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Review Article

Prosthodontic maintenance and peri-implant tissue conditions for telescopic attachment-retained mandibular implant overdenture: Systematic review and meta-analysis of randomized clinical trials

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ABSTRACT

The mandibular implant-retained overdentures (MIRO) are a highly successful prosthetic treatment option. However, an argument still present regarding its design and type of attachment system. This systematic review and meta-analysis aimed to perform a qualitative and quantitative analysis of the scientific literature regarding the telescopic attachments versus other attachment systems retaining mandibular implant overdentures. Manual and electronic database (PubMed and Cochrane) searches were performed to identify randomized controlled trials (RCTs) comparing telescopic versus other attachment systems. Independently, two investigators extracted the trials' data. The Cochrane tool was used for assessing the quality of included studies. Meta-analyses were performed for the included RCTs and reported the same outcome measures. Nine RCTs were identified. Three RCTs (corresponding to four publications) were included in the study. The other five trials were excluded from the study. The meta-analysis revealed no difference between telescopic crowns and ball attachment retaining mandibular implant overdenture as regards prosthodontic maintenance. Regarding peri-implant conditions, ball-retained mandibular overdenture showed statistically significant more probing depth around implants records in ball-retained overdenture when compared to the telescopic group. However, there are no statistically significant differences between two interventions in regard to marginal bone loss, bleeding index, gingival index, and plaque index. In conclusions, no significant differences in prosthodontic maintenance and peri-implant condition between telescopic attachments and ball attachments retaining MIRO. However, this should be considered with caution because of a limited number of included studies.

Key words: Ball attachment, bar attachment, implant overdenture, systematic review, telescopic attachment

INTRODUCTION

Usually, edentulous patients are complaining of difficulties during chewing and speaking leading to a decline in their quality of life. Especially in the mandibular arch, the space available to the prosthesis and its stability are reduced due to the presence of the tongue. The placement of two or more dental implants

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in the anterior mandible provides additional means of retention to stabilize mandibular overdentures and affords a safe and long-term clinical success.[1-3]

Mandibular implant-retained overdentures (MIRO) present a reliable and simple solution to enhance denture retention and stability. The retention and stability characteristics are provided mainly by implants through attachments. Hence, various types of attachment systems have been proposed for connecting implant-retained mandibular overdentures to the underlying implants.[4]

Splinted attachments as bar attachments is a popular choice because of its load sharing but requires sufficient interarch space;[4] it may cause mucosal hyperplasia underneath the bar if insufficient relief is present, and contraindicated to be used with a V-shaped ridge to avoid encroaching on the tongue space.[5]

Non-splinted attachments as telescopic and ball attachments.[6,7] Ball attachments are susceptible to wear and technique sensitive as they require parallel implants placement.[8] Telescopic attachments have excellent retention due to frictional fit between primary and secondary copings. The circumferential relation between telescopic attachment and the abutment allows better distribution of forces, results in transferring the occlusal load more axially leads to reducing the rotational torque on the abutment.[9,10] However, they require enough inter-arch space to be occupied. If there is no sufficient inter-arch space, telescopic attachment is not recommended to be used.[11]

To assess a MIRO, the implant survival rate and the complication rate are the most important factors.[12] To determine an implant prosthesis survival, it is better to mention "time to retreatment"[13] which is the time needed to perform any interference by the clinician to manage any prosthetic complications during the maintenance period.[14]

Implant overdentures complications may be biologic and technical complications. Biologic complications are any disturbances in implant function that affect the supporting peri-implant tissues in terms of early or late implant failures, and adverse reactions in the peri-implant hard and soft tissues. Technical complications are any mechanical damage of the implant, implant components, and suprastructures.[15] Prosthetic complications are the need of the final prosthesis after the insertion to be relined or repaired although it affects or not affects implant.[16]

In this review, the question is, Could the telescopic attachments in completely edentulous patients needing dental implant rehabilitation better than other attachment systems regarding implant survival, complications, and peri-implant tissue condition?

MATERIALS AND METHODS

Protocol registration

A prior protocol was made and registered at PROSPERO with registration NO: CRD42017054762.

The review structure

The "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" was followed.[17]

Eligibility criteria

According to the PICOS format provided by the Center for Evidence-Based Medicine, the focused question was formulated and served as a basis for the systematic literature search.[18]

- Population/problem: Completely edentulous patients with a MIRO
- Interventions: Telescopic crown attachments retaining MIRO
- Comparators: Other attachment systems (Ball, Bar, and Locator) retaining MIRO
- Outcome: Any outcome not predetermined or included in the search strategy
- Study design: Randomized-controlled trials (RCTs).

