

# Mandibular implant-supported overdenture: A systematic review and meta-analysis for optimum selection of attachment system

Priyanka Vaibhav Sutariya, Hitendra Mohanlal Shah, Surbhi Dipakbhai Patel, Hemil Hitesh Upadhyay, Mansoor Khan Rafikahmed Pathan, Rutu Paresh Shah

Department of Prosthodontics, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India

## Abstract

**Aim:** This systematic review aimed to compare different attachment systems used in mandibular implant supported overdentures by assessing outcomes such as prosthodontic maintenance and complication, peri implant tissue changes, retention, and patient satisfaction for optimum selection of attachment system.

**Settings and Design:** This systematic review conducted following Preferred Reporting Items for the Systematic Review and Meta Analysis (PRISMA) guidelines.

**Materials and Methods:** A systematic electronic literature search was conducted through PubMed, The Cochrane Central Register of Controlled Trials (Central), and Science direct. A hand search was also performed for individual journals and reference lists of selected studies. Randomized controlled clinical trials and crossover clinical trials from 2010 to 2020 with follow up of more than 1 year were included. The Cochrane Collaboration's tool was used for assessing the risk of bias of included studies.

**Statistical Analysis Used:** The statistical meta analysis was performed using Review Manager (RevMan) [computer program]. Version 5.4. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2020.

**Results:** Six studies that met the inclusion criteria possess the low risk of bias with follow up of more than 1 year were included in this systematic review. Out of four outcomes, meta analysis was performed for prosthodontic maintenance and peri implant tissue changes. Due to the limited availability of data, retention and patient satisfaction were reviewed systematically without meta analysis. The result of meta analysis for ball versus magnet attachment showed statistically significant differences in prosthodontic complications and maintenance, and ball attachment reported fewer complications than the locator attachment (risk ratio [RR] = 0.55, confidence interval [CI] = 95%,  $P = 0.03$ ). Peri implant tissue changes were analyzed in the included studies as probing depth and marginal bone loss. The result of meta analysis for probing depth showed no statistically significant difference between bar versus telescopic type of attachment (RR = 0.20, CI = 95%,  $P = 0.74$ ). The meta analysis results for marginal bone loss showed no statistically significant difference between bar versus telescopic type of attachment (mean difference = 0.35, CI = 95%,  $P = 0.10$ ).


**Conclusion:** It can be concluded from the current review that bar attachment provided the most superior retention. The telescopic attachment system not only showed the most favorable patient's satisfaction but also reported the least peri implant mucosal changes. The ball attachment system is a favorable choice for limited inter arch space and parallel implant placement.

**Keywords:** Edentulous mandible, implant overdenture, overdenture attachment systems, patient's satisfaction, peri-implant tissue changes, prosthodontic complication and maintenance, retention

**Address for correspondence:** Dr. Surbhi Dipakbhai Patel, Department of Prosthodontics, College of Dental Sciences and Research Centre, Opposite Pleasure Club, Ghuma-Bopal Road, Ahmedabad - 380 052, Gujarat, India.

E-mail: dr.surbhipatel22694@gmail.com

**Submitted:** 22-Apr-2021, **Revised:** 11-Jul-2021, **Accepted:** 22-Sep-2021, **Published:** 09-Nov-2021

Access this article online	
Quick Response Code:	Website: www.j-ips.org
	DOI: 10.4103/jips.jips_158_21

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** WKHLRPMedknow\_reprints@wolterskluwer.com

**How to cite this article:** Sutariya PV, Shah HM, Patel SD, Upadhyay HH, Pathan MR, Shah RP. Mandibular implant-supported overdenture: A systematic review and meta-analysis for optimum selection of attachment system. J Indian Prosthodont Soc 2021;21:317-27.

## INTRODUCTION

Edentulism is a debilitating and irreversible condition of sustained significance and prevalence in the aged population.<sup>[1]</sup> Adaptation to wearing complete dentures is complex and must be considered from various standpoints. Primary treatment options can be either conventional removable complete denture or implant-supported fixed or removable prosthesis for a completely edentulous patient.<sup>[2]</sup> Conventional complete dentures more often cause difficulties in chewing and speaking because of poor retention, stability, support, and various other factors.<sup>[3]</sup> Dental implants to replace natural teeth have become a common practice in restorative and surgical dentistry. Implants provide excellent support for fixed and removable prostheses, which increases functional efficiency compared with conventional removable complete and partial denture prostheses and restores the esthetics of the patients.<sup>[4]</sup> Rehabilitation with dental implants is considered to be the successful option of the edentulous arch, so it can be said that any edentulous area is a potential implant site.<sup>[5]</sup>

Implant overdenture has become the more successful option for completely edentulous arch rehabilitation. Broadly overdenture attachment systems are divided into four main categories: Ball or stud, bar and clip, magnet type, and telescopic attachments.<sup>[6,7]</sup> Each attachment system having a retainer consisting of the metal receptacle (the female or matrix) and a closely fitting part (the male or matrix), where one component is embedded within the undersurface of the prosthesis, and the other is connected to the implant.<sup>[8]</sup>

