# Attachments in single implant mandibular overdentures and their clinical performance: a systematic review of randomized controlled trials

Abstract

**Objectives** To compare results of the randomized controlled trials (RCTs) evaluating peri- implant tissue changes and patient reported outcome measures (PROMs) using different attachments in single implant retained mandibular overdentures (SIMO).

**Methods** A literature search were conducted in the Cochrane Central Register of Controlled Trials (CENTRAL) and PubMed MEDLINE and databases. Only RCTs done on SIMO measuring peri-implant tissue outcomes and PROMs were selected. Total 115 studies were shortlisted initially, and 13 full texts evaluated in detail and only 3 studies (2 cross-over studies, 1 parallel 2-arm studies) were included in the review. The risk of bias was assessed using Cochrane Risk of Bias Tool 2.0 (RoB 2.0).

**Results** All 3 studies were assessed to have low risk of bias. Total 30 patients with ball attachments (in 2 studies), 19 with Low-profile Locator attachments (in 2 studies), 18 with Low- profile Equator attachments (in 1 study), 18 with magnet attachments (in 1 study) and 12 with large ball attachments (in 1 study) were observed. All three studies utilized standard-sized implants with different manufacturers. Single study compared large ball, standard ball, and Locator attachments and revealed no differences. Two cross-over studies compared patient preference between (Locator and magnet) and (ball and Equator) and reveled no preference between ball and Equator while the patient preferred Locator attachments over magnets. Single study compared masticatory efficiency between the Locator and magnet attachment and another between ball and Equator attachments and both showed comparable results.

**Conclusions** Crestal bone level changes and masticatory efficiency were not influenced by any of the overdenture attachments system in SIMO. No difference in patient satisfaction using SIMO was observed between ball and low-profile attachments (Locator and Equator). Patients using SIMO preferred Locator attachments over magnets.

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Authors

**P. G. Patil** [1*]
**L. L. Seow** [2]
**T. J. Kweh**[3]
**S. Nimbalkar**[4]

*[1] BDS, MDS, PhD. Associate Professor, Department of Prosthodontics, Division of Restorative Dentistry, School of Dentistry, IMU University, Kuala Lumpur, Malaysia.*
*[2] BDS, MSc, PhD. Professor, Department of Prosthodontics, Division of Restorative Dentistry, School of Dentistry, IMU University, Kuala Lumpur, Malaysia.*
*[3] BDS, M Clin Dent. Lecturer, Department of Prosthodontics, Division of Restorative Dentistry, School of Dentistry, IMU University, Kuala Lumpur, Malaysia.*
*[4] BDS, MDS. Senior Lecturer, Department of Orthodontics, Division of Clinical Oral Health Sciences, School of Dentistry IMU University, Kuala Lumpur, Malaysia.*

**Corresponding Author*

Keywords

**Edentulism, Complete Denture, Implant Overdenture.**

## INTRODUCTION

### Background

Edentulism continues to represent an enormous global healthcare burden that is often neglected in both developed and developing countries(1). Conventional complete dentures are one of the most widely used treatment modalities for edentulous patients. However, lack of retention and stability result in decrease in chewing ability in these patients(2). The 2-implant-retained mandibular overdenture (TIMO) has been considered as the treatment of choice by expert consensus on the edentulous mandible(3). However, the concept of single implant retained mandibular overdenture (SIMO) is not new and was tried by many clinicians since it reduces patient's treatment cost, reduces post-surgical trauma and requires lesser maintenance as compare to TIMO. Takanashi et al. (4) reported that TIMO was 2. Four times costlier than that of a conventional denture, and Walton et al5 stated that TIMO is 1.Seventy-five times costlier than that of the SIMO. The concept of SIMO was introduced by Cordioli (6), and later, in 1997, he and his colleagues also published the first 5-year results with implant success rates of 100%(7). Walton et al.(5) reported on the satisfaction and prosthetic outcomes of a total of 86 patients after treating them with dentures with 1 or 2 implants and conventional loading protocols and concluded that the SIMO is a good option to the TIMO. The SIMO has biomechanical effects like those of the TIMO with regard to denture base movements and forces on the abutments(8). A recent systematic review including 9 prospective randomized clinical trials (RCTs) to determine the clinical viability of SIMO concluded that cumulative survival rate of 205 implants was 96.6% over a mean follow-up period of 37.3 months. Maxillary complete denture and SIMO was concluded to be an appropriate treatment option for the edentulous mandible (9). Mahoorkar et al concluded that SIMO is a successful treatment strategy after systematically reviewing 20 studies on SIMOs (1,3).