Exclusion criteria

Case report, case series studies, retrospective studies, cohort studies, animal studies, *in vitro* studies, or non-RCTs were not included. And any observation period of leass than 3 years.

Search strategy

The search was performed by two reviewers independently. Combinations of controlled terms (MeSH) and keywords were used whenever possible [Table 1]. A comprehensive electronic search was done in both PubMed and the Cochrane Central Register of controlled trials databases with language restriction to English only and without time restrictions. Furthermore, a manual search was done in the related journals, including; the Journal of Prosthodontics, the International Journal of Prosthodontics, Journal of Advanced Prosthodontics, the Journal of Prosthodontic Research, Journal of oral rehabilitation, Journal of Dental Research, and Journal of Oral and Maxillofacial surgery. Moreover, online databases providing information about clinical trials

Table 1: The search terms used for the search in electronic databases

(edentulous jaw) OR (edentulous mouth) OR (edentulous ridge) OR (edentulous arch) OR (edentulous mandible) OR (completely edentulous patient) OR (totally edentulous patient) OR (mandibular prosthesis) OR (mandibular prostheses) OR (mandibular overdenture) OR (mandibular implant retained overdenture) OR (mandibular implant assisted overdenture) OR (mandibular implant supported overdenture) OR (implant overlay) OR (implant prosthesis) AND (telescopic attachment) (OR telescopic crown) OR (telescopic overdenture) OR (telescopic prosthesis) OR (telescopic prostheses) OR (double crown) OR (double crowns) OR (double-crown) OR (conus attachment) OR (conical crown) OR (conical attachment) AND (bar attachment) OR (attachment bar) OR (bar overdenture) OR (bar overdentures) OR (bar retained implant overdenture) OR (ball attachment) OR (ball overdenture) OR (ball retained implant overdenture) OR (ball and socket) OR (locator attachment) OR (locator overdentures)

in progress were checked such as www.clinicaltrials.gov, www.centerwatch.com/clinicaltrials, and www.clinicalconnection.com. The last performed search was on December 5, 2016.

Study selection

Study selection and data extraction were performed independently by two reviewers and any disagreement was solved by discussion. If not, a third reviewer was consulted.

Data extraction

Two reviewers performed the data extraction independently and were reciprocally blinded to the extraction each other. The following information was extracted: author, country, follow-up year, age of the patient, gender, implant system, number of participants, the total number of implant placed, interventions, attachment system, participants per group, participant analyzed, implant per participant, implant survival rate, prosthetic maintenance, and peri-implant condition.

The quality assessment (risk of bias)

The risk of bias assessment of the included trials was done by two reviewers independently using the Cochrane collaboration's tool,[19] six specific domains titled sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting, and other bias. An RCT was assigned (Low risk of bias) if all domains were at low risk of bias, (Unclear risk of bias) if there was unclear risk of bias of at least one domain, and (High risk of bias) if at least one domain was scored as being at a high risk of bias. In the case of disagreement, discussion between the two reviewers reveals final decisions.

Statistical analyses

Measures of treatment effect

For dichotomous outcomes, the effect of an intervention was expressed as risk differences (RDs) together with 95% confidence intervals (CIs). However, for continuous outcomes, mean differences (MDs) and standard deviations were used to summarize the data for each group with 95% CIs.

Unit of analysis issues

The statistical unit was the patient.

Missing data

If there is any relevant missing information in the included articles, the corresponding authors of these articles were contacted by E-mail. In the situations of no responses, reminder E-mails were sent.

Data synthesis

All statistical tests were performed using the Review Manager (RevMan) software release version 5.3.[20] RevMan is The Cochrane Collaboration's software for preparing and maintaining Cochrane reviews. Meta-analyses were done for studies reported the same outcomes. Risk differences (RDs) for prosthodontic maintenance and MDs for peri-implant tissue were calculated and compared between the two studied interventions (telescopic crown versus ball attachment retaining mandibular implant overdenture). CIs were set at 95%. Weighted means across the studies were calculated using a fixed-effects model. A random-effects model was used to assess the significance of treatment effects.