Prosthetic maintenance and complications associated with different overdenture attachment systems are various such as matrix loosening, detachment of matrix, fracture of a denture, need for relining and rebasing, fracture of components such as bar fracture, crown fracture, etc.<sup>[9]</sup> Furthermore, the retention provided by various overdenture attachment systems is varied. Sometimes prosthesis retention is too high may cause problems in insertion and removal of the prosthesis. Effect on peri-implant tissue conditions such as plaque and calculus deposition, gingivitis, probing depth, marginal bone loss are also noteworthy complications associated with different attachment systems. Patient satisfaction is an important consideration, which can be affected by prosthesis maintenance, stability and retention of the prosthesis, and the prosthesis's ability to function properly. These factors collectively decide the success of prostheses.<sup>[10]</sup>

Several studies compare the different factors such as prosthodontic maintenance and complications, retention,

effect on peri-implant tissue condition, patient's satisfaction, masticatory effectiveness, the cost-effectiveness of the various overdenture attachment systems for maxillary, mandibular implant overdenture.

A systematic assessment published by Ha-young Kim *et al.* in 2012 compared the implant survival rate, prosthetic maintenance and complications, and patient satisfaction of various attachment systems. In this systematic review, authors have included studies up to August 2010.<sup>[2]</sup> The evolution of the overdenture attachment system is continuously ongoing to overcome the problems associated with prostheses. Various newer attachment systems have been introduced in the field with improvements in the bar, ball, telescopic, and magnetic attachments that claim to have minimum prosthesis complications, making clinicians confuse to select one for the best clinical outcome. Thus, the main purpose of this systematic review and meta-analysis was to compare studies from 2010 to 2020 for the comparison of various outcomes of newly marketed overdenture attachment systems.

The aim of this systematic review was to answer the PICOTS question: "In completely edentulous mandibular arch rehabilitated with late implant placement and delayed loading protocols, do the prosthodontic complication, retention, peri-implant tissue changes and patient's satisfaction vary with various implant overdenture attachment systems?"

## METHODS

This systematic review was performed according to the Preferred Reporting Items for the Systematic Review and Meta-Analysis guidelines.<sup>[11,12]</sup>

Randomized controlled clinical trials (RCTs) and crossover clinical trials with at least 1 year of follow-up on attachment systems for two or more implant-supported mandibular overdentures, reporting various outcomes such as prosthodontic maintenance/complications, patient's satisfaction, prosthesis retention, and peri-implant tissue evaluation were included in this systematic review.

The PICOTS format provided by the Centre For Evidence-Based Medicine for systematic literature search to answer the research question was formulated as below,

P - POPULATION: Patients having completely edentulous mandibular arch.

I - INTERVENTION: Late implant placement (minimum two implants in interforamina region) and delayed loading with implant-supported overdenture.

C - COMPARISON: Various overdenture attachment systems like ball attachment, bar attachment, magnet attachment, telescopic type of attachment.

O - OUTCOME:

1. Prosthodontic maintenance and complications
2. Retention
3. Effect on peri-implant tissue condition and
4. Patient's satisfaction.

T - TIME - Studies published from 2010 to 2020, with the minimum follow-up of 1 year.

S - STUDY DESIGN: Prospective RCT and crossed over clinical trial.

### 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 overdenture AND mandibular arch,” “mandibular implant overdenture AND overdenture attachment systems,” “implant overdenture attachments NOT maxillary implant overdenture,” “implant overdenture attachment systems NOT single implant overdenture,” “mandibular implant overdenture AND implant overdenture attachment systems NOT maxillary implant overdenture NOT single implant overdenture,” “mandibular implant overdenture attachments AND prosthodontic complication/maintenance,” “mandibular implant overdenture attachments AND retention,” “mandibular implant overdenture attachments AND patient's satisfaction,” “mandibular implant overdenture attachments AND peri-implant tissue condition.” The following journals were also searched manually: The Journal of the Indian Prosthodontic Society, The Journal of Prosthetic Dentistry, International Journal of Prosthodontics, The Journal of Advanced Prosthodontics, International Journal of Oral and Maxillofacial Implants, Clinical Oral Implants Research, Journal of Oral Implantology, British Dental Journal, Journal of Oral Rehabilitation, Journal of Dental Research.

### Study selection and intervention

#### *Inclusion criteria*

Articles that met the following inclusion criteria were included in this systematic review:

1. RCTs and cross-over clinical trials published only in the English language

2. Mandibular complete edentulous arch
3. Overdenture retained with two or more interforaminal implants
4. Late implant placement delayed loading protocol
5. Studies included from 2010 to 2020
6. Overdenture attachments placed on root-form endosseous implants
7. Follow-up period of a minimum of 1 year.

