

Systematic Review and Meta-analysis Dental Implants

Clinical viability of single implant-retained mandibular overdentures: a systematic review and meta-analysis

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V. E. de Souza Batista, A. J. Vechiato-Filho, J. F. Santiago Jr, M. V. Sonogo, F. R. Verri, D. M. dos Santos, M. C. Goiato, E. P. Pellizzer: *Clinical viability of single implant-retained mandibular overdentures: a systematic review and meta-analysis*. Int. J. Oral Maxillofac. Surg. 2018; 47: 1166–1177. © 2018 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

Abstract. The aim of this meta-analysis was to verify the clinical viability of single implant-retained mandibular overdentures (SIMO). An electronic search of the PubMed and Cochrane databases was performed (end date July 2017); this was supplemented by a manual search of the literature. Only prospective clinical trials and randomized controlled trials (RCTs) that evaluated SIMO with a minimum follow-up of 12 months were included. The meta-analysis was based on the Mantel–Haenszel method. Dental implant and prosthetic failure were the dichotomous outcome measures; these were evaluated through the risk ratio (RR) and odds ratio (OR), with corresponding 95% confidence intervals (CI). Of 499 articles identified, nine fulfilled the inclusion criteria. A total of 205 implants were placed in patients with a mean age of 64.1 years; the cumulative survival rate was 96.6% over a mean follow-up period of 37.3 months. The procedure used (SIMO vs. two implant-retained mandibular overdenture) did not affect dental implant failure ($P = 0.45$) or prosthetic failure ($P = 0.65$): RR 1.06 (95% CI 0.91–1.23) and RR 0.88 (95% CI 0.51–1.51), respectively; OR 2.56 (95% CI 0.27–24.39; $P = 0.41$) and OR 0.44 (95% CI 0.15–1.26; $P = 0.13$), respectively. Within the limitations of this systematic review and meta-analysis, SIMO with a complete denture as the opposing arch may be considered an alternative treatment for completely edentulous patients. However, this study also confirmed the need for more RCTs on this topic.

Key words: overdenture; dental implant; single-implant; meta-analysis.

Accepted for publication 30 January 2018
Available online 17 February 2018

Among the factors required for an adequate complete denture, retention and stability are considered fundamental to the success of treatment. The lack of such properties, especially for mandibular prostheses, affects the patient's quality of life and their social

relationships¹. For these patients, implant-supported prostheses may offer relief, comfort, and social well-being¹.

The McGill Consensus Statement on Overdentures (Montreal, Canada) established that mandibular overdentures

retained by two implants in the interforaminal area should be the first-choice treatment for all edentulous patients². However, recent studies have stated that a single implant in the midline of the edentulous mandible, also termed a single

median dental implant, may provide suitable retention for an overdenture (single implant-retained mandibular overdenture, SIMO)³⁻⁵, suggesting that this treatment could be successful⁶.

Resorption of the alveolar ridge⁶, as well as treatment costs³, may limit the number of dental implants when planning an overdenture implant-retained mandibular prosthesis. This is especially true among elderly patients, who usually have concerns regarding bone grafting surgery or do not have sufficient financial resources, especially in developing countries, where there is a larger contingent of people with economic limitations^{5,6}. In this scenario, the use of a SIMO may represent a treatment option for the patient. Therefore, a systematic review and meta-analysis evaluating the clinical outcomes of patients using overdentures (population) retained by a single implant (intervention), compared to patients using overdentures retained by two implants (comparison), through an assessment of dental implant and prosthetic failure, would appear to be of relevance to the dentistry community.

The aim of this meta-analysis was to verify the clinical viability of single implant-retained mandibular overdentures. For this, the systematic review was structured to answer the following focused question: Is the SIMO viable as prosthetic rehabilitation? The null hypothesis for this research was that the SIMO is viable when compared to two implant-retained mandibular overdentures.

Materials and methods

Registry protocol

This review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist⁷. At the outset, the study was registered in the International Prospective Register of Systematic Reviews (PROSPERO, CRD42014013051).

Eligibility criteria

In order to be eligible, the studies had to present the following characteristics: prospective clinical trial; randomized controlled trial (RCT); studies that only evaluated SIMO, or studies that evaluated single SIMO versus two implant-retained mandibular overdentures; and studies in English published within the last 10 years.

The exclusion criteria were as follows: retrospective studies; case reports; litera-

ture reviews; in vitro studies; computer simulations; patients or data repeated in other included articles; studies with less than a 12-month follow-up period; and review analysis.

A specific question was constructed according to the PICO approach. The focused question addressed was: Is SIMO viable as prosthetic rehabilitation? In this process, 'P' represented patients using overdentures that were 'I' retained by a SIMO, 'C' compared to patients using overdentures retained by two implants, with dental implant failure in the SIMO and two implant-retained mandibular overdenture groups being the primary outcome 'O' to be extracted and analyzed by meta-analysis. Prosthetic failure was the secondary outcome.