Heterogeneity assessment

Cochran's test for heterogeneity was used to assess any variations significance in the estimates of the treatment effects of the different trials, heterogeneity would be considered significant if $P < 0.1$. Heterogeneity between the studies was assessed using the I^2-statistic, which describes the variation percentage due to heterogeneity rather than chance.[21] I^2 over 50% was considered as moderate to high heterogeneity.

Reporting biases assessment

If there had been sufficient numbers of trials (>10) in any meta-analyses, publication bias would have been assessed according to funnel plot asymmetry. If asymmetry was identified, we would have examined possible causes.

RESULTS

The electronic search yielded a total of 54 articles (PubMed = 36 and The Cochrane Library = 13). 5 records identified from other sources. 25 potentially relevant articles were selected after screening with title and abstract and removing duplicates. After the initial screening, nine potentially eligible RCTs,[12,22-29] four publications[22,27-29] were included and five publications[12,23-26] were excluded. Reasons for exclusion were as follows: Three were nonrandomized clinical trials.[12,23,25] One was of unclear data.[26] One had a period of follow-up <1 year (3 months).[24]

Only two trials were subsequently analyzed in this systematic review [Figure 1]. Details of all included studies are summarized in Tables 2 and 3.

Characteristics of included studies

The included publications were published within 10 years (2006–2016). All of them were RCTs that examined edentulous mandibular arches. Their observation periods were 3 years, but one of them[27] has a follow-up period of 5 years.

One of the include trials is a 3-year follow-up study[29] which is a part of extended another trial of 5-year follow-up;[27] therefore, both studies are included in one study.

One trial[22] conducted in Germany, the other three trial[27-29] in Austria. All trials conducted in university dental clinics and their study protocols were approved by the Local Ethics Committee of their universities.

Three of the included trials compared the effect of telescopic versus ball attachments[22,27,29] and