#### *Exclusion criteria*

Studies meeting the following criteria were excluded:

1. Rehabilitation of partially edentulous arches with implant-supported overdentures
2. Studies with follow-up of <1 year
3. Immediate implant placement with immediate loading
4. Studies including overdenture implant attachment in the maxillary arch.
5. Nonclinical studies, reviews, papers without abstracts, case reports/series, letters to editors, and technical notes
6. Single implant-supported overdentures.

### Data extraction and collection

The full-text copies of all potential articles were independently evaluated by two authors (PS, PM). The data were recorded as per the following criteria.

1. Name of the author
2. Publication year
3. Type of implant placement
4. Number of implant placement
5. Area of implant placement
6. Implant with delayed loading
7. Overdenture for mandibular arch
8. Type of attachments for overdenture
9. Outcome assessment
10. Follow-up period
11. Type of study (RCT and crossover clinical trial).

### Selection of studies

The data extraction was once carried out independently by two investigators (PS, PM), and duplicates were eliminated by using Mendeley software and after that discussed to discover an agreement. The titles and abstracts of all studies identified through the electronic searches were scanned independently by four investigators (PS, UH, PM, SR). For articles that met the inclusion criteria or for which there was inadequate information in the title and abstract to make a clear decision, the full report was obtained. The full reports obtained from all the electronic and other strategies of searching were assessed independently by four investigators (PS, UH, PM, SR) to set up whether the studies did meet the inclusion criteria

or not. Disagreements were resolved by discussion. A fifth and sixth (SP, SH) review authors were consulted where a resolution was not possible. All studies meeting the inclusion criteria then underwent validity assessment and data extraction.

#### Assessment of risk of bias in included studies

Four investigators (SP, SH, PS, UH) independently assessed the risk of bias for each study using the standard guideline outlined in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins 2011).<sup>[13]</sup> There were no disagreements for the assessment of the risk of bias in the present study.

The Cochrane collaboration's tool, for author's judgments, were categorized on the study methods as "Low risk," "High risk," or "Unclear risk" of bias-related for following domains:

1. Random sequence generation (checking for possible selection bias)
2. Allocation concealment (checking for possible selection bias)
3. Blinding of participants and personnel (checking for possible performance bias)
4. Blinding of outcome assessment (checking for possible detection bias)
5. Incomplete outcome data (checking for possible attrition bias due to the amount, nature and handling of incomplete outcome data)
6. Selective reporting (checking for reporting bias)
7. Other bias (checking for bias due to problems not covered by the previously mentioned domains).

#### Measures of treatment effect

Based on the Review Manager software 2014, all the statistical tests were performed.<sup>[14]</sup>

#### Dichotomous data

For dichotomous data, results were presented as summary risk ratio (RR) together with 95% confidence intervals (CIs).

#### Continuous data

For continuous data, the mean difference (MD) was used with 95% CI.

## RESULTS

### Results of search

A total of 235 studies were identified from all search data sources, using search terms "mandibular implant overdenture AND overdenture attachment system." After using Boolean operator "NOT" "single implant

overdenture," 21 studies were excluded from the total search. And further search from studies from 2010 to 2020, another 92 studies were excluded, and a total of 122 full-text articles were assessed. Based on exclusion criteria, the systematic review, case reports, narrative review, *in vitro* study, and other nonrelevant studies were excluded, and the final 20 studies were found eligible for further evaluation. Based on exclusion criteria, studies including overdenture for both maxillary and mandibular implant overdenture, studies including both single and multiple implant overdentures, and overdentures supported with immediately loading implants were excluded. In this systematic review, final six studies that met the inclusion criteria were included [Figure 1].

### Characteristics of included studies

Six trials were eligible to be included<sup>[15-20]</sup> [Table 1].

#### The quality assessment (risk of bias)

As per the Cochrane collaboration's tool,<sup>[13]</sup> author judgment on the study methods was categorized as "low risk," "high risk," or "unclear risk" of bias.

#### Risk of bias in included studies

Detailed descriptions of the risk of bias in the included trials have been provided in the "Risk of bias" figures, as shown in Figures 2 and 3.

