



REVIEW ARTICLE

Do ball-type attachment systems for overdenture result in better patient-satisfaction? A systematic review of randomized crossover clinical trial



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Abstract Objective: This review is to compare patient-satisfaction with ball-type overdenture attachment systems with others attachment systems.

Material and methods: This study was registered in PROSPERO (CRD42018097234) and adheres the PRISMA guidelines. Electronic searches on PubMed/MEDLINE, Scopus, Cochrane, and Web of Science databases for published articles were performed before October 2020. The PICO question was: “Do patients with a ball-type overdenture retention system have greater satisfaction, when compared to other attachment systems?” The evaluation of risk of bias was performed using the Cochrane risk of bias tool.

Results: After searching the databases, seven articles were selected out of a total of 2583. A total of 312 implants were placed in 139 patients, with a mean age of 65.9 years. The risk of bias in the included studies varied according to the different domains in a risk of uncertain bias or low bias risk. No difference was found between the ball attachment systems and the others systems, with respect to patient-satisfaction. The meta-analysis revealed no statistically significant difference between the ball systems and another systems ($P = 0.11$; MD: 10.90; 95% CI: -2.55 to 24.35).

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Conclusions: Regarding patient general satisfaction, it was not possible to determine differences between the ball system and another types of attachment system for overdenture. The ball-type system was statistically superior only to the magnet system.

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1. Introduction

The principles of osseointegration in dentistry has enabled the emergence of a new perspective for the oral rehabilitation of completely edentulous patients, which include implant overdentures (Melas et al., 2001; Veyrone et al., 2005), in fact overdentures supported by two implants are considered to be the first choice of treatment for completely edentulous patients, according to the consensus of McGill in 2002 (Feine et al., 2002) and the York Consensus Statement with McGill (Thomason et al., 2009).

A wide variety of commercially available attachment systems are used to attach implants to overdentures (Alqutaibi and Kaddah, 2016). However, literature has several contradictory opinions regarding the type of attachment system that would be the most beneficial to the patient (Cicciù et al., 2019).

The ball-type system (O-ring) is one of the most commonly used overdentures, because it has a simple manufacturing technique, can be fabricated at low cost (Sadowsky, 2001), easy to maintain, and easy to keep a good hygiene. It consists of an intermediate with a spherical socket at its end, with the assembly (male component) being attached to the implant, and a female component, which has a retaining ring, associated with the base of the prosthesis. However, there is no strong evidence to prove superiority of this overdenture attachment system over other systems, regarding to patient satisfaction (Carlsson, 2014), mainly when considering the results of cross-

over studies, effective in reducing confounding factors on cause and effect relationships (Clancy, 2002).

Thus, this systematic review was conducted with the aim of comparing the ball-type attachment system with other systems, with respect to patient satisfaction. The null hypothesis of this study is that there is no difference in patient satisfaction between the ball-type attachment system and other overdenture attachment systems.

2. Materials and methods

2.1. Protocol registry

This systematic review followed the criteria established by PRISMA (Moher et al., 2010), and is registered with the international registration database for systematic reviews, PROSPERO (Reg. no: CRD42018097234).

2.2. Research methods and search strategy

Two investigators (C.D.D.R.D.R and R.S.L) independently performed electronic searches on PubMed/MEDLINE, Scopus, Cochrane and Web of Science databases for articles published prior to October 2020, which met the eligibility criteria.

The keywords used for the search were: “overdenture and satisfaction OR overdenture and ball attachment OR overden-

ture and nonsplinted attachment OR overdenture and un-splinted attachment". In addition, a manual search was performed in the following journals: Clinical Oral Implants Research, Journal of Oral Rehabilitation, The Journal of Prosthetic Dentistry, Journal of Prosthodontics, Journal of Dentistry, International Journal of Oral and Maxillofacial Surgery, and the Clinical Oral Investigations journal.

The inter-examiner test (Kappa) was used as an additional analysis to evaluate the researchers' agreement on the titles and abstracts selected for each database (PubMed / MEDLINE, Scopus, Cochrane and Web of Science). All disagreements were analyzed and resolved by a third reviewer (S.L.D.M), and a consensus was established.

