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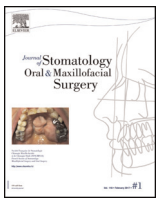

Review

Single versus splinted short implants at sinus augmented sites: A systematic review and meta-analysis

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ABSTRACT

Objective: This review primarily evaluated the success, survival and failure rates of implants shorter than 10 mm restored with single-unit or splinted fixed dental prostheses in maxillary sinus augmented sites.
Material and methods: Two reviewers independently performed the systematic search of electronic databases, including MEDLINE, EMBASE and CENTRAL, up to September 2019 with no language restriction. A supplemental hand search consisted of screening 13 journals. The inclusion criteria were: primary studies reporting implant, prosthetic and patient-reported outcome measures (PROMs) of extra-short and short implants placed in conjunction with sinus floor elevation in partially dentate patients, restored with single- and splinted-crowns for direct comparison, with a minimal 1-year follow-up. Weighted arithmetic mean (WAM) of the implant survival was performed according to the type of prosthesis. This was confirmed by using Review Manager software to perform meta-analysis.
Results: Two observational studies reporting on 106 tapered, press-fit, sintered porous-surfaced implants with a length ranging from 5 mm to 9 mm were included in this systematic review. Of these, 20 and 86 implants were restored with single and splinted prostheses, respectively. The risk ratio (RR) was 1.16 (95% CI: .31–4.30, p = .58, I^2 = 0%) for individually restored implants failure when compared to splinted implants, indicating that short dental implants restored with single crowns could have a 16% higher possibility of failure if compared to implants with splinted crowns. The heterogeneity value was not statistically significative (p = .58). No statistical difference in the implant survival rate of the two types of analysed prostheses was observed after WAM (p= .923). The level of evidence for the included studies ranged from low (4) to fair (2B).
Conclusion: Similar clinical outcomes up to a 9-year follow-up were observed in single and splinted porous-surfaced implants shorter than 10 mm located in sites with sinus lift. However, the conclusion shall be interpreted with caution due to the level of evidence and limited number of included studies included in this systematic review.

1. Introduction

Rehabilitation of the maxillary posterior region, presenting a diminished residual ridge height, is a frequent concern that poses a major challenge [1–3]. Currently, there is a growing interest in the use of short dental implants to overcome these compromised clinical scenarios and reduce treatment duration, cost, complications and failures [4]. The first studies on this topic reported a 25% failure rate for 7–8 mm implants [5,6], concluding that the shorter the implant, the higher the failure rate. More recent studies demonstrated that there was no difference in the failure rates

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based on the length of the titanium plasma-sprayed implants [7]. Short implants present similar or remarkably fewer complications than longer implants combined with lateral sinus floor elevation [8,9]. Nonetheless, it is generally considered that short dental implants need to be splinted for long-term success [10], especially in patients undergoing staged or simultaneous implant placement. For instance, a recent study concluded that non-splinted implants (odds ratio [OR] = 6.9) and shorter implants (OR = 3.4) showed a significant association with failure [11]. However, there is evidence that the type of prosthesis does not impact the outcomes [12]. Relatedly, excellent long-term outcomes were reported in a study including 6–9 mm-long moderately rough threaded implants supporting single-crowns in maxillary sinus augmented sites [13]. Adding to the controversy, there are no controlled studies using split-mouth designs to compare single- versus splinted-crowns [14]. Additionally, short and extra-short implants are attractive options to avoid sinus lifting when restoring the severely atrophic posterior maxilla. However, there is a paucity in the literature reporting data of short and extra-short implants in sites that still needed to undergo a sinus lift.

To the best of the authors' knowledge [15,16], no review to date has investigated the clinical outcomes of extra-short and short implants placed in maxillary sinus augmented sites and subsequently restored with either free-standing or splinted restorations. Hence, this review aimed to identify the literature published on the success, survival and failure rate of single-unit and splinted contiguous implants shorter than 10 mm aided by a sinus floor elevation approach.

Table 1
Search strategy used for OVID MEDLINE.