#### Meta-analysis

##### Analysis 1

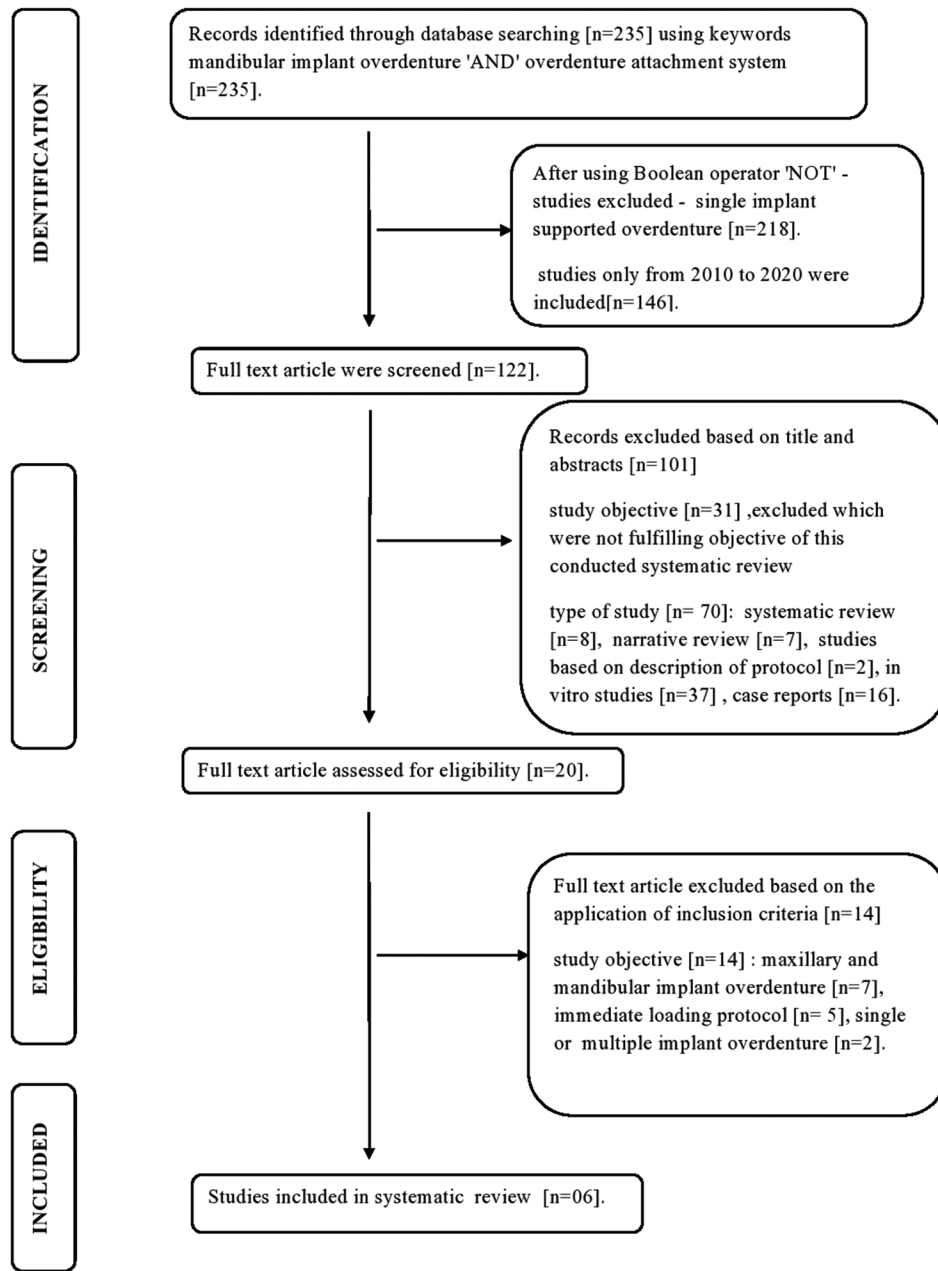
A RCT compared ball attachment and locator attachment for prosthodontic maintenance, patient's preference, biologic complications, and oral health-related quality of life.<sup>[19]</sup>

This study provided data for analysis only about prosthodontic maintenance. Upon pooling the data obtained from this single trial regarding the outcome prosthodontic success, it was identified that ball attachment reported fewer complications compared to the locator attachment (RR = 0.55, CI = 95%,  $P = 0.03$ , Heterogeneity = not applicable, single study, 48 Patients, 24 events of prosthodontic complications) [Figure 4].

Another study that compared the milled bar and telescopic attachment provided data for evaluating peri-implant parameters (probing depth and bone loss).<sup>[20]</sup>

##### Analysis 2-for probing depth

Upon pooling the data obtained from this single study, the milled bar and telescopic attachment results were almost similar, with 0.2 mm less probing depth observed in the milled bar (RR = 0.20, CI = 95%, heterogeneity = not



**Figure 1:** Study flow diagram

applicable,  $P = 0.74$ ,  $Z = 0.33$ , single study, total patient = 45) [Figure 5].

#### Analysis 3-for bone loss

Furthermore, it was identified that milled bar and telescopic type of attachment showed almost similar peri-implant bone loss (MD = 0.35, CI = 95%, heterogeneity = not applicable,  $P = 0.10$ , total patient = 45, one study,  $Z = 1.65$ ) [Figure 6].