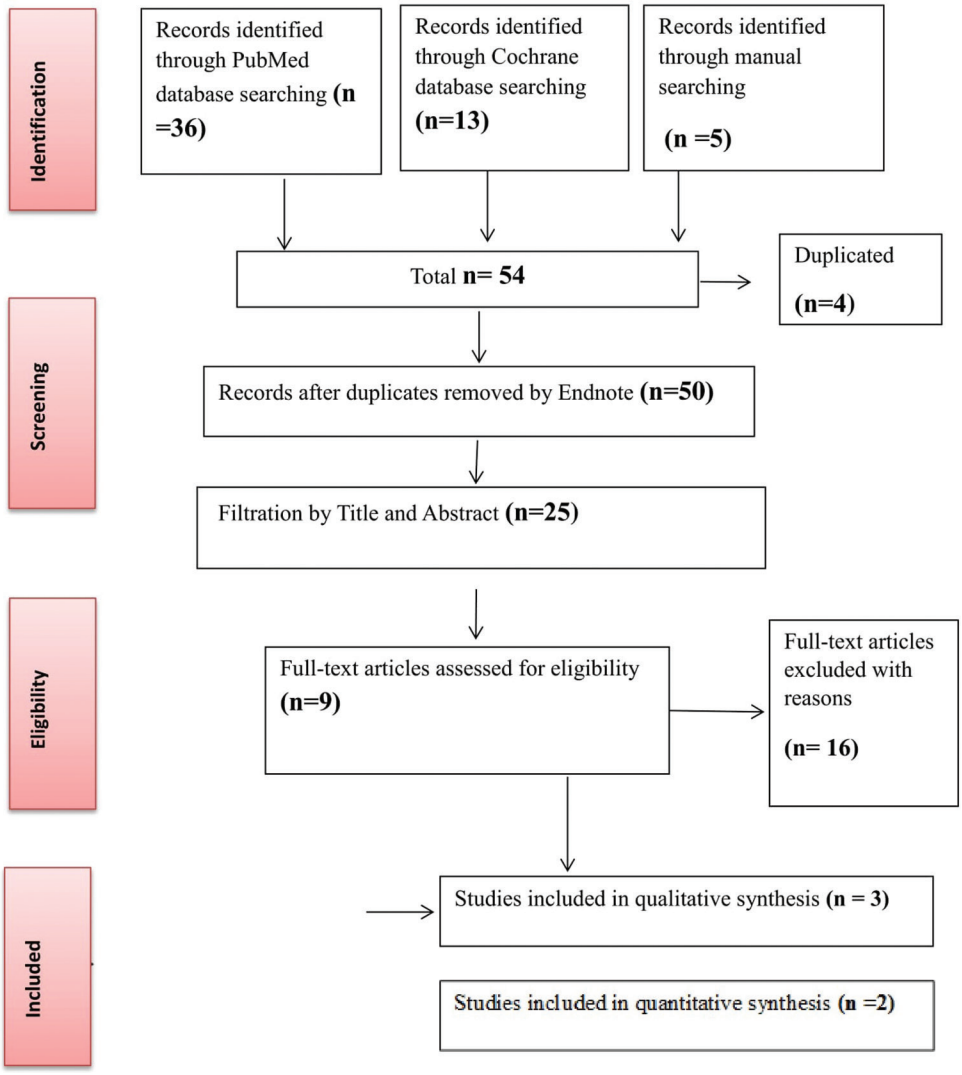

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart

Table 2: Data extraction

Study ID	Country	Follow-up year	Age	Gender	Implant system and type	Number of participants	Total number of implant placed	Interventions	Attachment system	Participants per group	Participant analyzed	Implant per participant	Implant survival rate (%)
Cepa *et al.* 2016	Germany	3	62.9±8.98	NR*	ANKYLOS, DENTSPLY implants, Manheim, Germany	25	50	Telescopic	ANKYLOS SynCone, DENTSPLY	13	5	2	38.5
			65.2±7.02	NR				Ball	ANKYLOS ball heads, DENTSPLY	12	11	2	91.7
Krennmair *et al.*, 2011 Krennmair *et al.*, 2006	Austria	3 and 5	63.2±8.4	(8 female, 5 male)	Camlog, Altatec	25	50	Telescopic	Camlog, Altatec + TC-SNAP (Si-Tec)	12	10	2	100
			58.1±9.2	(8 female, 5 male)				Ball	Camlog, Altatec	13	9	2	100
Krennmair *et al.*, 2012	Austria	3	61.1±7.6	(16 female, 9 male)	Camlog, root-line, screw line, Altec, Wurmberg, Germany	51	204	Telescopic	Gold alloy	25	23	4	100
			58.6±9.1	(12 female, 14 male)				Bar	The milled bar (titanium laser welding/gold alloy casting)	26	22	4	100

*NR: Not reported

Table 3: Data extraction

Study ID	Interventions	Prosthetic maintenance							Peri-implant condition					
		Attachment system maintenance					Overdenture maintenance		Bone loss		Probing depth	Bleeding index	Gingival index	Plaque index	Presence of calculus
		Retention loss	Fractured	Matrix activated	Matrix replaced	Replacement of patrix	Fracture/ remade	Relined/ rebased	Mesial	Distal					
Cepa *et al.*, 2016	Telescopic	5	1	0	4	1	0	3	1.7±0.4	0.7±0.3	2.9±0.5	0.43±0.53	0.68±0.66	0.83±0.80	NR
	Ball	9	0	6	7	6	0	7	1.6±0.3	1±0.2	1.8±0.4	0.35±0.34	0.43±0.18	0.99±0.65	NR
Krennmair *et al.*, 2011 Krennmair *et al.*, 2006	Telescopic	0	0	4	0	NR	2	4	1.5±0.8		3.4±2.2	0.6±0.5	0.5±04	0.6±0.9	NR
	Ball	1	0	4	0	NR	2	3	1.8±0.6		3.5±2.1	0.8±0.5	0.3±0.3	0.8±0.6	NR
Krennmair *et al.*, 2012	Telescopic	NR	0	2		NR	0	9	1.85±0.8		3.4±2.1	NR	NR	NR	NR
	Bar	NR	0	4		NR	0	8	1.5±0.6		3.2±1.9	NR	NR	NR	NR

NR: Not reported

one compared the effect of telescopic versus bar attachments[28] retaining mandibular implant overdentures.

The same participants' number was (25 patients) in three trials that compare between the telescopic and ball attachments retaining mandibular implant overdentures.[22,27,29] One trial had 51 participants which compared the effect of telescopic versus bar attachments[28] retaining mandibular implant overdenture.

The inclusion or exclusion criteria of patients were reported clearly in one trial.[22] However, regarding the other 3 trials, they are not mentioned[27-29] in all included trials, each patient was given a detailed prescription of the planned procedures and signed a written informed consent before participation.

One hundred and twenty-six patients received 354 implants. All implants were titanium implants, had various types and surface modifications and with different lengths and diameters. Implant numbers per patient varied between 2 implants in the mandible[22,27,29] and 4 implants in the mandible.[28] The mandibular interforaminal area was the implant positioning preferred area. A two-stage surgical procedure and conventional loading protocol were followed.