### What Is Already Known and What Is the Need for This Review

However, clinical parameters such as masticatory performance, stability and degree of retention needs to be evaluated further (10). Alsabeeha et al. reviewed the surgical and prosthodontic perspectives of the SIMO approach and mentioned the lack of clinical trials in this area hence routine use of this treatment approach was still not conclusively supported (11). Even though, much has been studied on SIMO with immediate loading protocols, there is not enough information on patient reported OHRQoL (12). In a recent systematic review13 on 9 RCTs and 8 prospective studies evaluated the effect of the SIMO on patient-reported outcome measures (PROMs) and masticatory function in the fully edentulous patients. Conflicting results were observed in OHRQoL when compared to TIMO and improved patient satisfaction and OHRQoL were observed when compared with conventional complete dentures (13).

### Types of Overdenture Attachments Used in SIMO

Four types of overdenture attachment systems are commonly used in clinical practice namely bar, stud, magnetic or telescopic (14,15). Bar attachments are considered as splinted attachments and other three basic attachments are stud, magnetic and telescopic are considered as free-standing or unsplinted. The different stud attachments are known by their tradenames such as Locator (Zest Anchors, CA, USA), Equator (Rhein83, Bologna, Italy), ERA (Sterngold, MA, USA)(16-18). Ability of newer designs to accommodate limited inter-arch space, hence sometime also referred to as low-profile attachments (16). The Locator (introduced in 2001 by Zest Anchors), low-profile stud attachment, was one of the most widely used and researched system in recent years. It requires as low as 2.5 mm vertical height clinically(16-18). The Equator, low-profile stud attachment, provides both castable and direct options for implant overdentures. It requires as low as 2.1 mm (18). Although these newer low-profile stud attachments were in dental practice for almost 2 decades, these were not being compared enough against their conventional counterpart of ball attachments. Gonçalves et al. (19), Miler et al. (20) Patil et al. (21), and Patil et al. (15) performed a systematic review comparing different attachment systems used in TIMO providing conflicting results. However, to authors' knowledge, the literature lacks the information on various attachment systems and their effect on crestal bone level changes and peri-implant health parameters and PROMs in SIMO.

### Focus Question (PICOS) and Objectives

A focus question was set as follows: Does one particular unsplinted attachment system (I) compared with another (C) results in better patient-reported and clinical outcomes (O) in SIMO.
(P) as studied through randomized controlled trials (S)? The objective of this systematic review was to determine the crestal bone level changes and peri-implant health parameters and PROMs in SIMO. The null hypothesis was that the peri-implant tissue health and PROMs are unaffected by various attachments in SIMO.

## MATERIAL AND METHODS

### Review Registry and Ethical Approval

Institutional ethical approval has been obtained from authors' institute (Project ID: 502/2020). This