## DISCUSSION

Implant overdenture can be an optimum choice for

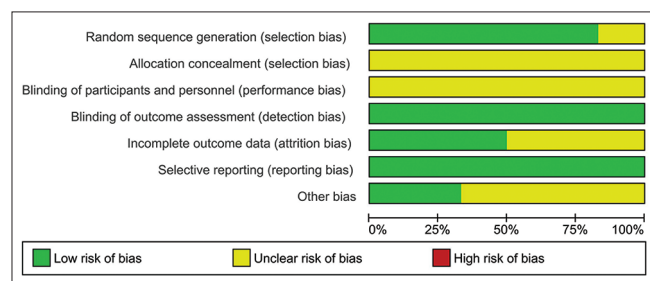
completely edentulous patients, who cannot opt for fixed implant prosthesis due to compromised posterior bone quality, anatomical limitations, increased treatment cost, and systemic medical conditions.<sup>[21-23]</sup>

For the completely edentulous mandible, the two-implant-supported overdenture should become the first treatment choice according to the statement given by McGill consensus.<sup>[24]</sup> The selection of attachment type depends on various factors such as bone height, bone width, inter-arch space, degree of retention required, patient's economic condition, patient's prosthetic

**Table 1: Characteristics of included studies**

Number	Author	Year	Study design	Follow-up (year)	Number of patients	Type of attachment	Outcome parameter
1	Albuquerque <i>et al.</i> <sup>[15]</sup>	2019	RCT (cross over clinical trial)	1	24	Cylindrical, ball attachment	Retention, Patient's satisfaction
2	Burns <sup>[16]</sup>	2011	Prospective RCT	1	30	2 implant supported bar, 4 implant supported bar, ball attachment	Prosthesis retention and stability, tissue response, patient satisfaction and preference and complications
3	Cepa <i>et al.</i> <sup>[17]</sup>	2017	Prospective RCT	3	25	Ball attachment, telescopic attachment	Implant survival, prosthodontic maintenance, peri-implant tissue evaluation, patient's satisfaction
4	Cristache <i>et al.</i> <sup>[18]</sup>	2014	Prospective RCT	5	69	Ball, magnet, locator attachment	Cost, success rate, prosthodontic maintenance/complication
5	Kleis <i>et al.</i> <sup>[19]</sup>	2010	Prospective RCT	1	60	Locator, 2 types of ball attachment	Prosthodontic maintenance, peri-implant soft tissue evaluation, oral health-related life quality
6	Krennmair <i>et al.</i> <sup>[20]</sup>	2012	Prospective RCT	3	51	Telescopic crown, milled bar attachment	Implant survival/success rate, peri-implant parameter, prosthodontic maintenance

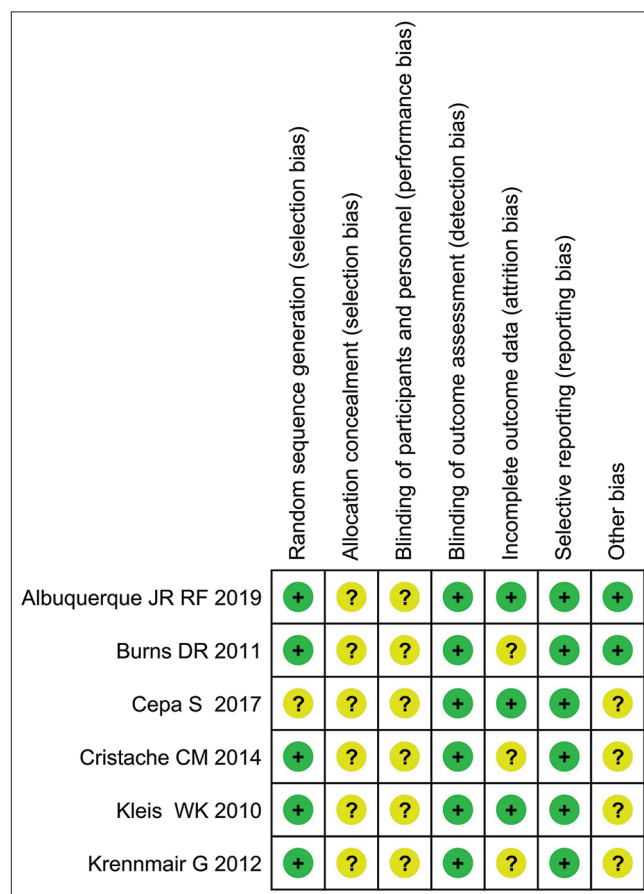
RCT: Randomised controlled clinical trials



**Figure 2: Risk of bias graph - Review authors' judgments about each risk of bias item presented as percentages across all included studies**