The outcomes were reported as follows:

- Implant survival rate (reported in all trials)
- Prosthodontic maintenance, which subdivided into two categories: (1) attachment system maintenance in terms of retention loss, fracture, matrix activated, matrix replaced, and replacement of patrix. (2) The overdenture maintenance in terms of overdenture fractured/remade and overdenture relining/rebased
- Peri-implant tissue condition evaluation in terms of plaque indices, bleeding indices, gingival indices, and probing depth. A radiographic evaluation was done to measure the marginal bone level around implants.

Quality assessment

The risk of bias assessment of the included trials is summarized in Table 4. Each trial was assessed to be at low, unclear, or high risk of bias. Two of three included RCTs were assessed to be at high risk and one at unclear risk of bias.

Effects of interventions

After 3-year follow-up, Cepa *et al*.[22] evaluated 25 patients with completely edentulous mandibular arches for implant survival, peri-implant tissue parameters, and patient satisfaction regarding two different attachment systems (ball and telescopic) retaining implant mandibular overdentures. Randomly, twelve patients have received ball attachments, and other thirteen patients received the prefabricated telescopic attachment. All follow-ups were done and documented annually up to 3 years.

The results showed 100% implant survival rate. No significant differences in the peri-implant tissue evaluation. About 64% of patients that received ball attachments were satisfied, but 100% patients that received telescopic attachments were satisfied. The latter only respecting five of initially 13 patients. In addition, Cepa *et al*.[22] concluded that the ball attachments group required intensive prosthetic maintenance.

Krennmair *et al*.[27,29] observed implant success, peri-implant conditions, prosthodontic maintenance, and patient satisfaction annually during a 5-year follow-up period by comparing ball and telescopic attachments retaining mandibular implant overdentures. Krennmair *et al*. published two articles, one during a 3-year period[29] and the other after a 5-year period.[27] Twenty-five patients were randomly distributed into; 13 patients received ball attachments and 12 patients received telescopic crowns.

The results revealed that peri-implant tissue conditions, implant survival rate, and subjective patient satisfaction scores did not show the difference between the ball and telescopic attachments. After 5-year follow-up, the prosthodontic maintenance was more significant in the ball group (87 interventions, 61.1%) than in the telescopic attachments group (53 interventions, 37.9%; $P < 0.01$). In the second and third years, differences in prosthodontic maintenance efforts were most significant ($P < 0.05$) but both were

Table 4: The risk of bias assessment

Study ID	Random sequence	Allocation concealment	Blinding	Incomplete outcome data	Selective reporting	Others
Cepa *et al*.[22]	Low risk	Low risk	Unclear	Low risk	Low risk	Low risk
Krennmair *et al*.[27,29]	Unclear	High risk	Unclear	Low risk	Low risk	Low risk
Krennmair *et al*.[28]	Unclear	High risk	Unclear	Low risk	Low risk	Low risk

similar at the end of the study for both attachment systems.

Krennmair *et al*.[27] concluded that 100% implant survival rate, good peri-implant tissue conditions, and general patient satisfaction were scored. Although the higher prosthetic maintenance incidence of the ball attachments group than of the telescopic attachments, similar frequencies of maintenance efforts may be anticipated for both retention systems over a 5-year period.

During a 3-year follow-up period, Krennmair *et al*.[28] evaluated 45 patients (dropout rate: 45/51 = 11.8%) who received four mandibular interforaminal implants in the edentulous mandible and complete maxillary dentures. Randomly, 23 patients were received milled bars and 22 patients received telescopic attachments.

The results showed high implant survival rate (100%). Peri-implant marginal bone resorption, pocket depth as well as bleeding index and gingival index did not differ for both retention systems. However, annually higher values for plaque index (NS) and calculus index ($P < 0.035$) were noticed for the bar than for the telescopic attachments.

Prevalence of prosthodontic maintenance did not differ between both retention modalities. However, prosthodontic adaption for handling mechanism showed benefits for the bar retention.

Krennmair *et al*.[28] concluded drawbacks such as higher plaque/calculus for bar retention and less favorable handling properties (output) for telescopic crown attachment leave the selection decision on the clinician.

Meta-analysis

A meta-analysis was performed for the studies having same comparison groups and same outcomes.

