

SYSTEMATIC REVIEW

Effect of the attachment system on the biomechanical and clinical performance of overdentures: A systematic review

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An overdenture prosthesis is an alternative that results in greater comfort, patient satisfaction, and retention for the rehabilitation of edentulous patients when compared with conventional complete dentures.^{1,2} When compared with fixed implant-supported complete dentures, overdentures require fewer implants, resulting in a lower initial cost and more rapid completion of the prosthesis.³ Furthermore, overdentures facilitate oral hygiene, maintaining the health of the oral mucosa and peri-implant tissues, especially in elderly patients with motor disabilities.⁴ However, although lower tensile and compressive stress develops in the implants, an overdenture is associated with an increased risk of prosthetic fracture.⁵

Clinical studies have reported the high survival rate of the implants that support overdentures, from 96% to 100% at 12 months⁶⁻⁸ to almost 95% at 24 and 55 months.^{5,9} However, the maintenance and complication rates are relatively high, especially when associated with loss of retention of the overdenture attachments.^{5,9}

ABSTRACT

Statement of problem. Overdentures can improve the quality of life of elderly patients compared with conventional complete dentures. Different attachment systems can be used to retain these prostheses, but which system results in better function, mechanical performance, and patient comfort is unclear.

Purpose. The purpose of this systematic review was to evaluate randomized clinical trials to compare overdentures supported by either bar and clip or ball and O-ring attachments for retention, masticatory efficiency, bone loss, and patient satisfaction.

Material and methods. A literature search was conducted in the PubMed and Web of Science databases. From 163 studies, 16 randomized clinical trials were included in this systematic review based on the inclusion and exclusion criteria. The risk of bias was evaluated according to the RevMan software Risk of Bias Table (RoB Table), and only the studies with a low or intermediate risk of bias were included in the review.

Results. From the limited number of studies, the attachment type did not affect the masticatory quality of the patients, bone loss marginal to the implants, or the degree of patient satisfaction. However, overdentures with the bar and clip attachment tended to have higher initial retention than the ball and O-ring system.

Conclusions. Both the bar and clip and ball and O-ring attachment systems presented similar clinical performance regarding mechanical and functional properties and patient satisfaction. (J Prosthet Dent 2019;■:■-■)

Different attachment types have been proposed for the retention and stabilization of overdentures, with different longevity, biomechanics, functionality, and patient comfort.¹⁰⁻¹² The most common attachment systems have been the bar and clip and ball and O-ring systems. The bar and clip can be more or less rigid depending on the shape of the transverse section and the clip material composition.¹³ With a bar and clip attachment, the presence of a bar extension on the distal of the

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Clinical Implications

Both overdenture attachment systems had similar performance regarding bone loss, masticatory efficiency, and patient satisfaction, so other factors such as patient motor skills, ability to clean the prosthesis, compliance with the treatment, and cost should be used to choose the attachment system.

last implant forms a cantilever that increases the retention area of the prosthesis,¹⁴ but loss of retention over time and a higher biofilm accumulation has been reported.^{14,15} The ball and O-ring attachments are resilient, and the polymeric retention ring allows for stress relief, reducing the stress over the implants.^{16,17} However, the main issue associated with this system is the high rate of maintenance and the need to change the ring, which leads to loss of retention over time.^{18,19}

Both the bar and clip and ball and O-ring attachments present advantages and limitations and have been used successfully for overdentures,^{17,18} so the selection of the optimal attachment type is unclear. Therefore, the purpose of this systematic review was to compare the behavior of overdentures supported by bar and clip or ball and O-ring attachments regarding retention, maintenance, masticatory efficiency, bone loss, and patient satisfaction.

MATERIAL AND METHODS

Randomized clinical trials that compared the ball and O-ring attachment system to the bar and clip attachment system for overdentures were evaluated in this systematic review. Data from edentulous patients using overdentures supported by 2 or more implants in the maxilla and mandible were included, and the outcomes evaluated were retention, masticatory quality, bone loss, and patient satisfaction. The study was registered in the PROSPERO platform (CRD42018110932). In the identification phase, the literature search was conducted independently by 2 researchers (F.G., V.L.C.) in the Web of Science (Thomson Reuters Inc) and PubMed (NCBI) databases by using the following terms: (((((((((comfort) OR satisfaction) OR welfare) OR masticatory efficiency) OR chewing efficiency) OR loss bone) OR retention) AND overdenture) AND ball) AND bar, with no language restriction. In case of any divergence between the reviewers, a prosthodontist (P.R.Z.) was consulted. The search retrieved 126 articles from the Web of Science database and 126 from PubMed, and removal of duplicate articles resulted in 163 studies (Fig. 1). A hand search was done in the reference lists, and a search of nonpeer-reviewed literature was conducted in the database