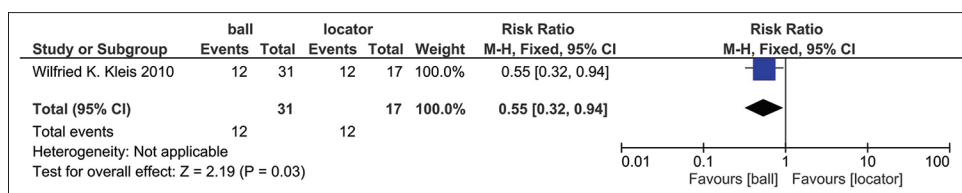
expectation, and preference by the clinician.<sup>[25,26]</sup> Minimum space available for rehabilitation between the mandibular incisal edge to mucosa should be 13–14 mm for bar attachment, 13–14 mm for telescopic attachment, 10–12 mm for ball attachment, 8.5 mm for locator attachment, and 8.5 mm for magnet attachment.<sup>[27,28]</sup> Angulation in between the implants of 10 degree or less is well tolerated by ball attachment.<sup>[29,30]</sup> While angulations up to 40 degree are easily compensated using locator attachment.<sup>[4]</sup> The parallelism of implants plays a very crucial role while using the telescopic attachment. However, bar at tachment can manage nonparallelism using angulated abutments.<sup>[30]</sup> However, the implant-supported overdenture is associated with frequent follow-up visits, prosthetic failure, overdenture attachment loosening, peri-implant soft and hard tissue complications.<sup>[31-33]</sup> Depending on the attachment, these complications may vary in their presentations.

Hence, the purpose of this systematic review and meta-analysis was to evaluate how various mandibular implant overdenture attachment systems differ in retention, prosthodontic maintenance, their effect on peri-implant tissue health and overall patient's satisfaction.

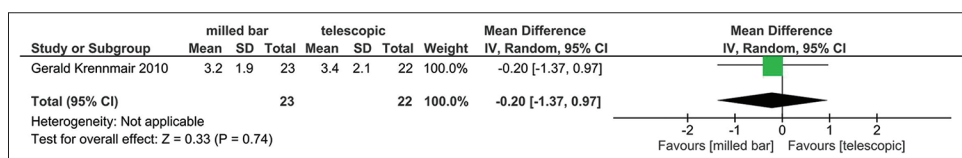


**Figure 3: Risk of bias summary - Review authors' judgements about each risk of bias item for each included study**

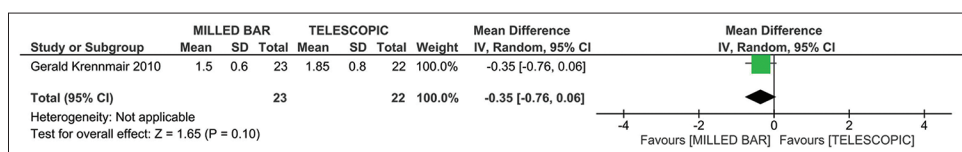
This meta-analysis included a RCT and crossover clinical trial with follow-up of more than 1 year, showing a low risk of bias published in MEDLINE (PubMed), Cochrane, Science direct databases. The attachment systems utilized by the included studies were ball, bar-clip, locator, telescopic and magnet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



**Figure 4:** Analysis 1 - Comparison of Ball and Locator attachment for Prosthodontic complication and maintenance



**Figure 5:** Analysis 2 - Comparison of milled bar and telescopic attachments for Probing depth around implant



**Figure 6:** Analysis 3 - Comparison of milled bar and telescopic attachments for bone loss around implant

Ball attachment was documented to be the most frequently used attachment in the included studies. Two studies compared the ball attachment with locator attachment and reported that ball attachment was more retentive than locator attachment based on patient perception.<sup>[15,20]</sup> An *in vitro* study reported that locator attachment showed the least amount of retention ( $33.5 \pm 9.77$  N) compared to the ball ( $40.3 \pm 15.83$  N) and bar attachments ( $46.9 \pm 13.9$  N).<sup>[34]</sup> When compared to bar attachment, ball attachment showed the same amount of stability (18–20 N) as the bar attachment when measured with force gauge, irrespective of the number of implants used.<sup>[16]</sup> It was documented that the ball attachment required more prosthetic maintenance compared to the locator, magnet, and telescopic attachments.<sup>[18,20]</sup> Whereas, Kleis *et al.* reported that locator attachment required frequent follow visits.<sup>[19]</sup> 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.<sup>[35]</sup> Optimum peri-implant tissue health was maintained using a ball and telescopic attachment systems.<sup>[16,17]</sup> The highest level of patient satisfaction was acquired on using telescopic attachment followed by ball and bar attachments.<sup>[16,17]</sup>

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.<sup>[36]</sup> The results for mucosal changes obtained

by a similar study performed by Varshney *et al.* were in conjugation with the above study.<sup>[37]</sup>

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.<sup>[38]</sup>

It was demonstrated by York that the patients' satisfaction and quality of life were substantially improved with mandibular implant-supported overdenture than conventional dentures.<sup>[39]</sup> 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

## SUMMARY OF EVIDENCE TABLE

Summary of the included studies and the results is summarized in Table 2.

