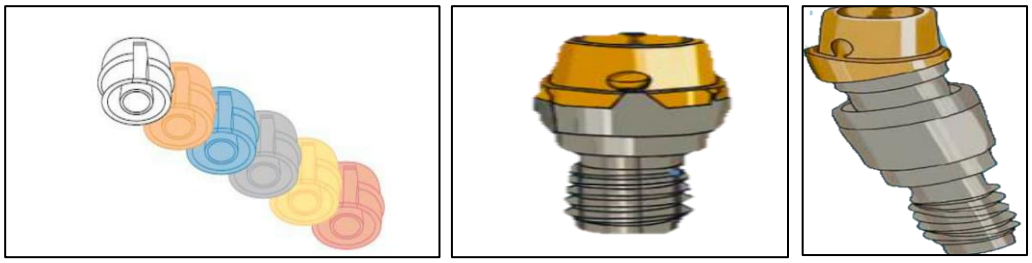
Resilient attachment system with color-coding resin unit providing various degrees of retention. Universal hinge with vertical movement. Metal jacket which holds the male attachments.

The ERA consist of:

- The nylon component (Patrix) is capture in denture acrylic
- The attachment portion (Matrix) screws directly into the implant coated with titanium nitride to decrease attachment wear.

Available in two types:

1. First is the straight one piece abutment type
2. Second are the two piece angulated abutment type



Ball attachment (O-ring attachment)

- Simple manufacturing process.
- The provision of a wide range of movement.
- Cost-effectiveness.
- Ease of use.
- Good retention.
- Easy hygiene maintenance.
- High patient satisfaction.

Disadvatages

- The abutment requires implants to be parallelly placed.
- The loss of parallelism may cause difficulty while inserting and removing the prosthesis or during the fracturing of the abutment.
- The O-ring needs to be regularly changed because it is subject to wear.

The matrix part may be one of the following types:

(a)- The O-ring - In which the retentive element is rubber ring. It's better to have parallel implants otherwise the rubber ring will wear within a few weeks.

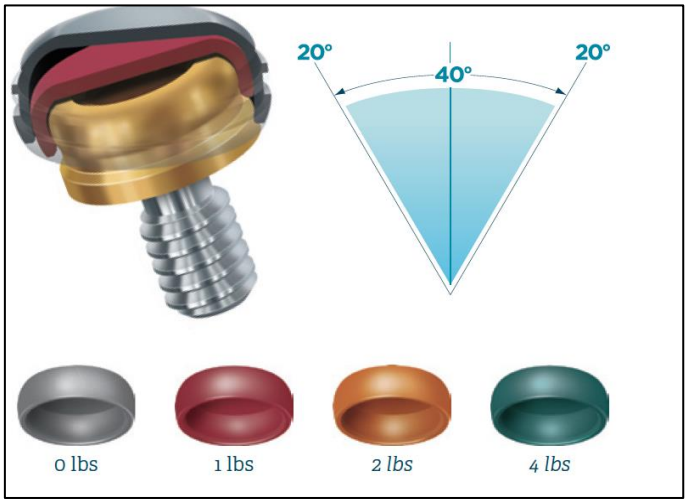
(b)- A metal part as in dalbo system- This permits less resilience. However the retentive forces are almost twice those obtained with the O-ring system.

A bar attachment offers retention, the splinting of implants, and the distribution of load, resulting in reduced implant stress, which is critical for the immediate loading protocol. The restoration of moderately to severely atrophic maxilla remains a challenge. In such cases, CAD/CAM titanium bar-supported over-denture can be an important treatment

Polymers choice for an edentulous patient's rehabilitation shows a maxillary over-denture supported by four or six implants for the minimally invasive rehabilitation of atrophic maxillae. The disadvantages of bar attachments include technique-sensitivity, high costs, and difficult hygiene maintenance under the bars that leads to mucosal swelling or gingival hyperplasia.

Furthermore, bars are not indicated in a V-shaped ridge because this causes the infringement of tongue space [7, 9].

Locators are currently popular attachments because of their low level of thickness (2.5 mm height) and ability to self-align, which can correct up to 40_ of implant angulations. They can be used in narrow inter-arch space and prevent the fracture of the denture base. Locators offer excellent retention and stability, and they allow for easy hygiene maintenance. The telescopic attachment, which offers a self-seating mechanism, is appropriate for patients with reduced manual dexterity, such as those with Parkinson's disease.