Search no. and keywords involved
1 exp MAXILLARY SINUS/ or sinus*.mp.
2 *Sinus Floor Augmentation/
3 lift*.mp.
4 elevat*.mp.
5 augment*.mp.
6 exp Dental Implants/
7 exp Dental Implantation, Endosseous/
8 ((dental or oral) and implant*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
9 splint*.mp.
10 2 or 3 or 4 or 5
11 6 or 7 or 8
12 1 and 9 and 10 and 11

2. Materials and methods

2.1. Protocol development

A systematic review was conducted and reported adhering to the PRISMA statement [17], the Cochrane Collaboration guidelines [18] and the AMSTAR quality standards for therapies [19]. The intention was to minimise potential bias in the review process by promoting transparency, quality methodology and better reporting, as published elsewhere [20–22].

2.2. Search strategy

The performed systematic search of electronic databases included MEDLINE via Ovid (Table 1), EMBASE via Ovid (Table S1) and the Cochrane Central Register of Controlled Trials (CENTRAL) via the Cochrane Library (Table S2) until the last week of September 2019 with no language restriction. Two reviewers (KIA and KI) independently screened the titles and abstracts of the publications that met the initial selection criteria and reviewed the entire article in the publications that were relevant. The reviewers were not blinded. The reasons for exclusion were reported for each study that was included in the systemic review. Both reviewers resolved disagreements by discussion to reach consensus.

Moreover, one reviewer (KIA) performed supplemental manual searches by cross-referencing the preliminary identified related studies and screening the following 13 journals between January 2015 and September 2019: *Journal of Prosthodontics, International Journal of Prosthodontics, Journal of Prosthetic Dentistry, The International Journal of Periodontics and Restorative Dentistry, Journal of the American Dental Association, Journal of Dentistry, Journal of Prosthodontic Research, The Journal of Periodontal and Implant Science, The International Journal of Oral & Maxillofacial Implants, Clinical Oral Implants Research, The Journal of Advanced Prosthodontics, Clinical Implant Dentistry and Related Research, European Journal of Oral Implantology, Implant Dentistry, and Journal of Oral Implantology*. Grey literature was also searched via the Open Grey database (http://www.opengrey.eu). A flow diagram was designed following the PRISMA statement to depict each step of the identification–inclusion process [17].

2.3. Types of studies and selection criteria

Both controlled trials and observational studies were considered for answering the research question, as suggested in the literature [23], and as other authors have previously done [20,22]. Reports were included if they met the following inclusion criteria:

- Population: Partially edentulous patients who received extra-short and short implants with simultaneous transcrestal/osteotome/vertical or lateral sinus floor elevation. Extra-short and short implants were defined as dental implants with a length of 6 mm or less and less than 10 mm, respectively [24,25]. Osteotome sinus floor elevation was defined as a crestal approach or internal sinus lift, whether it a 1-stage [26] or 2-stage technique was used [27]. The lateral sinus floor elevation was defined as accessing the maxillary sinus through the lateral sinus wall and displacing the floor with a bone graft [28]. The 2-stage approach is generally used in scenarios with a residual bone height less than 6 mm, which would compromise the implant primary stability [27].
- Intervention: Contiguous implant-supported splinted/coupled fixed dental prostheses.
- Control: Implant-supported single/free-standing crowns.
- Outcome measure: The primary outcome was to identify the success, failure and survival of the implant. The secondary outcomes were to assess the crestal/marginal bone loss (CBL/MBL) level [29], the incidence of biological complications [21] and patient-reported outcome measures (PROMs).
- Time: A minimum mean follow-up of 12 months after prosthetic treatment.

- Setting: No limits were established regarding the clinical setting. Therefore, participants recruited from a university, hospital, primary care or private office could be included.

To consider a study for inclusion, it had to report on the type of prosthesis used with short implants in augmented maxillae. Furthermore, single- and splinted-crowns had to be included to facilitate a direct comparison of the effects on implants shorter than 10 mm.

Reports were excluded if they did not pertain to the search terms described in the inclusion criteria; were in vitro or nonhuman studies; did not mention the type of bone (i.e. augmented) and implant (i.e. short and extra-short = less than 10 mm) in the title or abstract; did not report the outcome of interest; did not discriminate data on anterior or mandibular region; did not provide or did not allow extraction of the required data; reported indirect restorations other than fixed restorations (e.g. implant-assisted removable dental prosthesis); reported cases that did not have opposing teeth; was missing either a single- or splinted-crowns group; or placed implants in fully maxillary edentulous patient.