Information sources

The researchers performed a search of the PubMed and Cochrane Library databases for articles published up until July 2017. Furthermore, a manual search was conducted in order to identify grey literature and registered trials that had not yet been published, as well as a search of the following journals for the period July 2016 to July 2017: *The International Journal of Prosthodontics*, *Clinical Implant Dentistry and Related Research*, *Clinical Oral Implants Research*, *The Journal of Dentistry*, *The International Journal of Oral and Maxillofacial Implants*, *The Journal of Prosthetic Dentistry*, *The International Journal of Oral and Maxillofacial Surgery*, and *The Journal of Oral and Maxillofacial Surgery*.

Research strategy

Two independent researchers (V.E.S.B. and M.V.S.) performed the electronic search of the selected databases. The search terms used were: (1) "single implant AND overdentures"; (2) "central implant AND overdenture"; (3) "midline implant AND dental implant"; and (4) "single mandibular implant" separately.

Study selection

Two investigators (V.E.S.B.) and (M.V.S.) independently selected the studies according to their titles and abstracts, and classified them as 'included' or 'excluded'. Any disagreements were settled through discussion and consensus. Articles selected for inclusion were then read by both investigators, and a manual search was performed of the reference lists.

Data extraction

One of the authors (V.E.S.B.) collected relevant information from the articles, including the authors, year, type of study, follow-up period, loading protocol, number of patients and implants, length and diameter of implants, attachment system used, opposing arch, dental implant and prosthesis complications, and survival rates. Failures included implants removed regardless of the cause, and survivals represented stable implants without signs of pathology, mobility, resistance to removal torque, pain, or peri-implantitis. A second author (F.R.V.) checked all of the information collected. Any disagreements between the investigators were settled by a third author (E.P.P.) through discussion until a consensus was reached.

Risk of bias

Two investigators (A.J.V. and J.F.S.Jr) assessed the methodological quality of the studies according to the Jadad scale⁸, which ranges from 0 to 5^{8,9}. Scores higher than 3 were classified as representing high quality⁹. Additionally, the evidence level was set according to the guidelines of the Oxford Centre for Evidence-Based Medicine (OCEBM, 2011) (Table 1).

Summary measures

The meta-analysis was based on the Mantel-Haenszel method⁹. Dental implant failure and prosthetic failure were the two dichotomous outcome measures that were evaluated. To assess dental implant failure, the statistical unit for the outcome was the number of implants lost. To assess prosthetic failure, the statistical unit for the outcome was the number of fractures of the denture base or complications affecting the abutments. For recent studies, the risk ratio (RR) and odds ratio (OR), with corresponding 95% confidence intervals (CI), were calculated using a random-effects model^{9,10}. The RR values were considered significant when $P < 0.05$. The software program Reviewer Manager 5 (The Nordic Cochrane Centre, Copenhagen, Denmark) was used for the meta-analysis and to produce the funnel plots.

Risk of bias among the studies

An asymmetric funnel plot may indicate publication bias or other biases related to sample size, although the asymmetry may also show a true relationship between trial size and effect size¹¹. Heterogeneity was

Table 1. Level of evidence^a.

Level Evidence obtained from:	
1	Systematic review of cross-sectional studies with consistently applied reference standards and blinding; systematic review of inception cohort studies; systematic review of randomized trials or <i>n</i> -of-1 trials; systematic review of randomized trials, systematic review of nested case-control studies, <i>n</i> -of-1 trial with the patient you are raising the question about, or observational study with a dramatic effect
2	Systematic review of surveys that allow matching to local circumstances; individual cross-sectional studies with consistently applied reference standards and blinding; inception cohort studies; randomized trial; individual randomized trial; observational study with a dramatic effect
3	Non-consecutive studies, or studies without consistently applied reference standards; cohort study or control arm of randomized trial; non-randomized controlled cohort/follow-up study
4	Case series; case-control studies, or poor or non-independent reference standards; poor quality prognostic cohort studies; historically controlled studies
5	Mechanism-based reasoning

^aThe guidelines of the Oxford Centre for Evidence-Based Medicine (OCEBM, 2011).

assessed using the Q method (χ^2) and the I^2 value. The outcomes were dichotomized into good and poor results. An I^2 of <60% was the cut-off for homogeneity of the data, justifying pooling⁹.

Additional analysis

The kappa statistic was used to define the inter-reader agreement in the study selection process. According to Landis and Koch¹², the level of inter-reader agreement is almost perfect if the kappa value (κ) = 0.81–1.00, substantial if κ = 0.61–0.80, moderate if κ = 0.41–0.60, fair if κ = 0.21–0.40, and poor if κ < 0.20. The survival rate of the SIMO was calculated by Kaplan–Meier method. The failure rate was determined as the percentage of implants lost relative to the number of implants inserted for each study.

Results

Study selection and characteristics

The search strategy returned a total of 499 records. Forty-three studies were selected during the title and abstract analysis (inter-reader agreement, κ = 0.85 for PubMed/MEDLINE and κ = 1 for Cochrane Library). Next, a full-text analysis resulted in 12 studies that satisfied the inclusion criteria^{1,3,13–22}. However, three studies were excluded because they reported data that were repeated in other included articles^{14,17,18}. This way, only the more recent results were used^{19,22}. The search process is shown in Fig. 1.