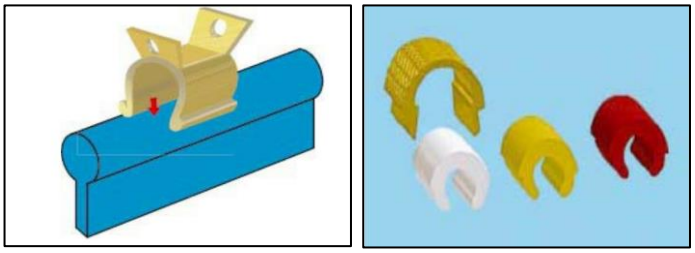
However, the periodic replacement of the male nylon part is required. Some prosthetic complications have been noted in locator attachments. One study reported 34 prosthetic complications and a locator housing requiring 16 replacements. To avoid complications, locator attachments require periodic repair and higher maintenance. Recently, researchers invented a double-crown attachment option for locator attachments have that connects dentures to prepared teeth. However, the disadvantages of locators include the need for sufficient inter-arch space and the metal display of attachments. The locator attachment system is a suitable choice for implant-retained or implant-supported over-denture [11, 18].

Bar Attachment

It consists of a bar spanning an edentulous area joining copings on the roots of the abutment teeth on either side of the arch. Sleeves and clips placed in the denture attach to the bar when the denture is inserted, providing retention. The bar splints the abutment teeth and thus distributes the forces. This type of bar attachment requires vertical and buccolingual space. Oral hygiene maintenance is very much essential otherwise may lead to abutment loss. It can be a bar joint or bar unit. Depending on the number it can be a single bar or multiple bars. Depending on movement it can be a bar unit that provides no movement and is made up of solid rigid material or bar joint which permits rotational movement between bar and sleeve and thus made up of resilient material [12, 19].

HADER BAR ATTACHMENT

Discovered In 1973 by Helmut Hader. It is named after the swiss tool and die technician "Helmut hader". It is a semi-precision /rigid bar connecting two or more attachments. When viewed from the cross-section it appears a keyhole consisting of a rectangular bar with a rounded superior ridge that creates a retentive undercut for the female clip within the removable prosthesis. The bar provides mechanical retention and the round part makes the bar resilient type and thus some amount of movement is seen in this attachment. The sleeves which are available commercially in plastic form can be cast and converted to metal if extra retention is required.



Bar clips or riders are available in different Materials and configurations:

The metal clips/riders are fully adjustable.

Plastic Hader clips are non-adjustable, but they can easily be replaced at chair side.

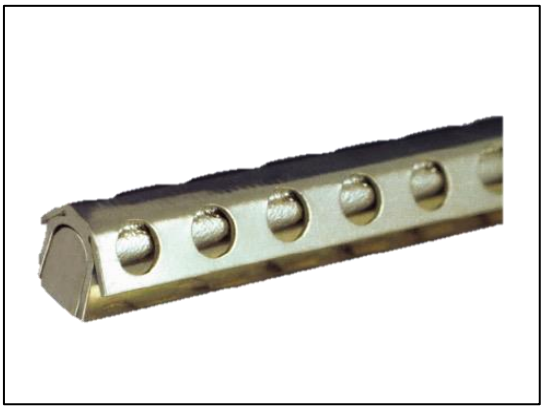
Use of a metal housing with Hader plastic clips is strongly recommended.

DOLDER BAR ATTACHMENT

It is named after swiss prosthodontist Eugene j dolder. The bar is straight and is rounded at the top. The Sleeves that fit over the bargain retention by friction only. The bar is available in various sizes and when cross sectionally viewed appears to be pear-shaped. The clip which is fitted in the denture base allows some rotational movement. It is available in sizes in diameter of 1.6 and 2.2 mm [7, 9, 13].

Ackermann and CM bar These bars are round when viewed in cross-section. As they are round they offer some resiliency and can be bent in all directions. A short extension of 5 mm is carried behind the most distal root and the sleeve is positioned on this section. Sleeves or clips are made up of gold. Available in 1.8 mm diameter in plastic and gold. The CM bar is available in a 1.9 mm diameter and used in long-span cases.

This type of attachment offers 45–55 percent load relief to the supporting implants.



