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Review article

Complete overdentures retained by mini implants: A systematic review

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ABSTRACT

Objective: The purpose of this systematic review was to evaluate the use of mini implants to retain complete overdentures in terms of survival rates of mini implants, marginal bone loss, satisfaction, and quality of life.
Data: This report followed the PRISMA Statement and PICO question. This review has been registered at PROSPERO under the number CRD42016036141.
Source: Two independent reviewers performed a comprehensive search of studies published until September 2016 and listed in the PubMed/MEDLINE, Embase, and The Cochrane Library databases. The focused question was: is the use of mini implants feasible for prosthodontic rehabilitation with complete overdentures?
Results: The 24 studies selected for review evaluated 1273 patients whose mean age was 65.93 years; these patients had received 2494 mini implants and 386 standard implants for retaining overdenture prosthesis. The mean follow-up time was 2.48 years (range: 1–7 years). There was a higher survival rate of mini implants (92.32%). More frequent failures for maxillary (31.71%) compared with mandibular arches (4.89%). The majority of studies revealed marginal bone loss values similar to those of standard implants (< 1.5 mm). All studies verified an increase in satisfaction and quality of life after rehabilitation treatment with mini dental implants.
Conclusion: The present systematic review indicates that the use of mini implants for retaining overdenture prosthesis is considered an alternative treatment when standard treatment is not possible, since it presents high survival rates, acceptable marginal bone loss, and improvements in variables related to satisfaction and quality of life.
Clinical significance: Based on the results of this study, the use of a minimum 4 and 6 mini implants can be considered a satisfactory treatment option for rehabilitation of the mandibular and maxillary arches respectively with a complete overdenture.

1. Introduction

Although there has been significant development in preventive treatments of complete edentulism still affects a large fraction of the population [1], and may be related to income [2]. In cases of edentulism, conventional dentures are a possibility for rehabilitation and restoring aesthetics and physiological functions. However, this type of rehabilitation is associated with reduces masticatory efficiency and discomfort that influences the quality of life of patients due to the limited stability of the prosthesis, especially in mandibular dentures [3].

Implant-retained overdentures are another possibility for rehabilitating patients with edentulism in which it is possible to improve functional activity and consequently characteristics that influence in the psychological of patients. Furthermore, according to the McGill consensus, the use of two standard implants is recommended with a first choice for making an overdenture prosthesis in edentulous patients [4,5]. Although there have been studies reporting that the longevity of single implant-retained overdentures is similar to that of implant-retained overdentures over two implants [6].

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The quantity and quality of bone tissue available in the jaw typically defines the characteristics (diameter and length) and the number of implants [7]. Overdentures retained by conventional implants exhibit good long-term results but also present some limitations such as: cost [8], difficultly with placing the implant in reduced buccolingual dimensions of bone without the need for bone-grafting procedures [9], and the presence of chronic systemic diseases that can prevent most advanced surgeries as bone grafts and lateralization of the inferior alveolar nerve [9,10].

Mini implants may be considered for the rehabilitation of patients who express dissatisfaction with conventional dentures and have limitations in terms of the placement of standard implants [9,11–13]. Mini implants presents a reduced diameter (<3 mm), while narrow/conventional diameter implants typically has diameter greater than 3 mm [11,14]. Therefore, the use of mini implants to retain overdentures enables the use of less-complex surgical techniques since the reduced diameter of the implant permits its placement in areas with low bone thickness [11]. Concomitantly, sometimes it is not necessary to open flaps, decreasing morbidity during the postoperative period [8]; these aspects are some of the attractive factors that increase patient acceptance of mini implants treatments to retain overdenture prosthesis.

However, there is no consensus about the use of mini implants to retain overdentures in the literature; some studies on this topic have demonstrated high survival rates for overdentures retained by mini implants [9,12], and other studies have reported low survival rates compared with conventional implants [13].

Therefore, the aim of this systematic review was to verify the viability of using mini implants to retain overdentures. The hypotheses of this study were: (1) There is no influence on the survival rates of mini implants retaining overdenture prosthesis compared with standard implants; (2) Mini implants do not affect marginal bone loss, satisfaction, or quality of life.

2. Materials and methods

2.1. Registry protocol

This present systematic review, which was structured based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) checklist [15], in accordance with models proposed in the literature [16–20]. Furthermore, the methods used in this systematic review were registered with PROSPERO (CRD42016036141).

2.2. Search methods

The selection of articles was conducted individually by two of the authors (C.A.A.L. and V.E.S.B.) using the databases PubMed/MEDLINE, Embase and The Cochrane Library, checking articles published until September 2016. The following terms were used in the search strategy: “mini dental implants OR narrow diameter implants OR mini implants overdentures OR mini implants and prosthodontics.”

The same researchers manually searched for articles published until June 2016 in the following specific journals: *Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, International Journal of Oral and Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, International Journal of Prosthodontics, Journal of Dental Research, Journal of Dentistry, Journal of Oral Rehabilitation, Journal of Prosthodontics, The International Journal of Prosthodontics* and *The Journal of Prosthetic Dentistry*. A third author (E.P.P.) analyzed all of the differences in choices between C.A.A.L. and V.E.S.B., and a consensus was attained via discussion.