Prosthetic maintenance

The meta-analyses of two trials[22,29] regarding the need for prosthetic maintenance comparing telescopic and ball-retained mandibular overdenture showed no differences between two interventions in regard to matrix activation, matrix replacement, patrix replacement, overdenture relining, and overdenture remake [Figure 2].

Peri-implant conditions

The meta-analyses of two trials[22,29] regarding peri-implant conditions comparing telescopic and ball-retained mandibular overdenture showed statistically significant more probing depth around implants records in ball-retained overdenture when compared to telescopic group ($I^2 = 47\%$, $P = 0.00001$; MD: 1.1, 95% CI: 0.52, 1.48). However, there are no statistically significant differences between two interventions in regard to marginal bone loss, bleeding index, gingival index, and plaque index [Figure 3].

DISCUSSION

The MIRO gave the best results compared to the conventional removable prostheses resulting in improved quality of life, the masticatory efficiency, and therefore, the nutritional condition and patient's health.[30]

The MIRO represents a first choice option, especially when there is a need to anchor the mandibular conventional denture. It is important to remember that dental implants, although they afford the overdenture with enhanced retention and support, differ significantly from the natural teeth. The most important difference from the biomechanical point of view is the absence of the periodontal ligament (PDL), which performs the amortization functions of occlusal loads, the proprioceptive sensitivity, and promotes bone regeneration activities.[31]

Under loading forces over the natural teeth, the PDL involved first followed by the alveolar bone. However, dental implant, due to the absence of the PDL, has a linear model of the deflection force that depends on the elastic deformation of the alveolar bone.[32]

This review delivers meta-analyses of the RCTs that is considered as the highest level of confirmatory scientific evidence today.[33] In terms of internal validity, RCTs represent the most scientifically rigorous study designs, as they are best able to control bias and serve as a gold standard of study designs for evaluating treatment efficacy.[34]

The meta-analysis of the two included RCTs[22,29] reveals that when comparing telescopic and ball-retained mandibular overdenture, there are no differences between two interventions regarding the need for prosthetic maintenance. This is in agreement with MacEntee *et al*.[35] and Watson *et al*.[36] who record no differences regarding postinsertion maintenance between interventions of the attachment systems that being compared.

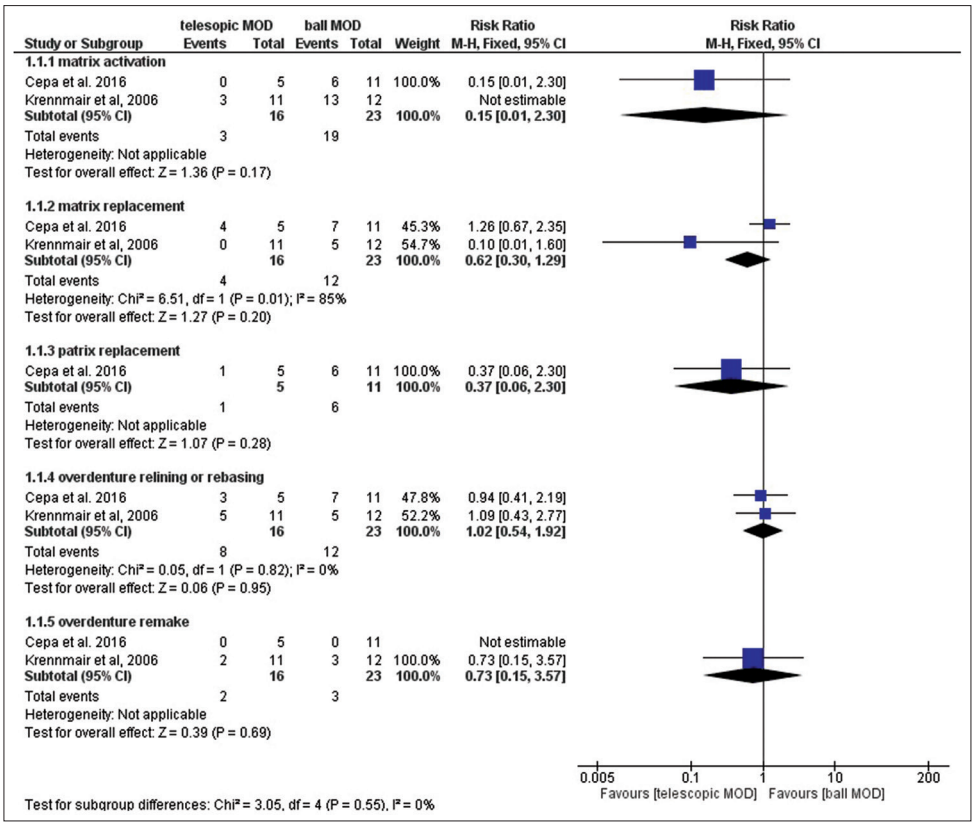

Figure 2: Forest plot telescopic versus ball implants-retained mandibular overdenture: prosthodontic maintenance