Indications:

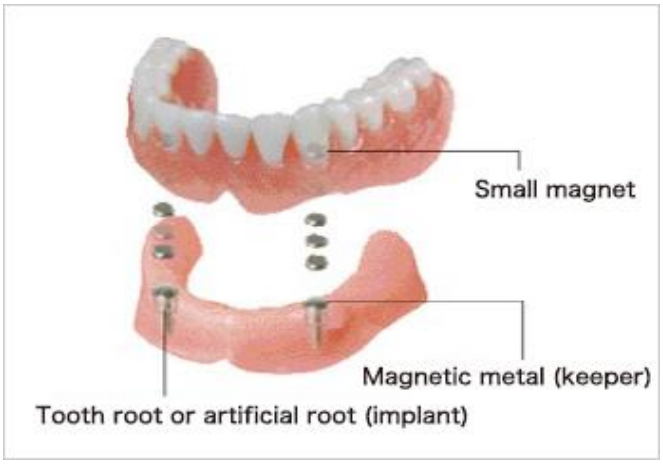
- Over-denture patients with adequate or relatively large inter-ridge space.
- When minimum resiliency and maximum retention from a removable denture is expected.

Contraindication

- Minimum inter-ridge space.
- Poor compliance in maintenance and oral hygiene.
- Financial limitations (Wiley. Kindle Edition; 2017)

Magnetic attachments

Magnetic attachments have a long history (>60 years) of use in denture retention. They reduce the transfer of horizontal stress to the implants and the bone during the insertion and removal of the denture. They are low-profile attachments, and the corrosion and loss of magnetism are significant complications associated with their usage. Over-denture attachments present very high survival rates.



DISCUSSION

Our study reported survival rates ranging from 96% to 97% for bar attachments, 96% to 100% for ball attachments, 90% to 92% for magnets, and 97% for locators with a mean follow-up period of 3 years. Other studies have reported a 94% five-year survival rate for the bar attachment 89% and 93% survival rates for the bar and locator, respectively, and 98% and 97% survival rates for the bar and the locator, respectively [1, 2, 4].

Whereas, Kleis *et al*., reported that locator attachment required frequent follow visits. This result is consistent with a systematic review reported by Miler AM *et al.*, which also concluded that the nylon ring of the male component of locator attachment required frequent replacement visits. Optimum peri-implant tissue health was maintained using a ball and bar attachment systems.

The highest level of patient satisfaction was acquired on using magnetic attachment followed by ball and bar attachments. Naert *et al*., compared splinted bar attachment with unsplinted ball and magnet attachments and found that the bar variety showed greater mucosal changes. At the same time, the other group studied showed more prosthetic complications.

Systematic review and meta-analysis performed by Chaware and Thakkar compare the reports pertaining to both maxillary and mandibular arch. At the same time, the focus of the current systematic review and meta-analysis was to evaluate randomized clinical controlled trials, and crossover studies performed only in mandibular overdenture cases. The present study exclusively included those studies with a longer follow-up period. The current meta-analysis utilizes the Cochrane Collaboration Tool of Risk of bias which was not correctly represented by Chaware and Thakkar.

It was demonstrated by York that the patients' satisfaction and quality of life were substantially improved with mandibular implant-supported overdenture than conventional dentures. The results obtained from this systematic review and meta-analysis would help injudicious selection, predictable functioning, and maximum longevity of prosthesis selected for rehabilitation of the oral cavity

CONCLUSION

For implant over-dentures in patients, bar attachments showed the highest incidence of complications related to mandibular over-dentures, and stud attachments showed the highest incidence of complications related to the attachment components.

There is still some controversy as to whether bars or stud attachments need more maintenance. There is no evidence for one outstanding attachment system. The choice of systems should be orientated on the individual clinical situation and the individual needs of the patients.

RECENT RESEARCH AND FUTURE PERSPECTIVES

Research and clinical applications in implant dentistry had led to the development of various bio and digital prosthetic dentistry materials. A key developmental component has comprised advances in artificial intelligence, which has been implemented in several dental and dental technology workflows. Newer materials can be integrated with over-denture attachment systems. Recently, polyether ether ketone (PEEK) and polyether ketone ketone (PEKK) have been widely used in implant and restorative dentistry (Li *et al*.,).

Evaluated the retention of PEEK post-core restoration with poly vinyl siloxane (PVS) attachment systems, and their cyclic dislodgement test showed an inverse linear relationship between cyclic times and retention force. The PVS's retention was enhanced with an increase in Shore hardness, thus showing a favorable retention force. Therefore, post-core PEEK with PVS attachments may comprise an excellent alternative attachment system in dentistry [12].

Digital dentistry is rapidly developing and is not limited to provisional restorations or implants; rather, it permeates all aspects of this profession. However, existing digital dentistry research and applications have limitations. It has been shown that dentists are using only a fraction of available data for planning and treatment, so they are not fully utilizing the growing body of information. Additionally, numerous studies have not entirely engaged with the rigorous planning, conducting, and reporting standards established by evidence-based research practice. There is a need to integrate this technology, clinical dentistry, and interdisciplinary research to overcome these issues [11, 22].

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