2.3. Eligibility criteria

Eligibility criteria included clinical human studies, randomized controlled trials (RCTs) or prospective studies that evaluated the use of mini implants for rehabilitation with overdenture prosthesis and studies published in English. The exclusion criteria were retrospective studies, in vitro studies, animal studies, biomechanical studies, case reports, and review papers.

2.4. Study selection and risk of bias

Clinical studies were selected based on their titles and abstracts from the electronic searches by two independent researchers. For studies presenting insufficient data in their title and abstract to make a decision about inclusion, the full manuscript was obtained. Studies that did not meet the inclusion criteria after the researchers read their title and abstract were excluded.

A specific question was formulated based on PICO (population, intervention, control, and outcomes) criteria. The focused question was: “Is the use of mini implants feasible for prosthetic rehabilitation with overdentures?” According to these criteria, the population consists of edentulous patients rehabilitated with overdentures; the intervention was edentulous patients rehabilitated with overdentures retained by mini implants; the comparison was edentulous patients rehabilitated with conventional dentures or overdentures retained by standard implants; the primary outcome was the survival rates of the mini implants; and the secondary outcomes included marginal bone loss, satisfaction and quality of life with the mini implants when they were used for retaining overdenture prosthesis.

2.5. Quality assessment

Two investigators (C.A.A.L. and V.E.S.B.) assessed the methodological quality of studies according to their level of evidence as proposed by the National Health and Medical Research Council (NHMRC) levels of evidence and grades for recommendations establish the levels of evidence according to the type of research question, taking into account: Intervention; Diagnostic accuracy; Prognosis; Etiology; Screening Intervention. The hierarchy of the studies are classified into scores (I; II; III-1; III-2; III-3; IV) [21,22]. In addition, also Newcastle-Ottawa scale (NOS) was used to assess risk bias of the selected studies based on three major components: selection, comparability, and outcome for cohort studies. According to that quality scale, a maximum of nine stars can be given to a study, and this score represents the highest quality. Five or less stars represent a high risk of bias, while six or more stars were considered of low risk of bias [19,23].

2.6. Data collection and analysis

The data extracted from the articles were sorted as quantitative or qualitative by one of the researchers (C.A.A.L.) and then checked by two other researchers (J.F.S.J. and F.R.V.). Any disagreements were solved via discussion until a consensus was obtained. The quantitative and qualitative data were tabulated for ease of comparison.

2.7. Additional analysis

Additional analysis was performed using a kappa coefficient calculated to determine the inter-reader agreement in the study-selection process for publication in the PubMed/MEDLINE, Embase and The Cochrane Library databases. The inter-investigator agreement (Kappa) was calculated by evaluating the selected titles and abstracts, and then obtaining a value for selected articles

Table 1
Reasons for the exclusion of "16" articles.

Author, year	Reason for exclusion
Kanazawa et al. 2016	Dental technique report
Mundt et al. 2016	Mini implants for removable partial denture
Schwindling e Schwindling, 2016	Retrospective study
Mundt et al. 2015 (A)	Retrospective study
Mundt et al. 2015 (B)	Retrospective study
Anitua et al. 2015	Not evaluated mini dental implants
Ma et al. 2015	Not evaluated mini dental implants
Kumari et al. 2015	Case reports
Banu et al. 2015	Not evaluated mini dental implants
Melescanu et al. 2013	Case reports
Choi et al. 2013	Evaluated single unit prosthesis
Jofre et al. 2010	Evaluated not clinical parameters
Singh et al. 2010	Case reports
Machado et al. 2008	Case reports
Cho et al. 2007	Retrospective study
Bouleard et al. 2005	Review

on PubMed/MEDLINE (kappa = 0.89), Embase (kappa = 0.91) and Cochrane Library (kappa = 1.00) presenting a high level of agreement between the reviewers under the Kappa criteria [24]. The survival rates of mini implants were calculated by Kaplan–Meier method in each follow-up interval (0–84 months).

3. Results

3.1. Literature search

The search performed in the databases yielded 1273 references, including 860 references from PubMed/MEDLINE, 351 references from Embase and 62 reference from The Cochrane Library. After duplicate references were removed, 942 studies remained. After detailed reviewed the titles and abstracts of the manuscripts, 40 studies were eligible for analysis. Upon reading the full texts, were excluded 16 studies for the following reasons: they were retrospective studies, case reports/reviews/dental technique, they did not evaluate mini implants in overdentures, there was an absence of clinical parameters, evaluated single unit prosthesis or removable partial denture and there were insufficient data (Table 1). Details about the search strategy are presented in a flow diagram (Fig. 1).