The reasons for excluding articles were classified as follows:

- Lack of maxillary sinus augmentation information (including records that precluded the option to separate the maxillary augmented sites from the non-augmented sites, or records that did not mention if the implant site was sinus lifted);
- Unfeasible to extract the type of prosthesis information on the maxillary grafted sites;
- Missing a single-crowns group;
- Missing a splinted-crowns group;
- Unfeasible to distinguish between implants splinted to teeth and implants splinted to implants;
- Included an implant splinted to teeth group instead of an implant splinted to implant group; or
- Evaluated dental implants with a length of 10 mm or longer

2.4. Focused question

In terms of the clinical performance of adjacent short and extra-short implants in the augmented maxillary sinus of partially edentulous patients, which type of prosthesis (i.e. single or splinted crowns) favours the clinical outcomes and PROMs after a minimum of 12 months follow-up?

2.5. Data extraction

If multiple articles presented trial data, only outcome data from the most recent report were assigned as the main focus of the study. The following data were extracted and recorded by two reviewers (KIA and KI) into a specifically-designed electronic spreadsheet: names of authors, year of publication, country of the trial, study design, mean follow-up, characteristics of the participants (e.g. age, gender, setting), dropouts, implant characteristics (i.e. length, diameter, shape, surface, connection, tissue or bone level, manufacturer), type of sinus augmentation procedure, surgical stages approach (i.e. 1 or 2), type of graft material, type of restoration (i.e. single crowns, splinted crowns), materials used in the restoration (e.g. porcelain fused to metal, zirconia), site localisation (i.e. premolar, molar), outcomes, methodological quality of the trials, conclusions and funding agencies.

When relevant data were combined or not available, a reviewer (KIA) attempted a maximum of two times to contact the authors of the publications for clarification or analyses of the raw data provided; however, the responses did not add relevant information.

2.6. Methodological assessment and risk of Bias

The same independent reviewers (KIA and KI) carried out the methodological quality assessment based on the type of the study, and compared their results.

The methodological quality of the nonrandomised cohorts was assessed using a seven-parameter quality domain-based evaluation: blinding of participants and personnel, comparability of the control and treatment groups, clear definition of the inclusion and exclusion criteria, recall rate, sample size calculation and the number of clinicians involved [20]. Each trial methodological quality parameter was graded as 'adequate,' 'inadequate,' 'unclear' or 'not applicable' [20]. Studies was defined as low risk of bias if the seven criteria listed above were clearly met in the study. If one or more of these criteria were not met, a study would be considered to have a moderate or high potential risk of bias, respectively.

To identify the best available evidence on the reviewed themes, the level of evidence of the included studies was further assessed based on the levels developed by the Centre for Evidence-Based Medicine (CEBM) for treatment (Table S3) [30].

2.7. Statistical analysis

The agreement between the reviewers for the inclusion of records based on title/abstract, full text and qualitative assessment was not reported since there was a discussion at each stage until consensus was reached. The outcome was treated as a continuous variable (0%–100%) to report the weighted arithmetic mean (WAM) that was calculated using the following formula:

$$x = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i},$$

where x_i = the average of sample $_i$, and w_i = size of sample $_i$ [21]. The WAM was calculated using Microsoft Excel 2013 version 15.0 (Microsoft, Redmond, WA, USA) for Windows.

A x^2 test was used to determine the significance of the WAM of the total number of implant failures and the total number of implants according to the type of prostheses. The statistical significance level was determined at $\alpha < .05$. The data were analysed using SPSS software version 24.0 (IBM Corporation, Armonk, NY, USA).

Inferential statistical analysis is not generally recommended when a limited number of primary studies are included in a review. However, analyses containing as few as two studies may provide some information about clinical behaviour [20]. Thus, to further analyse the outcomes as a dichotomous variable (i.e. failure as an adverse event) from the included studies, a meta-analysis was performed using the Mantel-Haenzel statistical method and the fixed effect analysis model. The effect measure selected was the risk ratio (RR), and heterogeneity was assessed using I^2 statistics. The findings were also visually presented as a forest plot, and a funnel plot was created. These data were analysed using Review Manager (RevMan) software (version 5.3. Copenhagen: The Nordic Cochrane Center, The Cochrane Collaboration, 2014).