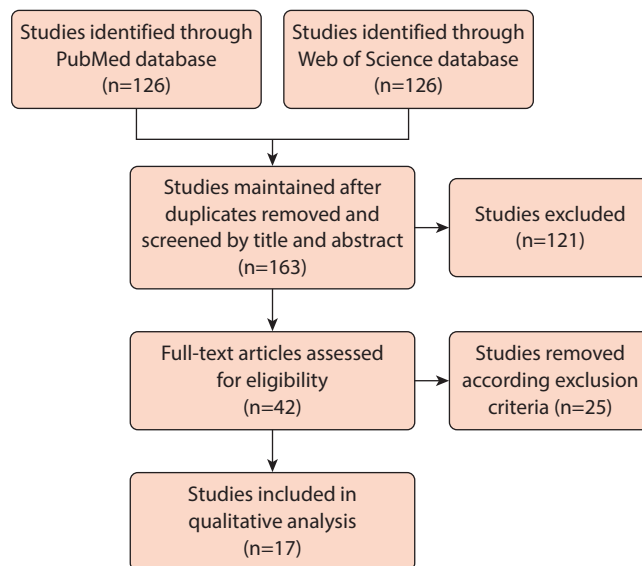


Figure 1. Flowchart of study selection.

OpenGray (INIST-CNRS), and in the database from the authors' institutions, and no additional publications were found. The studies were initially evaluated by their title and abstract according to the inclusion and exclusion criteria. The inclusion criteria were clinical trials that compared overdentures supported by bar and clip and ball and O-ring attachments regarding one of the following outcomes: retention, bone loss, masticatory efficiency, or patient satisfaction. The exclusion criteria were the absence of a direct comparison between the attachments, the absence of a statistical analysis, and studies with mini-implants. The risk of bias was evaluated according to the RevMan software Risk of Bias Table (RoB Table), and only studies with a low or intermediate risk of bias were included in the study. For clinical trials that evaluated the same study population, only the study with the higher observation time was included.

RESULTS

At the final screening, 17 studies were included in the analysis (Fig. 1). Of these, 3 evaluated retention, 3 observed masticatory efficiency, 7 observed bone loss, and 9 evaluated patient satisfaction.

Seven retrospective studies were excluded because of the high risk of bias^{18,20-25} such as the absence of clear random sequence generation, incomplete outcome data, and a large discrepancy in the sample size of the groups: 2 studies regarding masticatory efficiency,^{18,25} 4 that observed bone loss,^{18,20,23,24} and 5 that evaluated the patient satisfaction.²⁰⁻²⁴ Regarding retention analysis and bone loss, 3 clinical studies fulfilled the inclusion criteria²⁶⁻²⁹; however, they evaluated the same population at different time intervals, so of the 3 studies, only

Table 1. Characteristics of the included studies in retention analysis of overdentures supported by bar and clip or ball and O-ring attachments

| Authors | Year | Site, Number of Implants | Better Performance |
|--------------------------------|------|---------------------------|--------------------|
| Burns et al ¹⁴ | 2011 | Mandible, 2 or 4 implants | Ball and O-ring |
| van Kampen et al ³⁰ | 2003 | Mandible, 2 implants | Similar |
| Naert et al ²⁷ | 1999 | Mandible, 2 or 4 implants | Bar and clip |

Table 3. Characteristics of the included studies in bone loss analysis of overdentures supported by bar and clip or ball and O-ring attachments

| Authors | Year | Site, Number of Implants | Better Performance |
|---------------------------------|------|---------------------------|---|
| Elsyad et al ³⁵ | 2016 | Mandible, 2 implants | Bar and clip in vertical; similar in horizontal |
| Viswambaran et al ³⁸ | 2015 | Mandible, 2 implants | Similar |
| Stoker et al ³⁷ | 2012 | Mandible, 2 or 4 implants | Similar |
| Burns et al ¹⁴ | 2011 | Mandible, 4 implants | Similar |
| Cune et al ³⁴ | 2010 | Mandible, 2 implants | Similar |
| Naert et al ²⁶ | 2004 | Mandible, 2 implants | Similar |
| Gotfredsen et al ³⁶ | 2000 | Mandible, 2 implants | Similar |

that with the highest observational time was included in the current results.^{26,27} The others studies of retention, masticatory efficiency, bone loss, and patient satisfaction were randomized clinical trials and all presented with a low or intermediate risk of bias and were included in this review.

Only 3 clinical studies evaluated the retention of overdentures with bar and clip and ball and O-ring attachments, and the results were divergent: 1 reported better retention with the bar and clip system,²⁷ another with the ball and O-ring system,¹⁴ and 1 reported similar results for both³⁰ (Table 1).