3.2. Description of the studies

A total of 24 studies [8,9,12,13,25–44] are summarized in Tables 2 and 3. Of the 24 selected studies, four were RCTs and 20 were prospective studies. A total of 2494 mini implants and 386 standard implants were placed in 896 patients, with mean age of

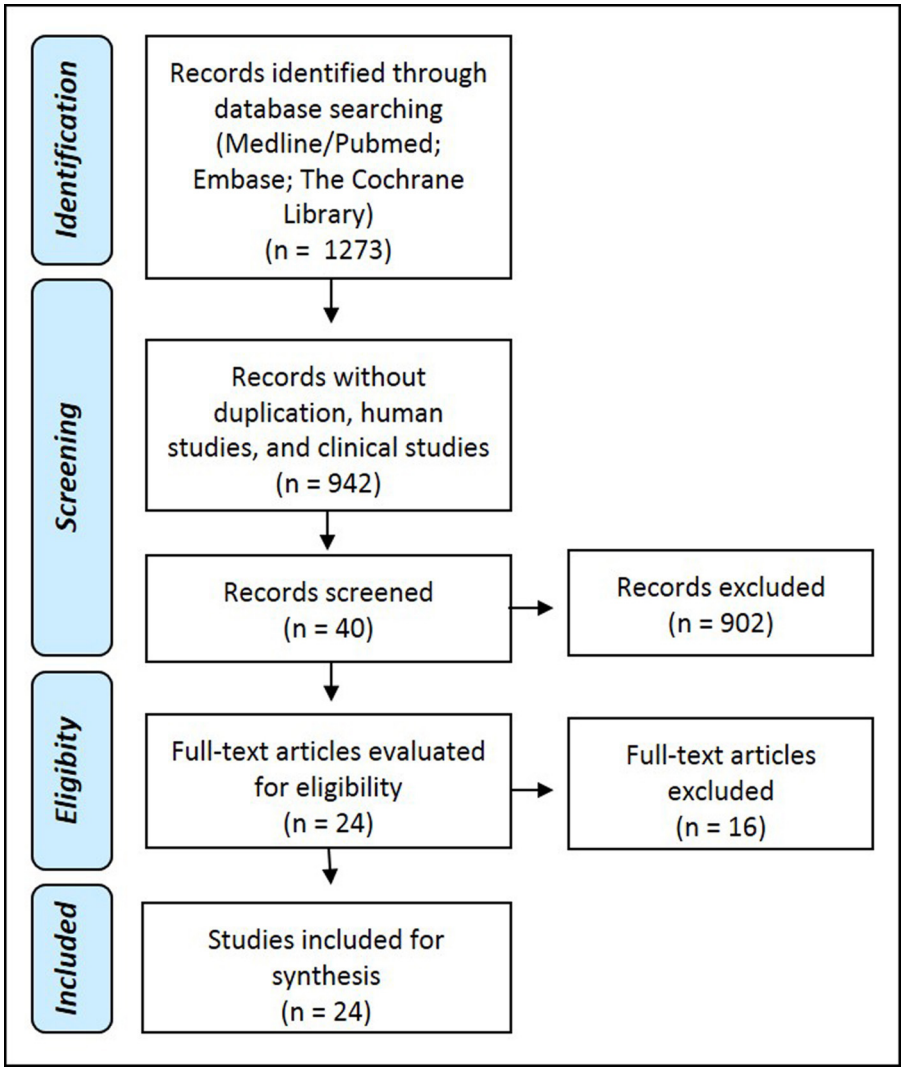

Fig. 1. Flow chart showing the steps in the literature search.

Table 2
Summary of quantitative characteristics of included studies.