Of the nine studies selected, five were prospective clinical trials^{1,3,13,16,20} and four were RCTs^{15,19,21,22}. Details of the studies and the main findings, aims, and conclusions are summarized in Tables 2 and 3. The excluded studies are listed in Table 4^{4–6,14,17,18,23–50}.

Assessment of study quality

A summary of the methodological quality assessment is given in Table 5. Of the nine

studies selected, four had a Jadad scale score of 1 (low quality), indicating a risk of extracting biased results^{3,13,16,20}. The remaining studies had a Jadad score of 3,

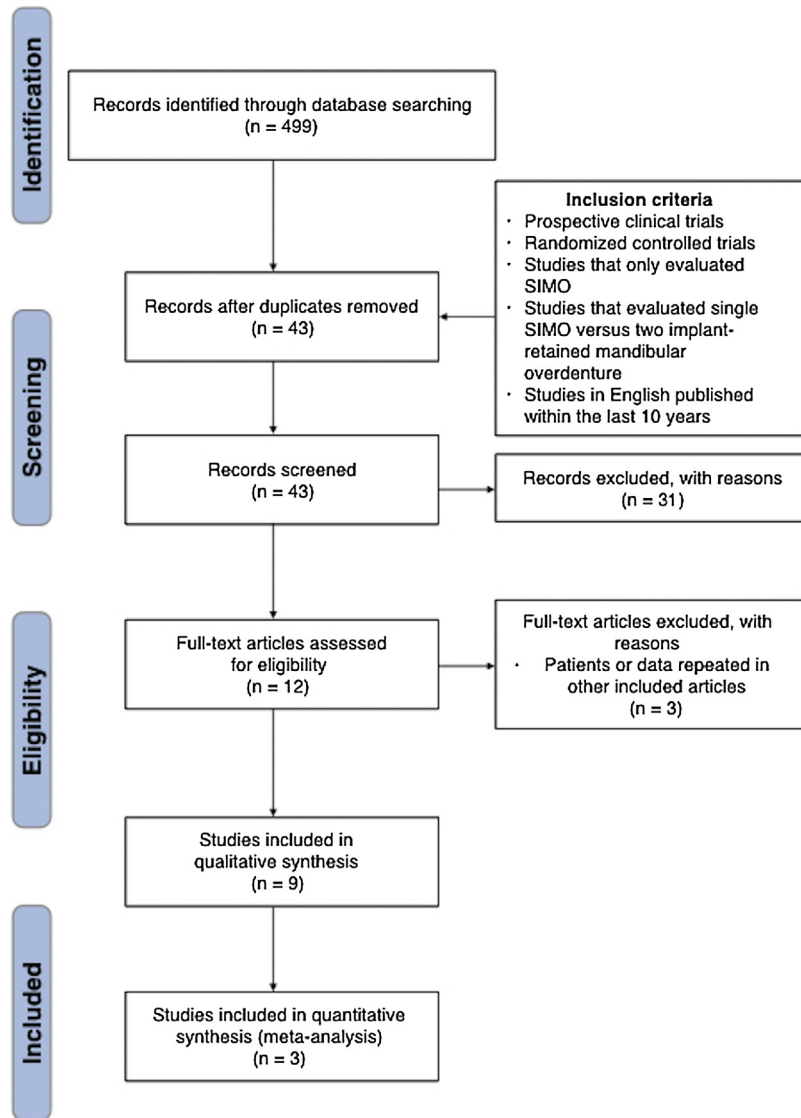


Fig. 1. Search process.

Table 2. Summary of the selected studies.

Authors	Year	Study type	Follow-up (months)	Number of patients with single implant	Age, mean (years)	Loading protocol	Length (L)/diameter (D), millimetres	Attachment system/ opposing arch	SIMO with metal framework	Survival rate for implants (%)
Liddelow and Henry ¹³	2007	Prospective CT	12	28	68	Immediate/ after 6 weeks	L: 10 D: 4.0	Ball/CD	No	100%
Liddelow and Henry ¹	2010	Prospective CT	36	35	68	Immediate	L: ≥ 10 D: 4.0	Ball/CD	No	Oxidized: 100% Machined: 57.1%
Alsabeeha et al. ¹⁵	2011	RCT	12	36	68	After 6 weeks	L: 7.0, 10, 11.5 D: 3.75, 4.0, 8.0	Large ball, stud type ^a and standard ball/CD	No	Southern regular implant: 75% Southern wide implant: 100% Neoss regular implant: 100%
Harder et al. ³	2011	Prospective CT	52	11	68.5	After 2 months	L: 11–13 D: 3.8	Ball/CD	No	100%
Passia et al. ¹⁶	2015	Prospective pilot study	80	11	66.7	After 2 months	L: 11–13 D: 3.8	Ball/CD	No	100%
Bryant et al. ¹⁹	2015	RCT	60	29	67	After 6 weeks	L: 10 or 12 D: NR	Ball/CD	No	100%
Tavakolizadeh et al. ²⁰	2015	Prospective CT	12	10	59	After 6 weeks	L: 10 D: 3.8	Ball/CD	No	100%
Alqutaibi et al. ²¹	2017	RCT	12	28	58.2	After 3 months	NR	Large ball, stud type ^a /CD	No	100%
Kronstrom et al. ²²	2017	RCT	60	17	53.3	Immediate	L: 11.5–15 D: ≥ 3.75	Ball/CD	No	82%

CD, complete denture; CT, clinical trial; NR, not reported; RCT, randomized controlled trial; SIMO, single implant-retained mandibular overdenture.