3. Results

3.1. Search findings and study characteristics

The initial search yielded 76 articles, of which 15 were duplicates. After excluding papers that were irrelevant to the topic based on abstract screening, 38 articles were kept. Only two of the 38 studies [31,32] were included after performing a full-text analysis (Fig. 1). The reasons for excluding 36 of the articles are addressed in Table S4. The two included studies were retrospective

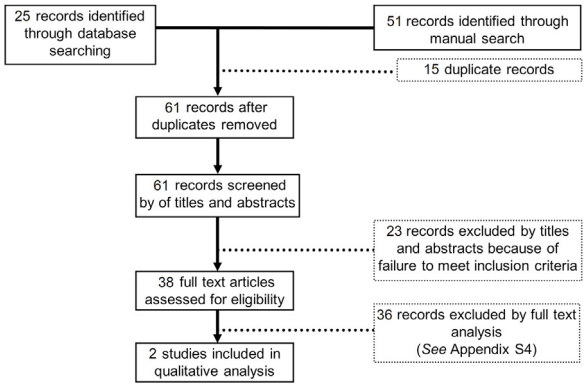

Fig. 1. PRISMA flowchart of study selection.

and published within the last 10 years. The selected articles reported on extra-short (5-mm-long, Innova Lifesciences, Toronto, ON) [31], short (7- and 9-mm-long, Endopore Dental Implant System, Innova Corporation) and standard (12-mm) sintered porous-surfaced dental implants (Table 2) [32]. The multicentre study [31] included 20 patients and 14 implants, while the more recent paper [32] included twice as many participants and six-times more implants shorter than 10 mm in the augmented maxillary sinus.

Neither of the manuscripts reported on the materials that were used for the implant-supported prostheses. Both studies used the same implant system, which had an external hex as the implant-abutment connection. Deporter et al. [31] reported that the prostheses retention mechanism was screwed or cemented and that when the most distal abutment was involved, it was decided that the prosthesis should be splinted rather than non-splinted. Both studies indicated that the dental antagonists were natural dentition or fixed prostheses (Table 2). Concerning the functional follow-up, both studies had a similar range. In Deporter et al., it ranged from 1 to 8 years; in Sohn et al., it ranged from 1 to 9 years. However, the mean was only reported in one study [31]. Deporter et al. [31] included data from four centres based in Canada, Japan, South Korea and Australia. Sohn et al. [32] only included data from South Korea. Both studies included data from teaching hospitals and private clinic settings.

3.2. Quality assessment

The studies [31,32] were analysed with the Cochrane Collaboration's tool for assessing the risk of bias (Fig. 2). Both studies had the same score in every assessed item. Therefore, the overall scores were also the same. Both studies provided sufficient data regarding the clear definition of selection criteria, clear definition of outcome assessment and success criteria and recall rate. However, the sample size calculation was at high risk, and the number of clinicians involved was unclear. Blinding of the participants and staff, as well as comparability among the groups, was not applicable. Industrial support represented a questionable source of bias in both cases despite the authors' denials of conflict of interests (Table 2). One study reported that the manufacturer provided the implants [31]. Both articles were considered to be at an overall high risk of bias; in terms of the level of evidence (Table S3), Deporter et al. [31] was classified as 4 (low), whereas Sohn et al. [32] was classified as 2B (fair). Deporter et al. included extra-short implants, whereas Sohn et al. included data on short (7 mm–9 mm) implants (Table 3).

3.3. Clinical outcomes

Both studies [31,32] used osteotomes for vertical sinus floor elevation. However, Sohn et al. [32] also provided data from patients managed with the lateral open window sinus elevation approach. All implants were placed simultaneously with maxillary sinus augmentation. Neither Sohn et al. nor Deporter et al. mentioned anything related to the decision for sinus elevation when using short implants or extra-short implants, respectively. Deporter et al. used well-known implant success criteria [33] to report the implant outcome, while Sohn et al. used two success criteria tools [34,35] to determine survival. Deporter et al. lacked standardisation of radiographs, whereas Sohn et al. used a standardised long-cone paralleling technique for radiographs. Consequently, only the latter study was able to report on marginal bone loss during the first year and follow-up periods. In Deporter et al., 14% of the short implants were lost in the augmented maxillary sinus, while close to a 9% were lost in Sohn et al.