Author	Study Design	Patients, n	Mini-implant, n	Mean age, years	Diameter/Length	Implant system	Arch (maxilla/ mandible)	Range of follow-up	Level of evidence		Groups evaluated
									NHMRC	NOS	
Temizel et al. [25]	Prospective	32	99 MI 35 SI	70.25	MI: 1.8–2.4 × 13–15 mm SI: 3.3–3.7 × 11–13 mm	MDI – O Ball /3M ESPE tioLogic-ST Implants / Dentaurum Implants GmbH	Mandible	2 years	III-2	9	G1: 4 or 5 MI G2: 2 or 4 SI
Zygogiannis et al. [26]	Prospective	10	40 MI 70 MI	70.6 68	1.8–2.1 × 10–15 mm MI: 1.8–2.4 × 13–15 mm	MDI – O Ball /3M ESPE	Mandible	1.5 years	III-2	6	G: 4 MI immediate loading
Hasan et al. [27]	Prospective	26	33 SI		SI: 3.3–3.7 × 11–13 mm	MDI – O Ball /3M ESPE tioLogic-ST Implants / Dentaurum Implants GmbH	Mandible	NR	III-2	6	G1: 4 or 5 MI G2: 2 or 4 SI
Batisse et al. [28]	Prospective	11	44 MI	72	2.7 × 9–15 mm	Eurotecknica	Mandible	NR	III-2	7	G1: Conventional denture G2: 4MI
Enkling et al. [29]	Prospective	20	80 MI	65	1.8 × 13–15 mm	MDI – O Ball /3M ESPE	Mandible	1 year	III-2	6	G: 4MI
Elsyad [9]	Prospective	28	112 MI	62.9	1.8 × 12–18 mm	MDI – O Ball /3M ESPE	Mandible	5 years	III-2	6	G: 4 MI
Peršić et al. [30]	Prospective	122	200 MI 144 SI	63.13	NR	MDI – O Ball /3M ESPE	Mandible	3 years	III-2	7	G1: 200 MI G2: 112 SI (Locator) G3: 32 SI (Bar)
Catalan et al. [31]	Prospective	7	14 MI	NR	1.8 × 13–15 mm	MDI – O Ball /3M ESPE	Mandible	7 years	III-2	6	G: 2 MI
Souza et al. [13]	RCT	120	236 MI 80 SI	59.5	MI: 2.0 ×10 mm SI: 4.0 × 10 mm	MDL - Intra-Lock Morse-Lock Straight Intra-Lock	Mandible	1 year	II	9	G1: 4 MI G2: 2 MI G3: 2 SI
Mangano et al. [32]	Prospective	NR	57 MI*	71.1	2.7 × 10–13 mm	Tixos Nano – Leader Implants	Mandible	4 years	III-2	6	G: 3 or 4 MI
Ribeiro et al. [8]	RCT	120	236 MI 80 SI	59.5	MI: 2.0 ×10 mm SI: 4.0 ×10 mm	MDL - Intra-Lock Morse-Lock Straight Intra-Lock	Mandible	NR	II	6	G1: 4 MI G2: 2 MI G3: 2 SI
Šćepanović et al. [33]	Prospective	30	120 MI	NR	1.8 ×13 mm	MDI – O Ball /3M ESPE	Mandible	1 year	III-2	6	G: 4 MI
Preoteasa et al. [12]	Prospective	23	110 MI	62	1.8–2.4 × 10–18 mm	MDI – O Ball /3M ESPE	Maxilla and Mandible	3 years	III-2	6	G1: 5 or 6 MI (maxilla) G2: 4 MI (mandible)
Maryod et al. [34]	Prospective	36	144 MI	64.1	1.8 × 15 mm	MDI – O Ball /3M ESPE	Mandible	3 years	III-1	9	G1: 4 MI with immediate loading G2: 4 MI with early loading
Ashmawy et al. [35]	Prospective	12	48 MI	NR	1.8 × 15 mm	MDI – O Ball /3M ESPE	Mandible	NR	III-2	8	G1: Conventional denture G2: 4 MI
Tomasi et al. [36]	Prospective	21	80 MI	71	1.8–2.4 × 7–14 mm	Dentatus AB – Stockholm	Maxilla and Mandible	1 year	III-2	6	G: 4 MI (except for two patients that used 3 MI, and one used 2 MI)
Elsyad et al. [37]	Prospective	19	114 MI	63.8	1.8–2.4 × 15 mm	MDI - MAX Thread / Sendaxs	Maxilla	2 years	III-1	9	G1: 6 MI with FPC G2: 6 MI with PPC
Omran et al. [38]	Prospective	14	28 MI 14 SI	55	MDI: 1.8 ×15 mm SI: NR	MDI: Sendax MAX–IMTEC SI: Tapered Internal, Biohorizons	Mandible	1 year	III-1	9	G1: 4 MI G2: 2 SI
Šćepanović et al. [39]	Prospective	30	120 MI	NR	1.8 × 13 mm	MDI – O Ball /3M ESPE	Mandible	1 year	III-2	6	G: 4 MI
Elsyad et al. [40]	Prospective	28	112 MI	62.9	1.8 × 12–18 mm	MDI – O Ball /3M ESPE	Mandible	3 years	III-2	6	G: 4 MI
Jofre et al. [41]	RCT	45	90 MI	71	1.8 × 15 mm	Sendax MDI – IMTEC	Mandible	2 years	II	9	G1: 2 MI BG2: 2 MI PB
Jofre et al. [42]	RCT	45	90 MI	71	1.8 × 15 mm	Sendax MDI – IMTEC	Mandible	1.25 years	II	8	G1: 2 MI B G2: 2 MI PB
Morneburg and Pröschel, [43]	Prospective	67	134 MI	69	2.5 × 9–15 mm	Komet – Dental Lemgo	Mandible	6 years	III-2	6	G: 2 MI
Griffitts et al. [44]	Prospective	30	116 MI	67	1.8 × 10–18	Sendax MDI – IMTEC	Mandible	1 year	III-2	5	G: 4 MI

NHMRC: National Health and Medical Research Council/NOS: Newcastle Ottawa Scale (Number of stars)/MI: Mini implants/SI: Standard implants/RCT: Randomized controlled trial/NR: Not reported/FPC: Full palatal coverage/PPC: Partial palatal coverage/B: Ball/PB: prefabricated bar/*Considered only mini implants with diameter <3 mm.

Table 3
Summary of qualitative characteristics of included studies.