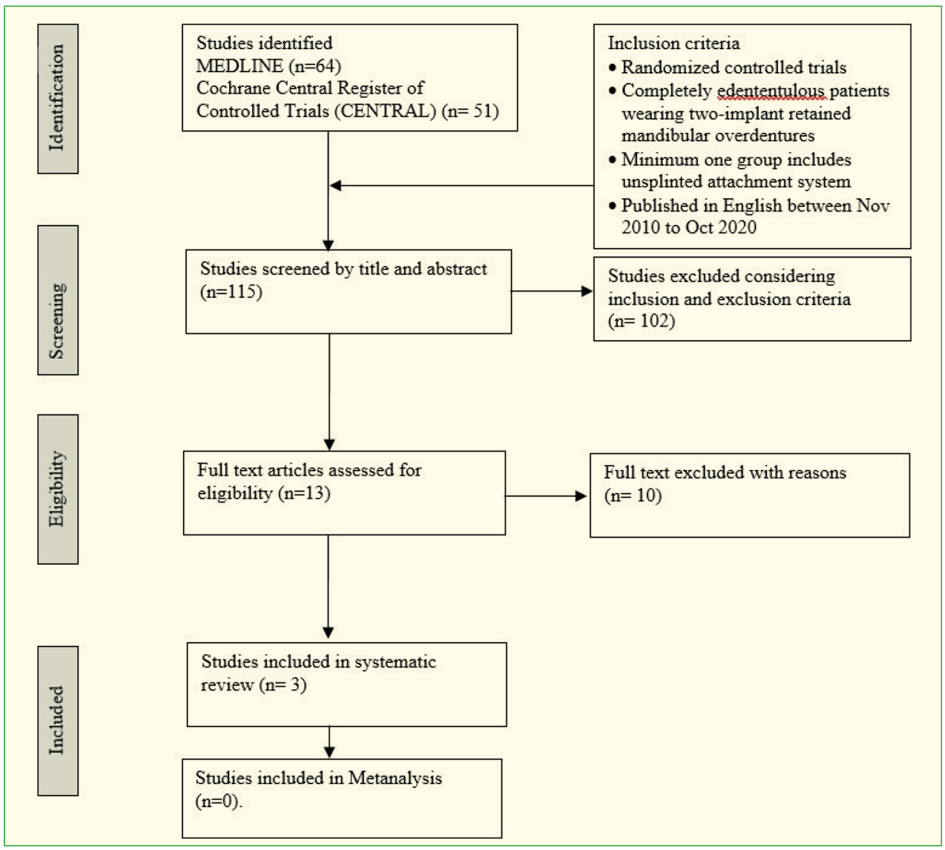


**Fig. 1.**
PRISMA Flowchart of study selection

systematic review and metanalysis included the RCTs comparing different attachment systems for SIMO. The proposal was registered in the PROSPERO platform (CRD42020218576) and was conducted according to the PRISMA checklist.

## Eligibility of the Studies

Following inclusion criteria were followed while selecting the literature:

1. Only randomized controlled trials
2. Completely edentulous patients using SIMO as the participants
3. Studies comparing different types of attachments as the intervention and comparison.
4. The PROMs and peri-implant tissue parameters as study outcomes.

Exclusion criteria were as follows: the studies, not comparing two different attachments but comparing other clinical parameters using same attachments.

## Search Strategy

The electronic literature search was conducted independently by 2 researchers (SN, KTJ) in the Cochrane Central Register of Controlled Trials (CENTRAL) and PubMed MEDLINE (Table 1). A literature search was also performed in ClinicalTrials.gov and WHO International Clinical Trials Registry. Manual search was also performed which did not reveal any eligible study. Only randomized controlled trials (RCTs) on SIMO were selected comparing different attachment systems for their clinical performance as well as PROMs.

## Risk of Bias

Two reviewers (KTJ, SN) independently appraised the selected studies regarding five domains using the revised Cochrane Risk of Bias Tool 2.0 (RoB 2.0). Third reviewer (SLL) resolved the disagreements between the two reviewers after discussion. Individual studies were categorized as high, low or some concerns. Any study indicating the high risk of bias in either of the domain was planned to exclude for the review.

## Summary of Studies

The data were extracted regarding study period, attachment pairs compared, number of patients in each group, study outcomes, type of by two reviewers (TJK, SN) and combined for analysis. The summary of the extracted information was compiled and presented in the tabular form. The meta-analysis could not be performed due to different pairs of attachments compared.

# RESULTS

## Study Selection

Total 30 patients received ball attachments (in 2 studies), 19 received Low-profile Locator attachments (in 2 studies), 18 received Low-profile Equator attachments (in 1 study), 18 received magnet attachments (in 1 study) and 12 received large ball