^aLocator attachment system (Zest Dental Solutions).

Table 3. Summary of the aims and outcomes of each study.

Authors	Years	Aim of study	Outcome
Liddelow and Henry ¹³	2007	To evaluate the predictability of simplifying mandibular overdenture treatment using single-stage surgery and immediate prosthetic loading of a single implant	The preliminary 1-year results indicated that immediate loading of a single oxidized-surface implant used to retain a mucosa-borne overdenture is a safe, reliable, and cost-effective treatment
Liddelow and Henry ¹	2010	To determine whether simplifying mandibular overdenture treatment using single-stage surgery and immediate prosthetic loading of a single implant will achieve acceptable implant success rates, functional improvements, and increased patient satisfaction	The immediately loaded single implant-retained mandibular overdenture, using an oxidized-surface implant and the existing prosthesis, in a small group of patients with maladaptive prostheses, could provide a beneficial treatment outcome with a minimum financial outlay over a 36-month observation period
Alsabeeha et al. ¹⁵	2011	To define surgical and prosthodontic outcomes of single implant-retained mandibular overdentures, opposing complete maxillary dentures, using a wide diameter implant and large ball attachment system compared with different regular diameter implants with standard attachment systems	Single implant-retained mandibular overdentures opposing complete maxillary dentures were a successful treatment option for older edentulous adults with early loading at 6 weeks using implants of different diameters and with different attachment systems Larger attachment systems on wide diameter implants were associated with reduced maintenance requirements
Harder et al. ³	2011	To evaluate the clinical outcome, OHRQoL, and subjective chewing ability of patients with a single implant-retained mandibular overdenture	Single implant-retained mandibular overdentures showed good clinical outcomes after 3 years After implant connection, a significant improvement in OHRQoL and subjective chewing ability of hard and fibred food was observed in the patients
Passia et al. ¹⁶	2015	To assess prosthodontic maintenance, as well as the implant outcome, of single implant-retained mandibular overdentures over an observation period of 6 years	The concept of one median implant to retain a complete mandibular denture is an alternative, especially if therapy with two or more implants is not affordable
Bryant et al. ¹⁹	2015	To determine that there was no significant difference in participant satisfaction after 5 years between single implant- and two implant-retained mandibular denture groups; furthermore, to evaluate changes in satisfaction between and within each group over 5 years and differences in implant survival and prosthetic maintenance between the groups	No significant differences in satisfaction or survival of implants for mandibular overdentures retained by one implant or two implants were observed after 5 years Additional research is required to confirm the long-term treatment effectiveness of single implant-retained mandibular overdentures and the implications of prosthetic maintenance with implant overdentures
Tavakolizadeh et al. ²⁰	2015	To compare the coronal bone loss and patient satisfaction between one-implant and two-implant anchored mandibular overdentures with the immediate loading protocol	In a group of patients with maladaptive mandibular dentures, the immediately loaded single implant assisted mandibular overdenture can provide a beneficial treatment outcome Functional improvement and implant survival were similar to those obtained with two-implant assisted mandibular overdentures
Alqutaibi et al. ²¹	2017	To evaluate whether the single-implant overdenture is a valid alternative treatment to the overdenture retained by two implants using a conventional loading protocol The question addressed was: "In the completely edentulous patient, is the single-implant overdenture as effective as that retained by two implants in regard to implant failure and muscle activity?"	No significant differences were found between the subjects in the two study groups with respect to implant failure With regard to the improvement in muscle activity, the two-implant group showed a statistically significant improvement compared to the single-implant group, but this difference was found to be too small to be clinically important Accordingly, single-implant mandibular overdentures may be suggested as an alternative treatment modality for the rehabilitation of the edentulous patient who cannot afford the cost of a two-implant overdenture
Kronstrom et al. ²²	2017	To evaluate patient satisfaction and clinical outcomes among subjects with mandibular overdentures supported by one or two immediately placed dental implants at 5 years after loading	The need for maintenance was low and patient satisfaction remained high after treatment with immediately loaded mandibular overdentures supported by one or two titanium dental implants

OHRQoL, oral health-related quality of life.

Table 4. Articles excluded.