Author	Retention System	Surgical Technique	Complications	Survival rates of mini implants, n	Overdenture fracture, n	Parameters evaluated	Outcomes
Temizel et al. [25]	Ball	Full-thickness flap	No surgical or prosthodontics complications	MI: 0 failed (100%) SI: 1 failed (97.1%)	0 failed	Bone density PD IS	MI had clinical outcomes similar SI to support overdenture prostheses. MI: 1250 HU/SI: 1100 HU ($p = 0.035$) MI: 1.2 mm/SI: 1.8 mm ($p < 0.001$) MI: −0.3 and −1.4/SI: −4.0 and −4.9 ($p < 0.001$)
Zygogiannis et al. [26]	Ball	Full-thickness flap	NR	0 failed (100%)	NR	MBL OHIP-20; VAS	1.04 mm (Mesial/Distal) The patients expressed a high level of satisfaction and oral health–related quality of life with this treatment modality.
Hasan et al. [27]	Ball	Full-thickness flap	NR	NR	NR	MBF	Biting forces improved with overdenture supported by conventional or mini implants MI: 81 N–138 N/SI: 167 N–235 N No significant difference was obtained between the MI and SI.
Batisse et al. [28]	Ball	Flapless	NR	NR	NR	Mastication performance Quality of life – GOHAI	More subjects were able to chew after setting the mini implants. This improvement was accompanied by changes in kinematic parameters. However, no significant change was observed for mean particle size values After MI placement the mean GOHAI scores were significantly higher in all the fields of the GOHAI questionnaire (functional field; adjusted discomfort field; psychosocial field; adjusted GOHAI-Add)
Enkling et al. [29]	Ball	Full-thickness flap	NR	0 failed (100%)	NR	Chewing efficiency MBF OHRQoL	The use of MI failed to demonstrate an increase in chewing efficiency MBF increased continuously during the observation period OHRQoL increased steeply after MI loading and continued improving
Elsyad [9]	Ball	Flapless	Wear/Damage/Replacement of O-rings, overdentures relines, worn teeth, detachment of housings	NR	8 failed	VAS Patient satisfaction	Eating, talking, appearance, comfort, healing, socialization, oral hygiene and stability and retention increased significantly with the use MI
Peršic' et al. [30]	Ball; Locator and Bar	NR	NR	NR	NR	OHRQoL	The MI used to retain overdenture showed better OHRQoL than bar and locator with standard implants.
Catalan et al. [31]	Ball	Flapless	NR	0 failed (100%)	0 failed	Patient satisfaction Retention Peri-implant mucosa	Patient satisfaction was significantly improved, and reported improvements in chewing, aesthetics, ability to socialize, and comfort levels. Retention without MI: (mean: 0.49 N) Retention with MI after 7 years: (mean: 6.21 N) Mucosa and peri-implant bone showed no pathological changes.
Souza et al. [13]	Ball (MI) Ball (SI)	MI: Flapless SI: Two-stage approach with full-thickness flap	Probing depth, bleeding, calculus and prosthetic complication was similar among groups, except for MPI that was higher for SI	G1: 16 failed (89%) G2: 15 failed (82%) G3: 1 failed (99%)	G1: 1 failed G2: 2 failed G3: 1 failed	OHRQoL Patient satisfaction	Overdentures retained by 4 or 2 MI showed OHRQoL and satisfaction similar to 2 SI; However the use of 4 MI showed higher overall ratings of satisfaction and masticatory ability
Mangano et al. [32]	Ball	Full-thickness flap	Hyperplastic mucositis Peri-implant infection Teeth fracture Replacement caps, Relining prostheses	1 failed (98.2%)	2 failed	MBL	MBL: 0.62 mm (±0.23)
Ribeiro et al. [8]	Ball	MI: Flapless SI: Two-stage approach with full-thickness flap	NR	NR	NR	VAS	Four mini implants induces more intense post-operative pain; but diameter (MI or SI) did not influence perceived swelling or functional discomfort
Šćepanović et al. [33]	Ball	Flapless/ Flap	NR	2 failed (98.3%)	NR	IS MBL	IS: 6.17 ± 6.15 MBL: 0.40 ± 1.24 mm

Table 3 (*Continued*)