In the selected studies, the efficacy of patient mastication was measured from different aspects, including maximum occlusal force, muscular activity, masticatory function (size of particles obtained), and masticatory efficiency (masticatory cycles needed). Three randomized clinical trials compared 1 or more of these masticatory aspects in patients with mandibular or maxillary overdentures supported by bar and clip or ball and O-ring attachments (Table 2),³¹⁻³³ and no differences were observed between the 2 attachment systems with regard to the mastication or maximum occlusal force of the participants.

Bone loss around the support implants for mandibular overdentures was evaluated in 7 randomized clinical trials (Table 3).^{14,26,34-38} Six of these trials did not observe a difference in bone loss between participants with overdentures supported by bar and clip or ball and O-ring attachments.^{14,26,34,36-38} Only the study by Elsyad and Khirallah³⁵ reported greater vertical bone loss with the ball and O-ring attachment on the buccal, mesial, and distal surfaces, but in the same study, differences in horizontal bone loss were not observed.

Table 2. Characteristics of the included studies in mastication analysis of overdentures supported by bar and clip or ball and O-ring attachments

| Authors | Year | Site, Number of Implants | Better Performance |
|----------------------------------|------|----------------------------------|--------------------|
| Elsyad et al ³¹ | 2014 | Maxilla and mandible, 4 implants | Similar |
| van der Bilt et al ³² | 2006 | Mandible, 2 implants | Similar |
| van Kampen et al ³³ | 2004 | Mandible, 2 implants | Similar |

Table 4. Characteristics of the included studies in patient satisfaction analysis of overdentures supported by bar and clip or ball and O-ring attachments

| Authors | Year | Site, Number of Implants | Better Performance |
|---------------------------------|------|---------------------------------------|---|
| Viswambaran et al ³⁸ | 2015 | Mandible, 2 implants | Similar |
| Burns et al ¹⁴ | 2011 | Mandible, 4 implants | Ball and O-ring |
| Cune et al ³⁴ | 2010 | Mandible, 2 implants | Similar |
| MacEntee et al ⁴⁰ | 2005 | Mandible, 2 implants | Similar |
| Naert et al ²⁶ | 2004 | Mandible, 2 implants | Similar in general and ball and O-ring in stability |
| Timmerman et al ⁴¹ | 2004 | Mandible, 2 or 4 implants | Bar and clip in retention and stability |
| Walton et al ⁴² | 2002 | Mandible, 2 implants | Similar |
| Bergendal et al ³⁹ | 1998 | Maxilla and mandible, 2 to 5 implants | Similar |
| Wismeijer et al ⁴³ | 1997 | Mandible, 2 implants | Similar |

Nine randomized clinical trials evaluating patient satisfaction in relation to the use of overdentures supported by bar and clip or ball and O-ring attachments were included in this systematic review (Table 4).^{14,26,34,38-43} General aspects were analyzed, which included esthetic outcomes, mastication, phonetics, retention, ease of use, and hygiene, and all studies reported no difference in the general satisfaction of the participants. However, when specific aspects were analyzed, Naert et al²⁶ reported higher satisfaction regarding overdenture stability using a ball and O-ring attachment after 10 years. In contrast, Timmerman et al⁴¹ reported higher satisfaction in participants with a bar and clip attachment regarding retention and stability after 8 years.

DISCUSSION

Several attachments systems are available for retaining and supporting overdentures. Although the bar and clip and ball and O-ring have been the most reported systems, others systems such as LOCATOR (Zest Dental Solutions), ERA (Sterngold), and magnets have been developed exhibiting better stress distribution^{12,44} and clinical success.^{45,46} However, these system attachments were not included in this study because of an insufficient number of randomized clinical trials comparing these systems with the bar and clip or ball and O-ring attachment system for the outcomes evaluated.

Two studies that compared retention had inconsistent results, and 1 showed similar performance for both systems. The main difference between the 2 studies was the observational time; Naert et al²⁷ evaluated a population with 5 years of overdenture use and observed better performance with the bar and clip system; Burns et al¹⁴ evaluated a short time of overdenture use (6 or 12 months) and reported higher retention with the ball and O-ring system. Clinical studies have reported that overdentures supported by ball and O-ring attachments need maintenance more often than those supported by bar and clip attachments. This is because of the wear of the polymeric ring component of the O-ring, which needs to be exchanged to maintain the retention of the prosthesis.^{16,27} However, loosening of the clip in the bar and clip system and the consequent loss of retention have also been observed.^{47,48} In vitro mechanical cycling resulted in a higher loss of initial retention with the bar and clip system⁴⁹ in up to 100 cycles of insertion and removal of the overdenture prosthesis because of clip loosening. However, considering over 14 600 movements, both systems tend to present similar results,⁵⁰ indicating that the elastomeric O-ring is worn out when used more. Therefore, better retention is obtained with the ball and O-ring system initially but is lost over time. Anas El-Wegoud et al⁵¹ also conducted a systematic review regarding retention among different attachment systems, but since only 1 study was included, it was not possible to draw conclusions.