## CONCLUSION

Out of the various treatment modalities available for rehabilitation of the edentulous mandible, the

**Table 2: Summary of the included studies**

Author	Year	Follow up (years)	Type of attachment	Number of patient	Prosthetic maintenance and complication	Retention	Peri-implant tissue condition	Patient's satisfaction
Albuquerque <i>et al.</i> <sup>[15]</sup>	2019	1	Locator, ball	Locator-11, ball-12	NR	Ball > locator	NR	NR
Burns <i>et al.</i> <sup>[16]</sup>	2011	1	4IB, 2IB, ball	4IB-10, 2IB-10 ball-10	NR	4IB > ball > 2IB	4IB > 2IB > ball	Ball > 4IB > 2IB
Cepa <i>et al.</i> <sup>[17]</sup>	2017	3	Ball, telescopic	Ball-11, telescopic-5	Ball > telescopic	NR	Ball=telescopic	Telescopic > ball
Cristache <i>et al.</i> <sup>[18]</sup>	2014	5	Ball, magnet, locator	Ball-23, locator-23 magnet-23	Ball > locator > magnet	NR	NR	NR
Kleis <i>et al.</i> <sup>[19]</sup>	2010	1	Locator, ball (TG-O, dal-RO)	Locator-17 ball-26	Locator > TG-O ring > dal-RO ring ball	Dal-RO ring > TG-O ring > locator	NR	NR
Krennmair <i>et al.</i> <sup>[20]</sup>	2012	3	Milled bar, telescopic crown	Bar-20 telescopic crown-19	Telescopic > bar	NR	Bar=telescopic	NR

NR: Not reported, 4IB: Four implant supported bar attachment, 2IB: Two implant supported bar attachment

implant-supported overdentures are documented to be less invasive and more economical than fixed implant prostheses.

The best retention system requiring a minor prosthetic follow-up was the bar attachment system, provided there was good inter-ridge distance and good hygiene maintenance. Bar attachment system was the most retentive attachment for implants placed in nonparallel alignment contrary to ball attachment system, which was most favorable when implants were placed axially parallel. The telescopic attachment system showed the least mucosal changes and favorable distribution of forces. However, when the patient's satisfaction came into the picture unsplinted a variety of attachment systems were preferred. Amongst all, the telescopic attachment system showed the most favorable satisfaction.

It was concluded from the current analysis that there was a scope for carrying out standardized studies paying specific attention to studying the same parameters for different attachment types.

### Acknowledgment

The authors received no financial support and declared no potential conflicts of interest with respect to the authorship and/or publication of this manuscript.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

### REFERENCES

- Emami E, de Souza RF, Kabawat M, Feine JS. The impact of edentulism on oral and general health. *Int J Dent* 2013;2013:498305.
- Kim HY, Lee JY, Shin SW, Bryant SR. Attachment systems for

- mandibular implant overdentures: A systematic review. *J Adv Prosthodont* 2012;4:197-203.
- Warreth A, Byrne C, Alkadhimi AF, Woods E, Sultan A. Mandibular implant-supported overdentures: Attachment systems, and number and locations of implants – Part I. *J Ir Dent Assoc* 2015;61:93-7.
- Prasad DK, Prasad DA, Buch M. Selection of attachment systems in fabricating an implant supported overdenture. *J Dent Implant* 2014;4:176-81.
- Fagan MJ. Implant prosthodontics: Surgical and prosthetic techniques for dental implants. *Implant Dentistry* 1992;1:163.
- Alqutaibi AY, Kaddah AF. Attachments used with implant supported overdenture. *Int Dent Med J Adv Res* 2016;2:1-5.
- Chandan K. Implant supported overdenture attachments – A review. *IOSR J Dent Med Sci (IOSR-JDMS)* 2017;16:87-91.
- Ferro KJ, Morgano SM, Driscoll CF, Freilich MA, Guckes AD, Knoernschild KL, *et al.* The glossary of prosthodontic terms. *J Prosthet Dent* 2017;117:12-13.
- Andriotti M, Att W, Strub JR. Prosthodontic complications with implant overdentures: A systematic literature review. *Int J Prosthodont* 2010;23:195-203.
- Lee DJ. Performance of attachments used in implant-supported overdentures: Review of trends in the literature. *J Periodontal Implant Sci* 2013;43:12-7.
- Fleming PS, Seehra J, Polychronopoulou A, Fedorowicz Z, Pandis N. A PRISMA assessment of the reporting quality of systematic reviews in orthodontics. *Angle Orthod* 2013;83:158-63.
- Mother D, Liberati A, Tetzliff J, Altman DG; The PRISMA Group. Preferred reporting items for systematic reviews and meta-analysis: The PRISMA statement. *PLoS Med* 2009;6:e1000097.
- Higgins JP, Green S, editors. *Cochrane Handbook for Systematic Reviews of Interventions*. Ver. 5.1.0: The Cochrane Collaboration; 2011.
- Review Manager (RevMan) [Computer program]. Version 5.4, The Cochrane Collaboration, 2020.
- de Albuquerque RF Jr., Fromentin O, Lassauzay C, Conceição Pereira Saraiva MD. Patient satisfaction versus retention of implant overdentures with two attachment systems: A randomized trial. *Clin Implant Dent Relat Res* 2019;21:21-31.
- Burns DR, Unger JW, Coffey JP, Waldrop TC, Elswick RK Jr. Randomized, prospective, clinical evaluation of prosthodontic modalities for mandibular implant overdenture treatment. *J Prosthet Dent* 2011;106:12-22.
- Cepa S, Koller B, Spies BC, Stampf S, Kohal RJ. Implant-retained prostheses: Ball vs. telescopic attachments – A randomized controlled clinical trial. *Clin Oral Implants Res* 2017;28:177-85.
- Cristache CM, Muntianu LA, Burlibasa M, Didilescu AC. Five-year