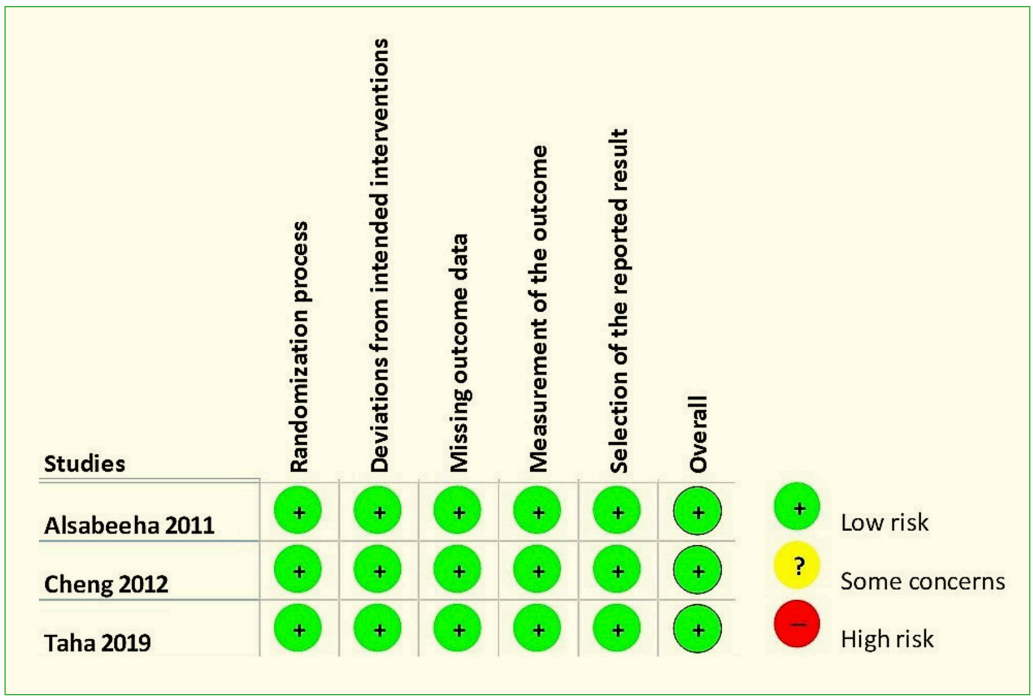


**Fig. 2.**
Risk of bias Table 1: Search strategy

| Database | Search strategy |
|---|---|
| PubMed MEDLINE (n = 64) | (((((single implant overdenture) OR (single implant retained overdenture)) OR (single implant retained mandibular overdenture)) OR (single implant-retained overdenture)) OR (single implant-retained mandibular overdenture)) OR (single implant-retained mandibular overdentures)<br>Filters applied: Clinical Trial, Randomized Controlled Trial. |
| Cochrane Central Register of Controlled Trials (CENTRAL) (n = 51) | #1 MeSH descriptor: [Mouth, Edentulous] explode all trees 756<br>#2 MeSH descriptor: [Dental Prosthesis, Implant-Supported] explode all trees 768<br>#3 MeSH descriptor: [Denture, Overlay] explode all trees 337<br>#4 MeSH descriptor: [Denture Precision Attachment] explode all trees 31<br>#5 locator* or ball* or magnet* or telescopic* or equator* or unsplinted* 54172<br><br>#6 (#1 or #2 or #3 or #4) and #5 162<br>#7 MeSH descriptor: [Alveolar Bone Loss] explode all trees 1260<br>#8 MeSH descriptor: [Peri-Implantitis] explode all trees 167<br>#9 MeSH descriptor: [Periodontal Index] explode all trees 1968<br>#10 MeSH descriptor: [Dental Plaque Index] explode all trees 1901<br>#11 #6 and (#7 or #8 or #9 or #10) 51 |

**Tab 1** Search strategy

| Sr. No. | Authors | Year | Reason for exclusion |
|---|---|---|---|
| 1. | Liddelow et al | 2010 | Only Ball attachments used |
| 2. | Abou-Ayash et al | 2020 | Loading protocols compared |
| 3. | Schwindling et al | 2018 | Loading protocols compared |
| 4. | Kern et al | 2018 | Immediate or Delayed Loading |
| 5. | Passia et al | 2017 | Loading protocols compared |
| 6. | Passia et al | 2017 | Loading protocols compared |
| 7. | Mundt et al | 2017 | Loading protocols compared |
| 8. | Kern et al | 2021 | Loading protocols compared |
| 9. | Davarpanah et al | 2014 | Different attachments used not mentioned |
| 10. | Cheng et al | 2012 | Duplicated interim study |