Author	Retention System	Surgical Technique	Complications	Survival rates of mini implants, n	Overdenture fracture, n	Parameters evaluated	Outcomes
		surgical approach in 7 patients					
Preoteasa et al. [12]	Ball	NR	MBL more 3 threads, apical radiolucency, mobility, spontaneous peri-implant bleeding, Relining prostheses, detachment matrices,	8 failed (92.7%)	7 failed	Success of MI	Survival rates and health status were better for MIs placed in the mandible than placed in the maxilla Patients are satisfied with aesthetics, retention and function, but complaint with pain or instability were related
Maryod et al. [34]	Ball	Flapless	NR	7 failed (91.7%)	NR	Peri-implant health (MPI, MBI, PD) MBL	Immediate loading of MI showed significantly higher MPI, MBI, and PD than delayed loading. MBL is greater for immediate loading of MI after 6 months than delayed loading; however, after 3 years no difference were observed
Ashmawy et al. [35]	Ball	Flapless	NR	NR	NR	Electromyographic activity of masseter During of chewing	Overdentures retained by MI show increased significantly masseter muscle activity and chewing than conventional dentures
Tomasi et al. [36]	Ball	Flapless	Pain, swelling and lateral bone perforation during placement	16 failed (80%)	NR	VAS	The use of MI showed increased significantly chewing, speaking, comfort, stability/function, improved in social life
Elsyad et al. [37]	Ball	Flapless	NR	38 failed (66.6%)	NR	VAS IS MBL	The use of MI showed increased significantly retention and chewing. IS: Full palatal coverage: 18 (±7.79) Partial palatal coverage: 13.67 (±5.28) VBL – G1: 5.38; G2: 6.29 mm HBL – G1: 1.52; G2: 1.93 mm
Omran et al. [38]	Ball	Flapless/ Subcrestal incision	NR	NR	NR	PD GI MBL	MI: 2.94 (±0.18); SI: 2.90 (±0.14) MI: 1.02 (±0.94); SI: 0.73 (±0.64) MI: 1.02 (±0.12); SI: 0.94 (±0.09)
Šćepanović et al. [39]	Ball	Flapless and Flap surgical approach in 7 patients	NR	5 failed (95.8%)	3 failed	VAS Quality of life (OHIP-EDENT)	The use of MI in showed improvement to quality of life, stability, comfort, chewing and speaking ability, but there is no significant in hygiene and aesthetics.
Elsyad et al. [40]	Ball	Flapless	4 mini-implants showed excessive marginal bone loss O-ring replacement if worn, relining dentures	4 failed (96.4%)	NR	MPI MGI PD IS MBL	MPI: 2 GI: 1 PD: 1.39 (±0.39) IS: 4.2 (±1.2) VBL: 1.26 (±0.64); HBL: 0.74 (±0.57)
Jofre et al. [41]	Ball/ Bar	Flapless	NR	NR	NR	MBL	MI with ball: 1.43 (±1.26); MI with splinted bar: 0.92 (±0.75)
Jofre et al. [42]	Ball/ Bar	Flapless	Rubber ring exchange	NR	NR	MBF	MI with ball: 247.5 (±139.9) MI with splinted bar: 203.2 (±76.8)
Morneburg and Pröschel, [43]	Ball/ Magnetic	Full thickness Flap	NR	6 failed (95.5%)	NR	VAS	The use of MI showed significant increase of denture retention (8.4 ± 1.3) and chewing (9.1 ± 1.2) The patients were satisfied with stabilization of complete mandibular dentures with MI
Griffitts et al. [44]	Ball	Flapless	NR	3 failed (97.4%)	NR	Patients satisfaction	The use of MI show highly statistically significant levels of satisfaction in patient comfort, retention, chewing ability, and speaking ability.

HU: Hounsfield unit/OHRQoL: Oral health–related quality of Life/VAS: Visual Analog Scale/GOHAI: Global Oral Health Assessment Index/MBL: Marginal bone loss/MBF: Maximum bite force/Ball = O-rings/MPI: Mean plaque index/MGI: Mean gingival index/PD: Probing depth/IS: Implant stability/.

65.93 years. The mini implant system MDI – O-Ball (3M – ESPE) was the most commonly used in the studies. The mini implants placement in mandibular arch was more prevalent (2330 MI – 93.42%) than the maxillary arch (164 MI – 6.58%).

The groups of evaluated patients varied according to the type of study; the majority of studies were performed with only mini implants [9,28,29,31–33,39,40,43–45], and some studies compared the influence on the rehabilitated arch [12,36]. Four studies compared the use of MDIs with standard implants [8,13,30,38], three studies evaluated the influence of the retention system [30,41,42], one study evaluated the influence of the loading of MDIs [34], the influence of the palatal coverage in overdenture prosthesis [37], and the use of overdenture MDIs compared with conventional dentures [35].

Table 4
Survival Analysis indicating the survival rate of mini-implants for the 15 studies.

Follow-up intervals of the study (months)	No. of mini-implants in each interval	No. of failures in each interval	Survival rate within each interval (%)	Cumulative survival rate (%)
0–12	1576	103	93.46	93.46
12–24	1473	16	98.91	92.44
24–36	1457	2	99.86	92.32
36–48	1455	0	100	92.32
48–60	1455	0	100	92.32
60–72	1455	0	100	92.32
72–84	1455	0	100	92.32

The use of 4 MDIs was more common for rehabilitation with overdenture prosthesis, mainly in the mandibular region. However, in seven studies [8,13,31,38,41–43] the authors evaluated the use of only 2 MDIs to retain overdenture prosthesis. Furthermore, the retention system ball was the system of choice for all of the overdenture prosthesis, except in two studies that evaluated another type of prefabricated bar retention system with splinted mini implants [41,42]. The surgical technique most frequently used for the placement of the mini implants was flapless surgery; three studies [43] performed full-thickness flap, being two studies [33,39] due the complications in some patients.

Most of selected studies were prospective presenting scores level III-2, while three studies presents III-1 and four RCTs studies showed scores level II based on NMHRC scale. Of the 24 studies, 13 studies showed six stars, two seven and eight stars, and four nine stars representing a low risk of bias, while only one showed a high risk of bias (5 stars). The absence of stars was related mainly to the absence of non-exposed cohort, also to comparability between groups (Table S1).

3.3. Effect of MDIs on implant survival

Despite of the 2494 mini implants placed, 15 studies evaluated the mini implant survival rate [12,13,25,26,29,31–34,36,37,39,40,43,44], totaling 1576 of mini implants, with 121 (7.68%) failed, which corresponds to a mini implant survival rate of 92.32% during the follow-up period, which ranged from 1 to 7 years (Table 4). Maxillary arch was associated with higher failure rates [52 failed (31.71%) of 164 MI] than the mandibular arch [69 failed (4.89%) of 1412 MI].