Authors	Year	Study type	Reason for exclusion
Cordioli ²³	1993	Comparative study	Year of publication
Cordioli et al. ²⁴	1997	Prospective clinical trial	Year of publication
Krennmair and Ulm ²⁵	2001	Case report	Year of publication, study type
Wolfart et al. ²⁶	2008	Case report	Study type
Maeda et al. ²⁷	2008	Strain gauges	Study type
Alsabeeha et al. ²⁸	2009	Literature review	Study type
Walton et al. ¹⁴	2009	RCT	Data repeated in another included article
Gonda et al. ²⁹	2010	Retrospective study	Study type
Alsabeeha et al. ³⁰	2010	Prospective randomized study	Follow-up <12 months
Alsabeeha et al. ³¹	2010	In vitro study	Study type
Kronstrom et al. ¹⁷	2010	RCT	Data repeated in another included article
Kronstrom et al. ¹⁸	2014	RCT	Data repeated in another included article
Alsabeeha et al. ³²	2011	In vitro study	Study type
Schneider and Synan ⁶	2011	Case report	Study type
El-Sheikh et al. ³³	2012	Prospective clinical trial	Retracted article
Kern ³⁴	2012	Literature review	Study type
Cheng et al. ³⁵	2012	Randomized clinical trial	Follow-up <12 months
Grover et al. ⁵	2013	Prospective clinical trial	Follow-up <12 months
Liu et al. ⁴	2013	3D finite element analysis	Computer simulation
Passia et al. ³⁶	2014	RCT	Not enough results
Passia and Kern ³⁷	2014	Systematic review	Study type
Kono et al. ³⁸	2014	In vitro study	Study type
Nascimento et al. ³⁹	2015	In vitro study	Study type
Ismail et al. ⁴⁰	2015	Retrospective study	Study type
Srinivasan et al. ⁴¹	2016	Systematic review and meta-analysis	Study type
Mahoorakar et al. ⁴²	2016	Literature review	Study type
Alqutaibi ⁴³	2016	Review analysis	Study type
Bhat et al. ⁴⁴	2016	Prospective clinical trial	Study type
Nischal and Chowdhary ⁴⁵	2016	Case report	Study type
Nogueira et al. ⁴⁶	2016	RCT	Not enough results
Lahoti et al. ⁴⁷	2016	3D finite element analysis	Study type
Mundt et al. ⁴⁸	2017	RCT	Follow-up <12 months
Passia et al. ⁴⁹	2017	RCT	Follow-up <12 months
Passia et al. ⁵⁰	2017	Multicenter study	Follow-up <12 months

3D, three-dimensional; RCT, randomized controlled trial.

indicating that they were high quality studies^{1,15,19,21,22}.

Qualitative analysis

A total of 205 implants were placed at the midline of the edentulous mandible. The average age of the patients considered in all of the studies was 64.1 years. The follow-up period ranged from 12 to 80 months, with a mean follow-up period of 37.3 months.

Attachment system, length and diameter of the implants, and opposing arch

Different attachment types were used in the studies, including ball and stud types (see Table 2). However, the ball type was preferred for use compared to the other attachments. The implant lengths ranged from 7 mm to 15 mm, and the diameter ranged from 3.75 mm to 8 mm; the most common implant was 10 mm in length and 4 mm in diameter. Only one study did not report the diameter or length²¹. All of the patients who received a SIMO had a complete denture on the opposing arch.

Implant and prosthesis complications

The selected studies revealed a cumulative survival rate of 96.6% for the SIMO (Tables 6 and 7).

The prosthetic repairs were mostly related to retention^{3,15,20,22}, such as the loss of retention from the retentive cap, and to denture base fractures^{1,3,13,15,16,19,22}. One study reported hyperplasia of the soft tissue around the implants¹⁵. Table 8 reports details of the prosthetic repairs (related to fracture of the denture base and complications associated with abutments) of SIMO compared to those of two implant-retained mandibular overdentures. Only one study did not report prosthetic complications²¹.

Patient satisfaction

Six studies provided information about patient satisfaction^{1,3,13,19,20,22}. Overall patient satisfaction was significantly improved with the SIMO compared to the conventional mandibular denture^{1,3,13}. Furthermore, no statistical difference in patient satisfaction was found between mandibular overdentures retained by one

implant and those retained by two implants^{19,20,22}.

SIMO versus two implant-retained mandibular overdentures

Four studies compared SIMO and two implant-retained mandibular overdentures^{19–22}. Table 7 shows the implant failures in greater detail. In addition, Table 8 reports the most cited prosthetic failures for both types of overdenture.

Meta-analysis—primary outcome

Only RCTs were used to perform the meta-analysis. To answer the PICO question, the primary outcome of dental implant failure was assessed for the three studies that compared overdentures retained by one or two implants^{19,21,22}. A weighted average across the studies was provided according to a random-effects model, which indicated that there was no statistically significant difference in dental implant failure between the groups (RR 1.06, 95% CI 0.91–1.23; $P = 0.45$, Fig. 2A) (OR 2.56, 95% CI

Table 5. Quality assessment of the selected studies.

Quality criteria	Liddelow and Henry ¹³	Liddelow and Henry ¹	Alsabeeha et al. ¹⁵	Harder et al. ³	Passia et al. ¹⁶	Bryant et al. ¹⁹	Tavakolizadeh et al. ²⁰	Alqutaibi et al. ²¹	Kronstrom et al. ²²
1. Was the study described as random?	No	Yes	Yes	No	No	Yes	No	Yes	Yes
2. Was the randomization scheme described and appropriate?	No	Yes	Yes	No	No	Yes	No	Yes	Yes
3. Was the study described as double-blind?	No	No	No	No	No	No	No	No	No
4. Was the method of double-blinding appropriate?	No	No	No	No	No	No	No	No	No
5. Was there a description of dropouts and withdrawals?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jadad score	1	3	3	1	1	3	1	3	3
Quality of study	Low	High	High	Low	Low	High	Low	High	High
Level of evidence ^a	3	3	2	3	3	2	3	2	2

^aThe guidelines of the Oxford Centre for Evidence-Based Medicine (OCEBM, 2011).