2.3. Eligibility criteria

The PICO strategy (population, intervention, comparison, outcome) was used to answer the question: "Do patients with a ball-type overdenture retention system have greater satisfaction, when compared to other systems?", where "population" referred to patients rehabilitated with overdenture prostheses, "intervention" referred to patients rehabilitated with ball-type overdenture prostheses, "comparison" referred to comparing the overdenture prosthesis with another type of attachment system (bar, magneto, locator and equator), and finally the "outcome" referred to the level of patient satisfaction with these systems.

The inclusion criteria was defined randomized crossover trials with at least 10 participants and at least 6 months of follow-up, and that the study was conducted in the English language, which compared ball retention systems with another type of attachment. Retrospective, in vitro and animal studies, computational studies and case series were the exclusion criteria used.

2.4. Risk of bias and evaluation of study quality

Two investigators (C.D.D.R.D.R. and R.S.L.) evaluated the methodological quality of the studies through the Cochrane risk of bias tool, to assess the risk of quality bias of the studies included for this review. This tool evaluates the quality and risk of bias of the studies based on sequence generation, allocation concealment, blinding of participants, personnel or outcome investigator, incomplete outcome data, selective outcome reporting and other sources of bias, and classified as Low, High or Unclear risk of bias, according to the studies evaluated.

2.5. Data extraction

Qualitative data were collected by one of the authors (C.D.D.R.D.R.), and a second author (R.S.L) verified the information. However, due to disagreement between these authors, a third author (S.L.D.M) minutely evaluated the disagreements and a consensus was arrived at, through a discussion.

The following information for each selected study was included in a Microsoft Office Excel table: author, number patient, mean age, number implant for patients, design of study, attachment types, arch (Maxilla / Mandible), implant system and dimensions (mm), satisfaction evaluated methods, outcomes results, conclusion, follow-up, patients preferences.

2.6. Summary measures

Quantitative analysis was performed based on a continuous outcome with the determination of inverse variance (IV) and respective 95% confidence intervals (CI) for the comparison of patient satisfaction (visual analogic scale (VAS) ranging from 0 to 100) to the type of attachment system (ball × another systems). For that it was using the mean difference (MD). The Reviewer Manager v5.4 software program (Nordic Cochrane Centre, Cochrane Collaboration, 2014) was used for the meta-analysis and creation of the forest plots, with a p-value < 0.05 considered indicative of statistical significance.

2.7. Additional analysis

In the meta-analysis, additional subgroup analysis was performed for the other types of attachment systems × ball systems (ball × magneto; ball × locator and ball × bar).

3. Results

A total of 2583 references were found from searches conducted in PubMed (897), Scopus (779), Cochrane (272) and Web of Science (665), and 13 articles were selected and analyzed fully, after screening the title and abstract. Three references were excluded due to the lack of comparison between the groups (Cune et al., 2010; Bilhan et al., 2011; Van der bilt et al., 2006). Three other articles were excluded because: it did not evaluate the general satisfaction of the patient (Pisani et al., 2017), it did not evaluate the attachment ball (Mahanna et al., 2020) and Cune et al., 2006 is not in English. The search strategy is detailed in the flow diagram (Fig. 1).

The inter-examiner test (kappa) presented a total score of 0.82 for PubMed/MEDLINE; 0.90 for Scopus and 0.93 for The Cochrane Library, and a high level of agreement among reviewers was considered according to the kappa criteria (Landis & Koch, 1977). All the 7 articles selected (Burns et al., 1995; Burns et al., 2011; Cune et al., 2005; Ellis et al., 2009; Krennmair et al., 2012; de Albuquerque et al., 2019; Taha et al., 2019) and randomized crossover clinical trials.

A total of 312 implants were used in 139 patients with a mean age of 65.9 years. All rehabilitations with overdentures were in the mandibular arch. Camlog, Screw-line, Altatec; Brånemark, Nobel Biocare; Frialit-2, Friadent; Calcitek Corp and Titamax, CM Cortical, Neodent Implants were the most widely used implant systems (Table 1).