Other factors can contribute to mandibular overdenture retention when supported by 2 implants, such as the distance between the implants.⁵² Michelinakis et al⁵² reported that at distances of less than 23 mm between the implants, there was no difference in retention based on the attachment type; however, at distances greater than 29 mm, retention increased with ball and O-ring attachments. With greater distances, only 1 clip in the center of the 2 implants concentrates the stress of a larger area over the clip and reduces its effectiveness compared with the ball and O-ring system, which has 2 O-rings between the implants and therefore better distribution of the load received, supporting higher stress.

Different aspects, including maximum occlusal load, muscular activity, masticatory function (size of particles obtained), and masticatory efficiency (masticatory cycles needed), were considered in determining masticatory performance. Three randomized clinical trials were evaluated in this systematic review,³¹⁻³³ and, although the studies showed high methodological variability regarding the number of implants and localization, none of them found any differences between the bar and clip and ball and O-ring attachment systems with regard to mastication or the maximum occlusal force; this finding is also in agreement with retrospective studies that compared these attachment systems.^{18,20} The sample size

among the studies varied between 11 and 18 participants, but no study reported a sample size calculation. The study by van Kampen et al³³ reported differences in masticatory function between the ball and O-ring and bar and clip systems in relation to the magnetic attachment, as well as between conventional complete dentures and overdenture prostheses. Furthermore, van der Bilt et al³² also reported differences between muscular activity with conventional complete dentures and overdenture prostheses, indicating that the sample size was sufficient to detect differences between the groups. More randomized clinical trials with a calculated sample size are needed to strengthen the results found in this systematic review. The higher stability and retention of overdentures compared with conventional complete dentures, depending on the attachment system, might be the main factor that enables the patient to reach a better titration capacity, increased occlusal force, and higher muscular activity.

The majority of the evaluated studies, 6 of 7, did not observe differences in bone loss between the 2 attachment systems.^{14,26,34,36-38} However, according to Elyasad et al,³⁵ the ball and O-ring system was associated with greater vertical bone loss on the buccal, mesial, and distal surfaces than the bar and clip system. Compared with the other studies, the study by Elyasad et al was the only one to use computed tomography to analyze the outcomes, being a more accurate methodology than the radiographic examination used in the other studies. However, the detected differences ranged from 0.3 to 0.6 mm after 3 years of prosthesis use,³⁵ and although the values were statistically different, they may not reflect a significant clinical difference.⁵³ Retrospective and cross-sectional clinical studies,^{15,17,19,20} although not included in this systematic review, corroborate the results found and did not observe differences in bone loss according to the attachment system, indicating a similar behavior of the 2 attachment systems regarding this variable.

Among the studied variables, patient satisfaction is one of the more relevant variables, since a lack of satisfaction may lead the patient to abandon the prosthesis or look for other treatments. None of the studies reported any differences in the general satisfaction of the participants, including esthetic outcomes, mastication, phonetics, retention, ease of use, and hygiene aspects. However, when specific aspects were analyzed, some differences were observed. Naert et al²⁶ reported higher satisfaction with the stability of the ball and O-ring attachment after 10 years, and Timmerman et al⁴¹ reported higher satisfaction regarding retention and stability after 8 years with the bar and clip system. Retrospective and cross-sectional studies also showed a similar performance for both attachment systems in this respect.^{17,20,44} A systematic review of only 1 study reported a similar performance between the 2 attachment types.⁵¹

In healthy patients, satisfaction with overdenture use is high with mandibular prostheses, especially if the patient has had a previous experience with conventional complete dentures.^{27,41} However, factors other than masticatory efficiency, bone loss, retention, and patient satisfaction can influence patient welfare and should also be considered by the dentist when planning which attachment system to use. For example, in patients with motor disabilities, the hygienic capacity can be restricted, and a greater degree of difficulty with hygiene has been highlighted with the bar and clip system¹⁵; some studies have also observed a higher index of hyperplasia,²² ulcers, and candidiasis in overdentures with this retention system.⁵⁴ Therefore, although a similarity in the performance of both the bar and clip and ball and O-ring systems can be observed in conventional situations, the particularity of each patient can be used to define the optimal attachment system.

CONCLUSIONS

Based on the findings of this systematic review, the following conclusions were drawn:

1. Mastication, bone loss, and patient satisfaction were not influenced by the attachment type (bar and clip or ball and O-ring) used for mandibular overdentures.
2. There is a tendency for better initial retention with the bar and clip attachments; however, other factors such as time of use, distance between the implants, and angulation of the implants can also significantly affect this variable and should be taken into consideration.

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