Table 6. Survival analysis showing the cumulative survival rate of single implant-retained mandibular overdentures, performed by Kaplan–Meier method.

Follow-up intervals of the study (months)	Total number of implants in each follow-up interval	Total number of failures in each follow-up interval	Survival rate within each interval (%)	Cumulative survival rate (%)
0–6	205	7	96.6	96.6
7–12	198	0	100	96.6
13–24	198	0	100	96.6
25–36	198	0	100	96.6
37–48	198	0	100	96.6
49–60	198	0	100	96.6
61–72	198	0	100	96.6
73–80	198	0	100	96.6

Table 7. Failed implants: single implant-retained mandibular overdentures and two implant-retained mandibular dentures.

Authors	Year	Failure	
		Single implant	Two implants
Liddelow and Henry ¹³	2007	0	NA
Liddelow and Henry ¹	2010	3	NA
Alsabeeha et al. ¹⁵	2011	1	NA
Harder et al. ³	2011	0	NA
Passia et al. ¹⁶	2015	0	NA
Bryant et al. ¹⁹	2015	0	5
Tavakolizadeh et al. ²⁰	2015	0	0
Alqutaibi et al. ²¹	2017	0	0
Kronstrom et al. ²²	2017	3	7

NA, not applicable.

Table 8. Prosthetic repairs: single implant-retained mandibular overdentures and two implant-retained mandibular dentures.

Authors	Year	Single implant		Two implants	
		Repair	Number	Repair	Number
Liddelow and Henry ¹³	2007	Fracture	3	NA	NA
		Total repairs	3		
Liddelow and Henry ¹	2010	Denture base fracture	3	NA	NA
		Total repairs	3		
Alsabeeha et al. ¹⁵	2011	Large ball		NA	NA
		Matrix replacement	2		
		Overdenture fracture	2		
		Stud type			
		Matrix replacement	16		
		Overdenture replacement	1		
		Standard ball			
		Matrix activation	13		
		Patrx activation	2		
		Overdenture fracture	2		
Harder et al. ³	2011	Total repairs	38		
		Fracture	6	NA	NA
		Loss of retention	12		
		Loosening	3		
		Replacement abutment (male part)	2		
		Replacement attachment (female part)	2		
Passia et al. ¹⁶	2015	Total repairs	25		
		Fracture	6	NA	NA
Bryant et al. ¹⁹	2015	Total repairs	6		
		Fracture	12	Fracture	7
Tavakolizadeh et al. ²⁰	2015	Reattachment	12	Reattachment	14
		Total repairs	24	Total repairs	21
		Rubber O-ring replacement	2	Rubber O-ring replacement	1
Alqutaibi et al. ²¹	2017	Total repairs	2	Total repairs	1
		Not reported	–	Not reported	–
Kronstrom et al. ²²	2017	Fracture	0	Fracture	1
		Replaced resilient O-rings	23	Replaced resilient O-rings	26
		Re-attachment of metal housing	1	Re-attachment of metal housing	2
		Total repairs	24	Total repairs	29

NA, not applicable (no group with two implant-retained mandibular dentures in the study).