Five studies used only 2 implants (Burns et al., 1995; Cune et al., 2005; Ellis et al., 2009; Krennmair et al., 2012; de Albuquerque et al., 2019), one study used 4 implants (Burns et al., 2011) and one study used 1 implant (Taha et al., 2019). Overall, 323 overdentures were installed, and all patients received the ball-type system, during treatment. Other fittings used in the studies included 43 overdentures with Locator retention system, 9 overdentures with Equator retention system, 27 overdentures with splint bar in 4 implants, 45 overdentures with splint bar in 2 implants, and 51 overdentures with magnet clamps. The mean follow-up time was 11 months (range: 6–36 months). Qualitative data can be observed in Table 1.

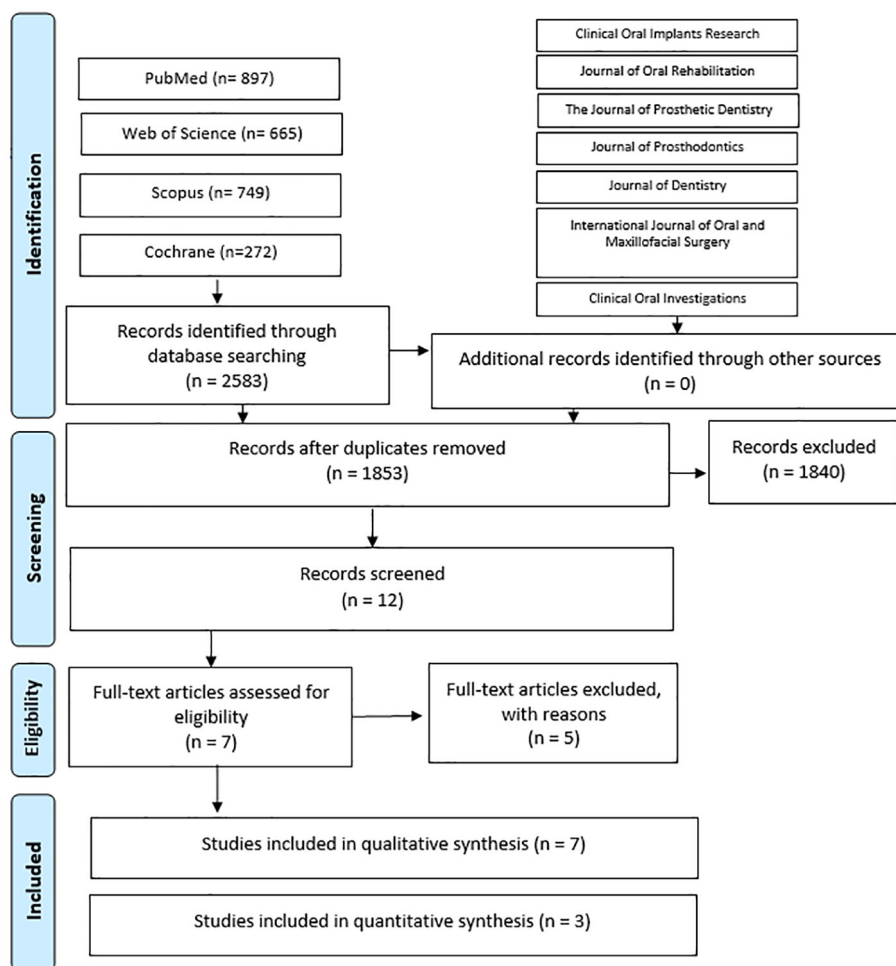


Fig. 1 Search strategy.