**Tab 2.** Excluded studies with reasons

| No. | Authors | Follow up | Mean age | Loading time | Implant system | Attachment | Subjects per group | Subjects analysed | Maxillary arch | Crestal bone loss | Patient satisfaction | Prosthodontics outcome | Masticatory efficiency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Alsabeeha et al, 2011 | 1 year | 68 y/o | Early loading (6 weeks) | > Southern regular implant (3.75mm) > Southern wide diameter implant (8mm) Neoss regular implant | > Standard 2.25mm ball Large 5.9mm ball > Locator | n=12 each group | > n=10 > n=12 > n=12 | Edentulous | no diff | N/A | Success higher in the group with the large ball attachment systems, but not statistically significant | N/A |
| 2 | Cheng et al, 2012 | 3 months + 3 months (crossover trial) | N/A (53-83 y/o) | Delayed (10 weeks after the implant surgery) | Straumann Standard Implants (Institut Straumann AG, Basel Switzerland) 4.1 mm in diameter, 10mm or 12mm | > Locator Magnet | > n=7 > n=8 crossover | n=12 (3 dropped out) | Edentulous | N/A | Locator performed better in perceived chewing ability than the Magfit attachments ($p < 0.05$) Twice as many patients (8 vs 4) preferred the Locator to the Magfit attachments, but not statistically significant | N/A | Improved significantly with both attachments ($p < 0.05$) |
| 3 | Taha et al, 2020 | 3 months + 3 months (crossover trial) | 66.1 y/o | Delayed (3-month healing) | Titamax CM Cortical, Neodent Implants, 3.75 mm diameter | Ball Equator | n=18 (9 per group, crossover) | n=17 (1 dropped out) | Edentulous | N/A | Significant differences between the baseline and all the combinations of periods and attachments (ball and Equator) No significant differences between ball and Equator at the initial and final periods Patient preference might be biased by the randomisation sequence for a higher preference for the second attachment used | Matrix replacement: no diff | No diff |

**Tab 3.** Summary of selected studies

attachments (in 1 study). All three studies used standard sized implants, however, differed in implant manufacturers. Two studies compared ball attachments with low-profile attachments (either Locator or Equator) and revealed no differences in crestal bone level changes. Two studies compared patient satisfaction amongst ball, Locator and Equator attachments and revealed comparable results. Three studies compared masticatory performance amongst Locator, magnet, ball, and Equator attachments and revealed comparable results.

### Summary and Characteristics of the Studies

Initial literature search revealed total 115 studies which were further shortlisted to 13 studies(22-34) (for full text evaluation) (Fig. 1) by screening the titles and the abstracts. After full text evaluation, only 3 studies(22-24) meet criteria and included in the systematic review and had to exclude remining 10 studies (25-34). For different reasons mentioned in the Table 2. The extracted information of the final 3 studies have been summarized in Table 3. All three studies (22-24) have used standard sized implants. Loading protocols were different for all three studies (22-24). These confounding factors were not considered as the potential exclusion criteria due to limited number of clinical studies. Single study (22) was a randomized controlled trial (with follow up period of 1 year) and Taha et al. (24) and Cheng et al. (23) were crossover clinical trials (with cross-over period of 3 months for each attachment). All three studies considered the complete denture prostheses in the maxillary arch.

### Effect of Attachments on Different Clinical Outcomes and PROMs

Cheng et al. (23), conducted cross over trial comparing the Locator and the magnet attachments. Taha et al. (24) conducted a cross over trial comparing the ball and the Equator attachments. They concluded that the use of a single midline implant to retain a mandibular overdenture significantly improves patient satisfaction irrespective of the attachment used, but patients' preference for the second treatment suggested a learning effect (24). Alsabeeha et al. (22) concluded that there is no difference in peri-implant crestal bone loss between the ball and the Locators attachments. Masticatory efficiency was improved significantly between both ball and Locator attachments (22).