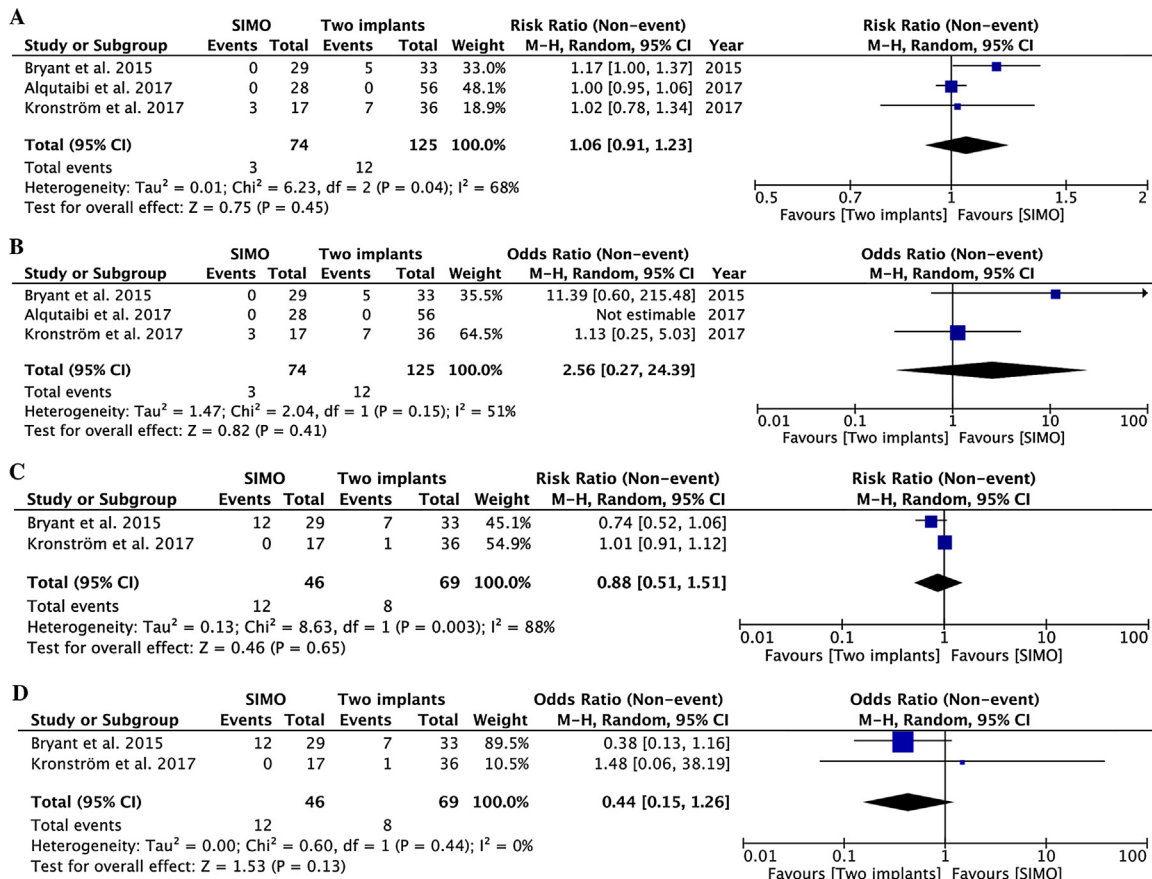


Fig. 2. Forest plots: (A) comparison of studies evaluating the failure rates of implants using the risk ratio; (B) comparison of studies evaluating the failure rates of implants using the odds ratio; (C) comparison of studies evaluating the number of fractures of the denture base using the risk ratio; (D) comparison of studies evaluating the number of fractures of the denture base using the odds ratio.

0.27–24.39, $P = 0.41$, Fig. 2B). For RR, $\chi^2 = 6.23$ for intra-study heterogeneity; for OR, $\chi^2 = 2.04$ for intra-study heterogeneity. With regard to inter-study heterogeneity, $I^2 = 68\%$ for RR and $I^2 = 51\%$ for OR. The funnel plot showed evident symmetry among the differences of means for

the studies evaluated, indicating an absence of bias (Fig. 3A).

Meta-analysis—secondary outcome

A specific analysis of the number of prosthetic failures (fracture of the denture

base) indicated that there was no difference between overdentures retained by one or two implants for fracture of the denture base (RR 0.88, 95% CI 0.51–1.51; $P = 0.65$, Fig. 2C) (OR 0.44, 95% CI 0.15–1.26, $P = 0.13$, Fig. 2D)^{19,22}. For RR, $\chi^2 = 8.63$ for intra-study heterogeneity;

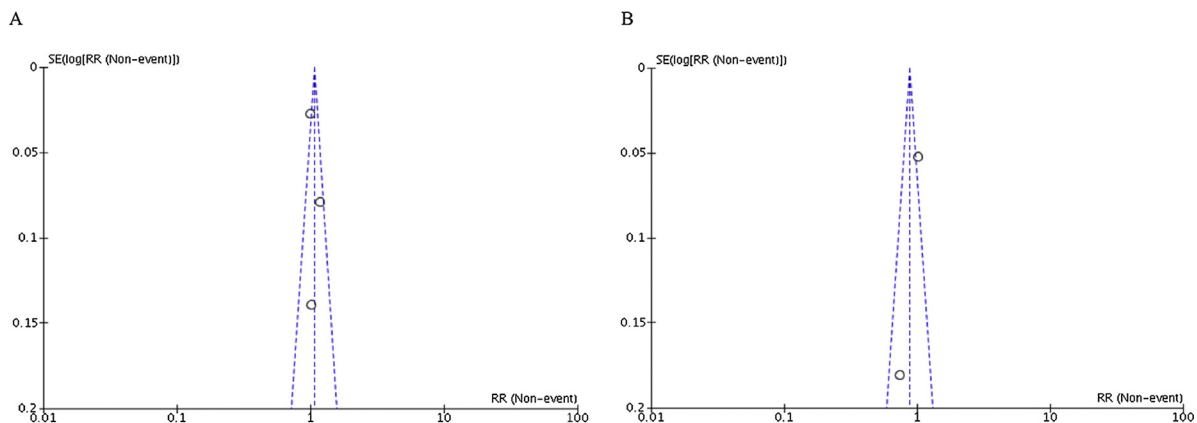


Fig. 3. Funnel plots to evaluate the risk of bias: (A) analysis of implant failure rates among the selected articles; (B) analysis of the number of fractures of the denture base among the selected studies.

for OR, $\chi^2 = 0.60$ for intra-study heterogeneity. With regard to inter-study heterogeneity, $I^2 = 88\%$ for RR and $I^2 = 0\%$ for OR. The funnel plot showed evident symmetry among the differences of means for the studies evaluated, indicating an absence of bias (Fig. 3B).