Five studies evaluated patient satisfaction using only the Visual Analogue Scale – VAS (Cune et al., 2005; Ellis et al., 2009; Krennmair et al., 2012; de Albuquerque et al., 2019; Taha et al., 2019). Two studies evaluated patient satisfaction using only a questionnaire (Burns et al., 1995; Burns et al., 2011). Five studies reported that there was no statistically significant difference between attachment systems (Burns et al., 1995; Burns et al., 2011; Cune et al., 2005; Krennmair et al., 2012; Taha et al., 2019); one study (Ellis et al., 2009) showed that there was a statistically significant difference for three domains: general satisfaction ($P = 0.024$), stability ($P = 0.049$) and chewing ability ($P = 0.024$), with the results being higher for the ball attachment group and De Albuquerque et al., 2019 showed Significant differences, in retention domain for ball attachment. For the included studies the meta-analysis revealed no statistically significant difference between the ball systems and another systems ($P = 0.11$; MD: 10.90; 95% CI: -2.55 to 24.35). Subgroup analysis showed that only the magnet system was statistically different from the ball. ($P < 0.00001$; MD: 26.08; 95% CI: 16.56 – 35.59). In addition to these results the analysis of the selected studies (Taha et al., 2019; Burns et al., 1995; Cune et al., 2005; Ellis et al., 2009) showed that there was an increase in patient satisfaction after replacing the conventional full mandibular prosthesis with overdentures regardless of the attachment system.

3.1. Risk of bias

The Cochrane risk of bias tool was used to assess the risk of bias of clinical trials and the outcome is described in Fig. 2 and Fig. 3. This scale presents evaluation by different domains. Only studies with a low or intermediate risk of bias were included in the review. In general, 3 domains (concealment of allocation, blindness of participants and professionals, and blindness of outcome assessors) presented a risk of uncertain bias; however, since the study does not report those information, and additional information is necessary to ascertain the risk of bias. In the other domains (random sequence generation, incomplete outcomes, selective outcome reporting, other sources of bias), at least 50% index was obtained for low bias risk.

4. Discussion

Patient expectation regarding treatment is a predictor of satisfaction (Jackson et al., 2001; Linder, 1982), in which completely edentulous individuals is related to the retentive capacity of the prostheses. Machado et al, 2017 identified that the factor that damages masticatory function most is the movement of the mandibular prosthesis. Rehabilitation with

Table 1 Summary of characteristics of included studies.

Author	Patient (n)	Mean age, years	Number implant for patients	Design of study	Attachment types	Arch	Implant system and dimensions (mm)	Satisfaction Evaluated Methods	Outcomes Results	Conclusion	Follow-up, months	Preference
Burns et al., 1995	17	61.2	2	RCT CROSSOVER	Ball (17) Magneto (17)	Maxilla: 0 Mandible: 17	Calcitek Corp., Carlsbad, Calif. D = NR L = NR	Questionnaire	NR	NS	12	Ball
Cune et al., 2005	18	45.5	2	RCT CROSSOVER	Bar (18) Ball(18) Magneto(18)	Maxilla: 0 Mandible: 18	Frialit-2, Friadent D = NR L = NR	VAS	Bar = 85.2 Ball = 86.2 Magneto = 60.2	NS	9	Bar
Ellis et al., 2009	22	64.3	2	RCT CROSSOVER	Ball (16) Magnetos (16)	Maxilla: 0 Mandible: 16	Bra°nemark Nobel Biocare D = NR L = NR	VAS	Ball = 97.0 Magneto = 55.0	Ball is better than magneto in the general satisfaction, stability and ability to chew.	6	Ball
Burns et al., 2011	30	58.9	4	RCT CROSSOVER	Bar 4 implants (27) Bar 2 implants(27) Ball 2 implants(27)	Maxilla: 0 Mandible: 27	Brånemark, Nobel Biocare D = 3.75 mm L = Varied	Questionnaire of 40 questions	NR	NS	36	Ball
Krennmair et al., 2012	20	62.4	2	RCT CROSSOVER	Ball (19) Locator(19)	Maxila:0 Mandible:19	Camlog, Screw-line, Altatec D = NR L = NR	VAS	Ball = 9.5 Locator = 10.0	NS	12	NR
De Albuquerque et al., 2019	24	73.2	2	RCT CROSSOVER	Ball (24) Locator(24)	Maxila:0 Mandible:24	Straumann implants D = 4.8 L = NR	VAS	Ball = 93.5 Locator = 94.0	Ball is better than Locator in retention.	12	Ball
Taha et al., 2019	18	66.1	1	RCT CROSSOVER	Ball (18) Equator (18)	Maxila:0 Mandible:18	Titamax, CM Cortical, Neodent Implants D = 3.75 L = 9 mm 11 mm 13 mm	VAS	Ball = 85.0 Equator = 91.7	NS	6	Equator