3.4. Effect of MDIs on marginal bone loss

Marginal bone loss analysis was performed in seven studies [26,32–34,37,38,40,41]. Most studies showed marginal bone loss values below 1.5 mm [26,32–34,38,40,41], except one study [37] that evaluated with higher bone loss values (>1.5 mm) in maxillary arch.

Regarding different retention system, the splinting of MDI with prefabricated bar was associated with lower marginal bone loss (0.92 mm) than the ball system (1.43 mm); however, without significant difference ($P = 0.116$) [41]. Moreover, in overdenture prosthesis in maxilla, palatal coverage was considered an important factor to prevent vertical bone loss ($P = 0.045$), but without difference for horizontal bone loss ($P > 0.05$) [37].

3.5. Effect of MDIs on satisfaction and quality of life

Most studies evaluated the degree of satisfaction/quality of life of patients after they received rehabilitation treatment with MDIs [8,9,13,26,28–31,36,37,39,43,44]. The indices reported by the authors included Oral health-related quality of life (OHRQoL), Oral Health Impact Profile (OHIP-EDENT; OHIP-G14; OHIP-20), Global Oral Health Assessment Index (GOHAI), Visual Analog Scale (VAS) Satisfaction, and Patient Satisfaction Questionnaire.

Overdenture prosthesis retained by MDIs exhibited a significant increase in terms of retention [9,12,31,37,43,44], stability [9,36,39,43], chewing [9,26,28,31,35–37,39,43–45], speaking [9,26,36,39,44], comfort [9,26,28,31,36,39,44], aesthetics [12,31], improvements in satisfaction [9,12,26,31,37,43,44], and consequently social life or quality of life [9,28–31,36,39,44,45]. Overdentures retained by MDIs exhibited better OHRQoL results compared with overdentures supported by standard implants [30]; however, in other studies OHRQoL was similar for both treatments [8,13]. Three studies evaluated maximum bite force (MBF) and reported high values after use of mini implants [27,29,42] with similar values of bite force when compared with standard implants [27].

3.6. Effect of MDIs on overdenture survival

Overdenture survival was reported in seven studies [9,12,13,25,31,32,39]. Of the 244 overdentures retained by MDIs evaluated, 23 (9.42%) fractured, which corresponds to survival rate of overdentures of 90.58%. The overdenture fracture in the area of metal housing showed higher incidence [12,39], likely due to a thin layer of resin [39]. Moreover, in most cases the fracture was repaired of overdenture prosthesis [9,12,39].

4. Discussion

Recently, the use of mini implants in the specialty of prosthodontics has become a rehabilitation option for patients who have limitations that precluding placement of conventional implants [11]. The first hypothesis has been accepted since was reported high survival rates (92.32%) of the mini implants for overdenture prosthesis (Fig. 2), and these rates were comparable to those of conventional implants for retention overdenture prosthesis [46,47].

This results suggests that mini implants for overdenture prosthesis may become an accepted treatment modality, especially suitable for patients who have limitations such as limited finances since standard implants require a specific retention system to retain prostheses (e.g., O'ring, ERA®, bar-clip), and mini implants are often single-body implants including the ball system. Moreover, there are the benefits of reducing postoperative morbidity given the absence of bone tissue for the placement of standard implants or patients who cannot be subjected to extensive surgical procedures; in most cases, the placement of the mini implants is performed without the use of surgical flaps [8,9].

The results of survival rates of mini implants were similar to those recovered in a systematic review by Bidra and Almas [11] that demonstrated the possibilities of using mini implants for prosthetic rehabilitation such as overdenture prosthetics. These authors reported that there are still questions about treatment

with mini implants to retain overdenture prosthesis. Therefore, some variables such as marginal bone loss, satisfaction, quality of life, different arches, retention systems, might influence the longevity of this type of treatment, and because of this was analyzed in this study.

The overdenture prosthesis in the maxilla showed higher failures rates (31.71%) when compared with mandible (4.89%) and this should be considered during treatment plan. Maxillary arch typically presents low bone density and consequently an increased risk to failures [7,37]. Moreover, the thick masticatory mucosa on the maxilla often necessitates longer implant abutments, which increases lever arm length [37,48]. The type of overdenture prosthesis also influence the survival rate of the mini implants, since full palatal coverage exhibited lower failures (21.6%) than partial palatal coverage (46.2%). This difference can be explained by the presence of a larger overload on mini implants since the palatal coverage provides additional support to the overdenture bases [49], and improves stress distribution between implants and adjacent soft tissue support areas [37,50].

Although general values are favorable for the survival rate of the implants, two studies [13,25] evaluated the use of mini implants compared with standard implants. Temizel et al. [23] reported that one standard implant failed, with no failures for the mini implants. However, Souza et al. [13] presented lower survival rates for mini implants (85.5%) than conventional implants (99%). This difference in this study may have been influenced by biomechanical factors such as length that has an influence on the longevity of the treatment [16]. The mini implants system used in this study had lengths of 10 mm; while in other studies the lengths of the mini implants varied from 12 to 18 mm.