Discussion

The null hypothesis for this research was accepted, since the meta-analysis showed no statistically significant difference between the overdentures retained by one implant and the overdentures retained by two implants, with respect to dental implant failure ($P = 0.45$) or prosthetic failure ($P = 0.65$) (see Fig. 2). Moreover, the cumulative survival rate calculated in this study (96.6%) is within the limits of what is acceptable⁵¹, although this percentage is lower than the implant survival rate described in the literature (98.1–100%)^{52–54}.

Passia and Kern developed a systematic review that focused on clinical studies on SIMO; however, the authors did not perform a meta-analysis comparing the numbers of implants³⁷. In addition, new studies on the SIMO have recently been published, justifying the need for the present systematic review and meta-analysis^{21,22}. Srinivasan et al. performed another systematic review and meta-analysis, but the authors did not evaluate prosthetic complications⁴¹. Thus, the systematic review and meta-analysis reported herein offer new and relevant information on overdentures retained by one or two implants.

Concerning the quality of the studies selected (using the Jadad scale⁸ and Cochrane risk of bias tool), a lack of blinding among the participants was noted. This would be expected given the difficulty of blinding the surgeon, patients, and/or investigators to the number of implants placed (one or two), since this would be evident²¹. However, randomization and double-blinding could have been performed regarding the surface treatment of the implants in one of the studies, but the authors chose not to meet either of these criteria¹. In this respect, the CONSORT checklist⁵⁵ was used by two studies among the nine selected^{15,21}. This suggests that further standardized studies are necessary.

Alsabeeha et al. stated that the attachment system does not interfere with the treatment outcome¹⁵. The attachment system most used by the authors was the ball type, probably due to the better retention it provides³¹, besides allowing more freedom of denture rotation compared with

more rigid stud attachments¹⁸. The disadvantage of this system is an increase in the incidence of lateral forces to the implants^{27,56}. Liu et al. demonstrated that, when functioning of the anterior teeth was simulated, the denture base movements in a SIMO were wider than those in overdentures retained by more implants⁴. Thus the patient should always be advised about this denture base movement before initiating the treatment²⁷. In this context, clinicians should pay attention to the peripheral sealing and extension of suitable denture bases and occlusal harmony, in order to minimize the rotational movement.

Among the studies selected, the length of the implant ranged from 7 mm to 15 mm, with the most common being the 10-mm implant. This suggests that this treatment may be indicated for patients with reduced bone quantity. The implant diameter had a greater range (3.75–8 mm), due to the usage of wider implants that were especially designed for the research of Alsabeeha et al.^{15,31}. According to Alsabeeha et al., attachment systems of larger dimensions associated with a wide diameter provide higher retentive forces for mandibular single-implant overdentures³⁰.

All of the studies selected reported complete dentures in the opposing arch, which suggests that these patients presented lower masticatory forces⁵⁷. This fact might have contributed to the survival rate of the SIMO, since patients with a complete denture show reduced muscle activity⁵⁷. Thus, the opposing arch must be carefully evaluated when planning the prosthetic. Furthermore, patients treated with a single implant-retained overdenture must be assessed based on the differing situations of their opposing arch.

With regard to the failures reported, the most common were the replacement of attachment system components and fractures of the acrylic base, probably due to structural overload^{1,13}. In this context, the literature suggests the use of implants with a higher diameter to reduce the need to maintain attachment system components³², in addition to reinforcing the denture bases with a metal framework^{16,37}. Thus, further research is necessary in order to assess the influence of reinforcement of the denture base to prevent fractures of the SIMO²⁹. Only one study reported hyperplasia of the peri-implant soft tissues among the selected studies¹⁵. This issue may be of major concern and should be reported in future studies, since the median implant is constantly in contact with the lip and tongue frenulum.

Harder et al. analyzed the quality of life and subjective chewing ability of patients who underwent rehabilitation with a SIMO³. After the implant placement, the patients reported both improved quality of life and chewing ability when compared to the conventional complete denture. Moreover, Kronstrom et al.¹⁸ and Bryant et al.¹⁹ reported that rehabilitated patients with SIMO showed satisfaction levels similar to those of patients rehabilitated with two implant-retained mandibular overdentures. Thus, the use of the SIMO is an alternative for improving the level of satisfaction of completely edentulous patients.

The inclusion of prospective studies may be a limitation of this systematic review and meta-analysis. However, few RCTs on SIMO, concerning the comparison of mandibular overdentures supported by one or two implants, are reported in the literature. Thus, a new meta-analysis should be performed once the results of further RCTs are published.

Finally, SIMO has been demonstrated to be a successful treatment^{1,14,15,19–22}. However, further RCTs with longer follow-up periods are necessary to validate the outcomes of this procedure, especially regarding the longevity of the dental implant, and to consolidate its use in routine clinical practice. The results of this systematic review suggest that in cases where the amount of bone is inadequate and the patient is not willing to undergo bone grafting surgeries (usually elderly patients)¹⁶, or when the patient has financial limitations^{14,19}, this treatment option could be applied, since it presents a satisfactory survival rate.

In conclusion, within the limitations of the present systematic review with meta-analysis, SIMO with a complete denture as the opposing arch may be considered an alternative treatment for completely edentulous patients. However, this study also confirmed the need for more RCTs on this topic.

Funding

Not applied.

Competing interests

None declared.

Ethical approval

Not required.

Patient consent

Not required.

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