D = diameter; L = length NS = not significant; NR = not related; VAS = visual analog scale.

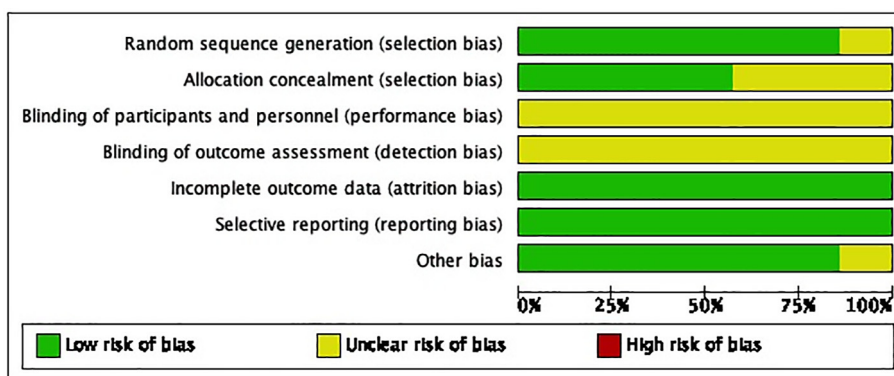


Fig. 2 The Cochrane scale for bias risk.

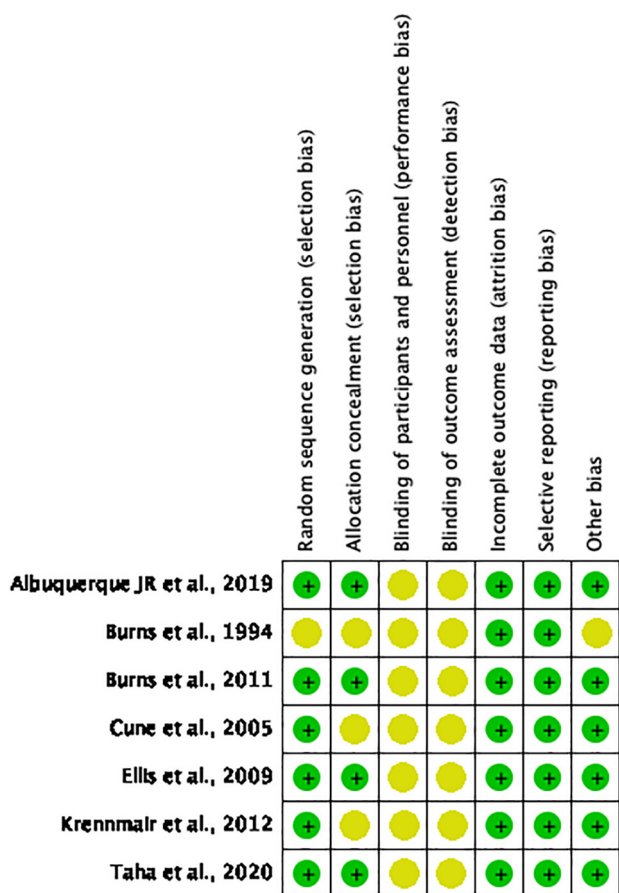


Fig. 3 Fig. 2. Assessment of the risk of bias in the included studies based on the Cochrane Risk of Bias Tools.

overdentures, when compared to conventional complete dentures, tend to promote greater patient satisfaction due to their greater functional capacity (Harris et al., 2013; Awad et al., 2014; Geckili et al., 2012; Jabbour et al., 2012).