Similarly, Tomasi et al. [16] found that mini implants with length (7–10 mm) presented a higher failure rate than the longer mini implants (14 mm), 38% versus 3%. In addition, the use of the long mini implant in the replacement of the lost implants resulted in maintenance of mini implant in the observation period. Thus, length may affect the longevity, and long mini implants should be selected for the best prognosis of the treatment [16]. Thus, in cases of bone availability is recommended of the use of the longest mini implants in order to ensure the longevity of the treatment. In addition, future studies should investigate if longer or wider mini implants, can combine the versatility of these variables [13].

According to the McGill consensus, two standard implants are suggested to retain mandibular overdenture [4]. However, regarding the use of mini implants, the majority of the studies of this systematic review used four mini implants to retain overdenture prosthesis in mandibular arch [8,9,12,13,25–29,32,33,35,36,38–40,44], while some studies evaluated two mini implants [8,13,41,42]. When evaluated the influence of the number of mini implants in the same study, higher failure rates were noted for the use of two mini implants (18%) compared with 4 mini implants (11%) [13]. Additionally, four mini implants were associated with higher rates of satisfaction and masticatory ability [13]. Therefore, may be recommend the use of four MI for rehabilitation with mandibular overdenture prosthesis. Some instructions manufacturers recommends the number required of mini implants is at least four in the mandible (interforaminal region), with at least 5 mm from each other, and should be at least 7 mm anterior to the mental foramen, while in the maxilla the use of a minimum of six mini-implants is recommended.

The second hypothesis was accepted as well; Six studies reported the acceptable marginal bone loss, and only one study [37] exceeded the limits of 1.5 mm marginal bone loss established for the clinical success of standard implants [51]. It is worth noting that this study evaluated bone loss values in the maxillary arch, and this may have influenced this difference. Therefore, additional studies following patients over longer periods to evaluate marginal bone loss should be performed comparing the bone loss of mini implants with standard implants.

A significant increase in quality of life and satisfaction aspects has been reported; these factors contribute significantly to the enhanced social life of patients [9,31]. Mini implants were associated with better [30] or similar [8,13] OHRQoL scores compared with standard implants. This may be related to the behavior of the retention system since the nylon matrices used for standard implants can be more susceptible to wear than the O-rings used for mini implants, and this can necessitate periodic maintenance to exchange these systems [13].

Two studies have compared the influence of overdentures retained by mini implants with conventional dentures [28,35]. Chewing/electromyography of the masseter muscle and observed a significant increase in the values of these variables for overdenture prosthesis retained by mini implants [35]. In addition, the use of mini implants showed better kinematic parameters of mastication (chewing cycles and chewing time), independently of food, and consequently in the quality of life, increasing the values of geriatric oral health assessment Index (GOHAI: functional field, adjusted discomfort field, psychosocial field and adjusted GOHAI) [28]. Thus, the use of mini implants for rehabilitation of edentulous patients can be considered a treatment more favorable than use of conventional dentures.

Some complications have been reported related to mini implant fracture [39], high bone loss that can lead to mobility of the mini implant [12], and lateral drilling of the bone tissue due to the lack of vision of the surgical field with a flapless surgery [36]. As a result, the reverse planning using complementary tests can be recommended.

Biological complications related to soft tissue were also observed, including peri-implantitis or mucositis, bleeding, increased pocket depth, and calculus [12,13,32], as well as mechanical complications related to the type of the overdenture prosthesis, such as the exchange of the rubber ring and/or retention system, detachment of the metal housings, fracturing of artificial teeth, or fracturing of the prostheses [9,39,42]. However, it is important to emphasize that these related complications are not inherent only to mini implants; such complications can also be observed in overdentures retained by standard implants [13].

The most widely used retention system was the ball type (O'rings), and three studies assessed other retention systems such as bars [41–43] and magnetic housings [42]. This prevalence may be attributed the high retention rates of this system for retaining overdentures [52]. In addition, ball-type systems are effective both in terms of time and cost [44], since the mini implants already have this system type attached to their end.

In terms of the surgical technique, almost all of the studies [8,9,13,28,31,33–36,38–42,44] used the flapless technique. According to some authors, this technique may reduce postoperative pain, discomfort, and consequently the morbidity of patients [11,40,45]. However, Ribeiro et al. [8] compared the flapless technique with the flap technique in the placement of standard implants and found no difference in terms of pain and/or postoperative morbidity.

The limitations of present systematic review is that despite the significant increase in the number of studies that have assessed the behavior of mini implants for retaining overdenture prosthesis there is a fewer numbers of RCTs. Additionally, the difficulty of blinding of participants, personnel and outcome assessors can be considered a bias of this study. Thus, these results should be interpreted with caution due to reduced number of RCTs, and further RCTs should be performed to better answer in terms of rehabilitation treatment with overdentures supported by mini implants. Even so, the use of MDIs to retain overdenture prosthesis

demonstrates viability, adequate survival rates, marginal bone loss and good patient satisfaction; it may therefore represent a viable clinical indication for appropriate cases, especially in situations where it is not possible rehabilitate the patient with standard implants.

5. Conclusion

Within the limitations of this study, the present systematic review indicates that the use of mini implants for retaining overdenture prosthesis may be considered an alternative treatment, since it presents high survival rates of mini implants, acceptable marginal bone loss, and improvements in variables related to satisfaction and quality of life of patients.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jdent.2016.11.009.

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