- clinical trial using three attachment systems for implant overdentures. *Clin Oral Implants Res* 2014;25:e171-8.
19. Kleis WK, Kammerer PW, Hartmann S, Al-Nawas B, Wagner W. A comparison of three different attachment systems for mandibular two-implant overdentures: One-year report. *Clin Implant Dent Relat Res* 2010;12:209-18.
  20. Krennmair G, Suto D, Seemann R, Pichslinger E. Removable four implant-supported mandibular overdentures rigidly retained with telescopic crowns or milled bars: A 3-year prospective study. *Clin Oral Implants Res* 2012;23:481-8.
  21. Mericske-Stern RD, Taylor TD, Belser U. Management of the edentulous patient. *Clin Oral Implants Res* 2000;11:108-25.
  22. Chowdhary R, Kumararama SS. "Simpli5y" a novel concept for fixed rehabilitation of completely edentulous maxillary and mandibular edentulous arches: A 3-year randomized clinical trial, supported by a numerical analysis. *Clin Implant Dent Related Res* 2018;20:749-55.
  23. Gonzalez-Gonzalez I, deLlanos-Lanchares H, Brizuela-Velasco A, Alvarez-Riesgo JA, Llorente-Pendas S, Herrero-Climent M, *et al.* Complications of fixed full-arch implant-supported metal-ceramic prostheses. *Int J Environ Res Public Health* 2020;17:4250.
  24. Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, *et al.* The McGill consensus statement on overdentures. Montreal, Quebec, Canada. May 24-25, 2002. *Int J Prosthodont* 2002;15:413-4.
  25. Alqutaibi AY, Kaddah AF. Attachments used with implant supported overdenture. *Int Dent Med J Adv Res* 2016;2:1-5.
  26. Daou EE. Biomaterial aspects: A key factor in the longevity of implant overdenture attachment systems. *J Int Soc Prev Community Dent* 2015;5:255-62.
  27. Bansal S, Aras MA, Chitre V. Guidelines for treatment planning of mandibular implant overdenture. *J Dent Implants* 2014;4:86.
  28. Pasciuta M, Grossmann Y, Finger IM. A prosthetic solution to restoring the edentulous mandible with limited interarch space using an implant-tissue-supported overdenture: A clinical report. *J Prosthet Dent* 2005;93:116-20.
  29. Preiskel HW, Arvindson K, Geering AH. Overdentures Made Easy: A Guide to Implant and Root Supported Prostheses. London: Quintessence; 1996. p. 212-32.
  30. Gulizio MP, Agar JR, Kelly JR, Taylor TD. Effect of implant angulation upon retention of overdenture attachments. *J Prosthodont* 2005;14:3-11.
  31. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. *J Prosthet Dent* 2003;90:121-32.
  32. Vahidi F, Pinto-Sinai G. Complications associated with implant-retained removable prostheses. *Dent Clin North Am* 2015;59:215-26.
  33. Steffen RP, White V, Markowitz NR. The use of ball-clip attachments with an implant-supported primary-secondary bar overdenture. *J Oral Implantol* 2004;30:234-9.
  34. Shastry T, Anupama NM, Shetty S, Nalinakshamma M. An *in vitro* comparative study to evaluate the retention of different attachment systems used in implant-retained overdentures. *J Indian Prosthodont Soc* 2016;16:159-66.
  35. Miler AM, Correia AR, Rocha JM, Campos JC, da Silva MH. Locator® attachment system for implant overdentures: A systematic review. *Stomatologija* 2017;19:124-9.
  36. Naert I, Gizani S, Vuylsteke M, Van Steenberghe D. A 5-year prospective randomized clinical trial on the influence of splinted and unsplinted oral implants retaining a mandibular overdenture: Prosthetic aspects and patient satisfaction. *J Oral Rehabil* 1999;26:195-202.
  37. Varshney N, Aggarwal S, Kumar S, Singh SP. Retention and patient satisfaction with bar-clip, ball and socket and kerator attachments in mandibular implant overdenture treatment: An *in vivo* study. *J Indian Prosthodont Soc* 2019;19:49-57.
  38. Chaware SH, Thakkar ST. A systematic review and meta-analysis of the attachments used in implant-supported overdentures. *J Indian Prosthodont Soc* 2020;20:255-68.
  39. Thomason JM, Feine J, Exley C, Moynihan P, Müller F, Naert I, *et al.* Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients – The york consensus statement. *Br Dent J* 2009;207:185-6.