Treatment satisfaction is a complex phenomenon, which is influenced by numerous factors, and is not strictly related to the stomatognathic system (Al Quran et al., 2001). Currently, there is no consensus on which overdenture retention system provides greater patient satisfaction (Anas El-Wegoud et al., 2018). The results of this systematic review are in agreement

with other studies (Naert et al., 1994; Naert et al., 1998; Kleis et al., 2010; Timmerman et al., 2004) that did not detected differences in patient satisfaction between the ball-type system, which is most commonly used, and other attachments, thus accepting the null hypothesis of this study, even though the majority of articles point to a preference for the ball-type system.

Studies that highlighted the main systems (ball, clip and magnetic bar), found that retention, chewing and comfort were the main factors that influenced patient-satisfaction. According to the Meta-analysis (Fig. 4) conducted in this study, there is a significant difference ($P < 0.00001$) in patient satisfaction when comparing the ball and magnet system, this can be explained by the difference in retention promoted by the systems. Van Kampen et al, found mean retention force for magnetic systems was 8.1 N (Bar-clip 31.3 N and Ball 29.7 N). This result may explain the greater patient satisfaction for the ball system in the work of Ellis et al, 2009 in which patients reported the perception of a difference in retention between the two systems, with the ball attachment system offering better retention than the magnetic system. In the study by Cune et al., 2005 patients preferred the ball attachment system, arguing that the mandibular denture was very stable during chewing and biting. Burns et al, 1995 also reported that the patients with ball-type fitting mentioned greater difficulty in removing the denture, when compared to those patients with the magnetic attachment. One aspect cited in the question “comfort” is the sensation of the abutments when the prostheses are out of the mouth. The ball fit is more prominent and angular and several patients reported a tongue discomfort as a result of the resting sensation over the abutment (Ellis et al, 2009).

On comparing the Locator and O-ring attachments, there were no significant differences in satisfaction, comfort, speech, aesthetics, chewing ability, or stability of the denture that could be identified (Krennmair et al., 2012). A overall average retention throughout the study was higher for the ball attachment, with a difference of 5.0 N (De Albuquerque et al., 2019), but no preference for one type of attachment versus the other was seen (De Albuquerque et al., 2019; Krennmair et al., 2012).

For patients who preferred the bar-clip attachment, the following issues were important: greater stability during chewing, compared to the magnet and O-ring, and a feeling of reassurance. However, the patients found that sanitization of the bar was harder, and thus a greater chance of marginal bone loss was possible due to peri implant causes (Cune et al., 2005).

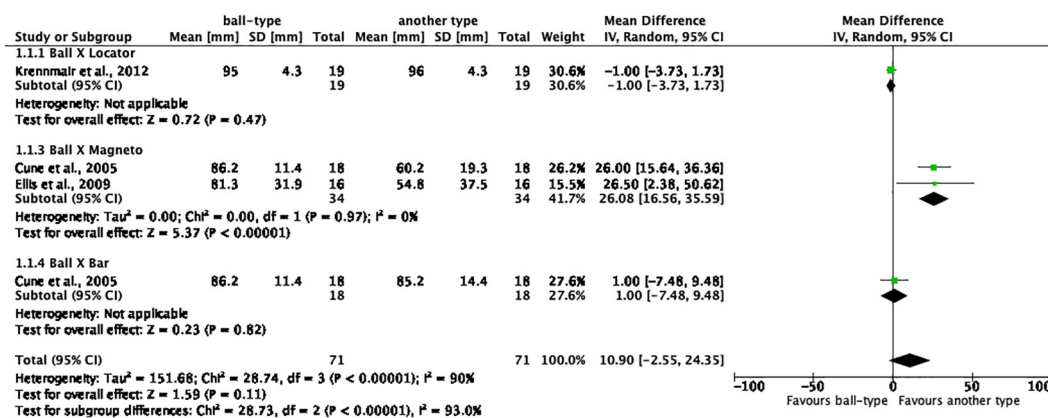


Fig. 4 Forest plot: comparison of studies evaluating patient satisfaction.