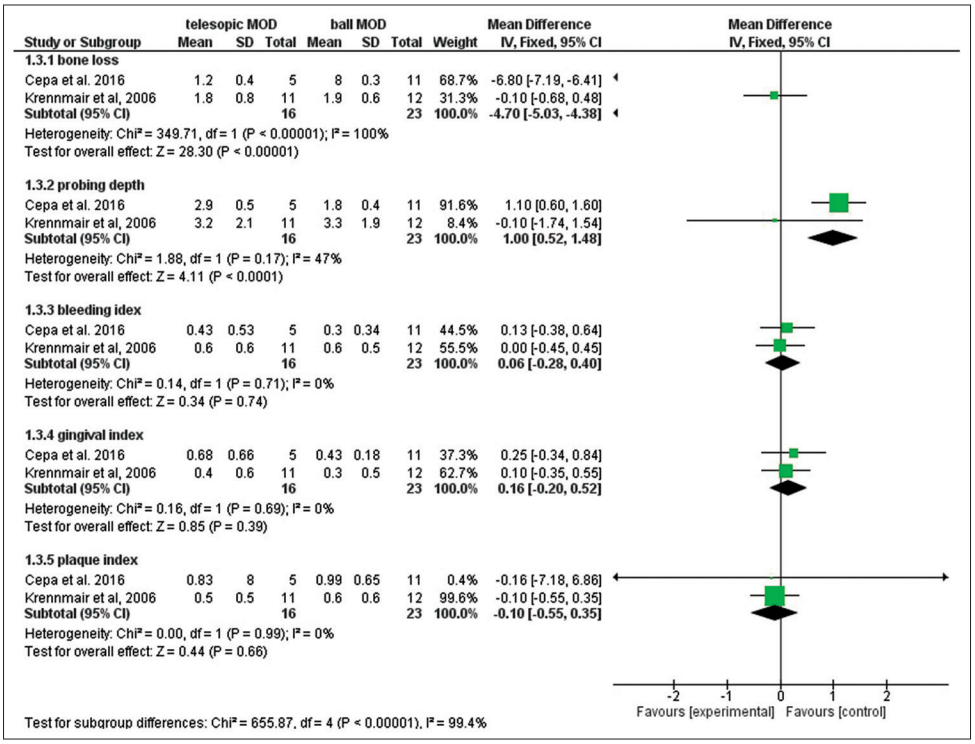

Figure 3: Forest plot telescopic versus ball implants-retained mandibular overdenture: peri-implant condition

Karabuda *et al*.[37] found similar results. They compared overdentures with bar and ball abutment on two to four implants in 26 patients. The treatment success with both techniques was also compared with our

meta-analysis as they reported a total of 20 prosthetic complications were recorded in both groups. No differences in prosthetic complications were observed for two attachment systems.

Regarding peri-implant tissue conditions, when comparing the telescopic and ball retained mandibular overdenture the results showed statistically significant more probing depth around implants. This may be explained by bone remodeling and consolidation of biological width after implant placement.[38,39]

However, the meta-analysis showed no statistically significant differences between two interventions in regard to marginal bone loss, bleeding index, gingival index, and plaque index. Naert *et al*.[40] studied the influence of splinted and unsplinted oral implants retaining mandibular overdentures. Over 10 years, no implants failed. Mean plaque index, bleeding index, change in attachment level, periotest values, and marginal bone level at the end of the follow-up period were not significantly different among the groups. Periotest values and marginal bone level at the end of the follow-up period were not significantly different among the groups.

CONCLUSION

The meta-analysis revealed no significant difference regarding peri-implant tissue condition and prosthodontic maintenance when comparing telescopic attachments with ball attachments. However, this should be interpreted with caution because limited number included studies. More well-designed RCTs are highly recommended to evaluate the effectiveness of telescopic versus other attachment systems retaining mandibular implant overdentures.

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Conflicts of interest
There are no conflicts of interest.

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