### Risk of Bias

The final risk of bias assessment of the included studies is illustrated in Figure 2. All the studies (22-24) were judged to have low risk of bias, based on the RoB 2.0 analysis (Fig. 2). The Kappa score for both reviewers (KTJ and SN) agreement was 0.85.

Discussion The null hypothesis was not rejected as the crestal bone level, and the peri-implant tissue health does not get affected by different unsplinted attachment systems in 1 implant retained mandibular overdentures. Only 3 clinical studies may not provide consistent results and reliable comparison between different attachment pairs used in the SIMO and a greater number of studies are advocated. All three studies were found to be with a low risk of bias an all five domains of RoB 2.0.

Confounding Factors in Measurement of PROMs Dissimilar clinical parameters like implant surface topography, design, and loading protocols may contribute to the effect of the attachments on the peri-implant outcomes or PROMs and one should be cautious to interpret the results (15,35). In this regards, Cehreli et al. (36) systematically reviewed the effects of implant design and attachment type on marginal bone loss in implant overdentures with a total of 4,200 implants from thirteen different manufacturers and found our no significant difference. Crestal bone level changes recorded with the help of intraoral peri-apical radiograph must be normalized for potential image changes taken at different timepoints. Intra- and inter-examiner agreement could also be another influencing factor when assessing radiographic measurement of crestal bone levels (37).

### Clinical features of SIMO and influence of attachment designs

Regarding patient satisfaction, ball attachments shown comparable satisfaction as compared with low profile attachments (Locator or Equator) in three studies (22,24). However, single study (23) comparing Locator (in 8 patients) versus magnet attachments (in 4 patients) indicated higher satisfaction with Locator attachments. This could be interpreted cautiously due to very few patients studied. During mastication, SIMO patients, the denture may move in all possible directions around the midline-implant-attachment. In such situation, any unsplinted attachment type (either ball or low-profile or magnet) act as a pivot for overdenture movements. This could be the reason the crestal bone level changes might not have affected by the type of attachment.

Present study indicated crestal bone level changes are comparable between any pair of attachments studied. Usually, the low-profile and the magnet attachments are lower in height as compared with the ball attachments leading to favorable leverage action against the total implant length embedded in the bone under the occlusal forces. However, the height of the attachments varies minimally and hence might not have affected the crestal bone level significantly.

Immediate loading in SIMO and its clinical viability. Liddelow and Henry (38) studied the survival rate and patient-satisfaction for 25 immediately loaded implants for overdentures and found out high patient satisfaction at 1-year recall.

Liddelow and Henry (25) again reported a 100% 3-year survival rate of immediately loaded oxidized-surface implants and only 37.5% for machined implants (3

failed out of 8). Kronstrom et al. (39) observed 81.8% 1-year implant survival rate for 17 patients with SIMO loaded immediately using the ball attachments. In contrast, various clinical studies have demonstrated successful immediate loading protocols for the SIMO (25,35,38).

The loading protocols may influence clinical outcomes of the SIMO (25,35,38,39), and hence more clinical trials are advocated in future to compare different parameters. The present review, 3 studies used 3 different loading protocols leading to inconclusive results.

### Limitations, Clinical Recommendations and Future Directions

The study had limitations, including the small number of clinical trials. While measuring the crestal bone loss, typically used intraoral peri-apical radiograph. Positioning the X-ray film and maintaining the same direction of the X-ray at different recall visits for single-implant overdenture patients could be practically a challenging task. However, the errors can be minimized by normalizing the values described by Patil and Nimbalkar-Patil (40). This systematic review provided understanding amongst the RCTs carried out with direct comparison between any 2 different combinations of unsplinted attachments studied. Similar crestal bone level changes between any pair of attachments were observed in all 3 studies. The patient satisfaction scores, and masticatory performance were also found to be comparable between any pair of attachment.

In principle clinician can choose any attachment system based on available vertical restorative space, ease of use, and the patient preference.

## CONCLUSIONS

Within the limitations of this systematic review, the following conclusions were drawn.Crestal bone level changes and masticatory efficiency were not influenced by any of the overdenture attachments system in SIMO. No difference in patient satisfaction using SIMO was observed between ball and low-profile attachments (Locator and Equator). Patients using SIMO preferred Locator attachments over magnets.

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