In this study, the patients reported retention of the attachment system as the main satisfaction factor. Timmerman et al., 2004 also suggested that patient satisfaction was linked to retention and stability of the prosthesis.

Retention and stability are important factors that determine patient satisfaction. Although retention of the prosthesis with O-ring supported by 2 implants is inferior to that of the bar-clip system with 4 implants, parameters such as chewing, phonetics, ease of hygiene, health of the periodontal tissues, maintenance, and complications favor the ball-type attachment, when compared to the bar-type (Burns et al., 2011). These factors, together with the small discrepancy between the retentive capacities of the systems (bar-clip 31.3 N and ball 29.7 N) (Van Kampen et al., 2003) may explain the lack of difference in patient satisfaction for the main systems found this review. There are other factors besides attachment retention in the success of the rehabilitation treatment with implant overdentures and the lack of retention does not prevent patients from eating satisfactorily (de Albuquerque et al., 2019).

In addition, over time, there was a notable increase in the retentive force of the O-ring system, whereas the bar and magnet systems showed a decrease in the retentive force. The increased retentive force in the ball group can be explained by improvement in seating of the overdenture base, that occurs with years of usage, unlike the attachment bar and magnet, which function as an “articulated” device for the overdenture (Naert et al., 2004). Thus, ball-type retentive fittings are known to be advantageous for overdentures with respect to stress optimization, minimizing prosthetic movements (Tokuhisa et al., 2003), simplicity, and fewer complications (Naert et al., 2004).

Crossover-type randomized clinical trials are effective in reducing confounding factors on cause-and-effect relationships when compared to other designs, hence, they are of great value as a source of evidence (Clancy, 2002). In this study, each subject functioned as their own control, and the comparison of the different interventions on intra-subject variation, thus, generating more reliability to the results of this systematic review. In addition, statistically, crossover studies are more powerful than parallel groups (Cleophas and de Vogel, 1998).

The results of this meta-analysis should be viewed with caution, due to the small sample included. In addition, there was a high rate of heterogeneity, which can also be attributed to the small number of studies included in the meta-analysis, which made it impossible to compare all types of attachments. Fur-

ther clinical trials are necessary to compare all attachments regarding patients satisfaction, to confirm this reviews results

In view of this, it is worth mentioning that in addition to the knowledge about the level of satisfaction of the retention systems, the professional should consider clinical and technical aspects such as implant parallelism, distance between implants, simplicity of the technique, cost, and patient hygiene, among others, that can guide the choice of the type of system to be used (Leão et al., 2018). However, the findings of this review should be analyzed with caution, since qualitative studies of patient satisfaction depends on patients’ capacity for comprehension. In addition, a limitation of this meta-analysis is the high heterogeneity of the included studies. Therefore, this study demonstrates the need for further randomized control trial studies on the subject, especially with long follow-up cases, which can also be considered as a limitation of this study.

5. Conclusion

Regarding patient satisfaction general, it was not possible to determine differences between the ball-type system and other types of attachment system for overdenture. The quantitative analysis showed that the ball-type system was statistically superior only to the magnet system.

CRedit authorship contribution statement

Cleber Davi Del Rei Daltro Rosa: Conceptualization, Data curation, Investigation, Writing - original draft. **Rafaella de Souza Leão:** Conceptualization, Data curation, Investigation, Supervision, Writing - review & editing. **Cátia Maria Fonseca Guerra:** Methodology, Supervision, Validation. **Eduardo Piza Pellizzer:** Methodology, Project administration, Validation, Visualization. **Bruno Gustavo da Silva Casado:** Data curation, Software, Writing - review & editing. **Sandra Lúcia Dantas de Moraes:** Methodology, Project administration, Supervision, Validation, Visualization, Writing - review & editing.

Declaration of Competing Interest

The authors of the manuscript declare that they have no conflict of interest: financial, commercial, political, academic, personal and no other relationships / conditions / circumstances that present a potential conflict of interest.

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Ethics approval

Not applicable.

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