Deporter et al. [31] included four-times more splinted-crowns than single-crowns and found a 18% failure for the former option; there were no failures in the small sample sized single-crown group (Table 4). Consequently, the authors concluded that the extra-short implant was highly promising for mandibular posterior cases, but it should still be used with caution in the maxillary sinus augmented cases. Sohn et al. [32] did not find statistical differences between single- and splinted-crowns. Interestingly, Sohn et al. also presented four-times more splinted-crowns than single-crowns. Moreover, the authors supported using short implants in broad practice when treating the augmented maxillary sinus since the survival rate was over 90%. Neither of the articles reported on prosthetic outcomes or complications (Table 4). The two studies included a total of 106 short implants (Table 5). While 20 implants supported single-crowns, 86 implants had splinted-crowns reconstructions. There was no statistically significant difference in clinical outcomes between the two types of prostheses when supported by short sintered porous-surfaced implants placed in maxillary sinus augmented sites after WAM statistics (Table 5). Interestingly, the meta-analysis showed that Deporter et al. [31] slightly favoured single crowns, whereas Sohn et al. [32] leaned towards splinted crowns (Fig. 3). Additionally, the meta-analysis revealed a RR of 1.16 (95% CI: .31–4.30) for individually restored implants failure when compared to splinted dental implants (Figure S1). It indicated that the short implants restored with single crowns could have a 16% higher possibility of failure if compared to short implants restored with splinted crowns (Fig. 3). The heterogeneity value was not statistically significative (p = .58).

4. Discussion

This review intended to provide clinical recommendations on the type of prosthesis (splinted or non-splinted restoration) for improved long-term outcomes in patients managed with implants shorter than 10 mm in the augmented maxillary sinus. Two reviewers with vast experience in evidence synthesis conducted an electronic and manual search (Table 1; Tables S1 and S2) of the published literature up to September 2019. Based on the prespecified focused question and after applying the inclusion criteria, only two articles (Fig. 1; Table 2) were included. It is not uncommon to find systematic reviews with a limited number of included studies reporting pooled estimates or inferential statistics [22,36,37]. The present review also created a funnel plot (see Figure S1). There were several reasons for excluding full texts, even if they included one or both types of prostheses (Table S4). The conclusions from the present review should be interpreted with caution for the following reasons [38]: the risk of bias in both articles was less than ideal (Fig. 2); Deporter et al. [31] did not reach a fair level of evidence (Table S3); the sample size of both articles was less than ideal (Table 5) due to the limited number of

Table 2
Characteristics of the included articles: demographics and prosthetic characteristics.

Authors, year	Country	Patients, n	Female, n(%)	Age, years	Restorations, n Single/ Splinted	Implant-abutment connection	Placement-loading time	Implant-restoration retention mechanism	Antagonist dentitions to implant sites	Other assessed variables	Functional follow-up, years	Clinical setting
Deporter et al. 2008 [57] [1]	Canada, Japan, South Korea, Australia	20	12(60)	Range: 21 to 69	3/11	Standard 0.7-mm-high external hex connection	Prosthesis begun after at least 4 weeks post-re-entry	Screw- or cemented-retained implant prostheses	Natural teeth, tooth-supported fixed dental prosthesis, or teeth and implants	Mx vs Mn failure rates	Range: 1 to 8	2 dental schools, 1 hospital, and 1 private clinic
Sohn et al. 2014 [58]	South Korea	42	NR	NR	17/75	External hex connection	Provisional prosthetics were connected to all implants for 4–8 weeks	NR	Natural teeth or fixed dental prostheses	Location, length, diameter, crown-to-implant ratio	Mean: 6.1 Range: 0.9 to 8.9	1 teaching hospital and 1 private clinic

n, number; hex, hexagonal; Mn, mandibular; Mx, maxillary.
[1] Data other than posterior maxillary implants was excluded.

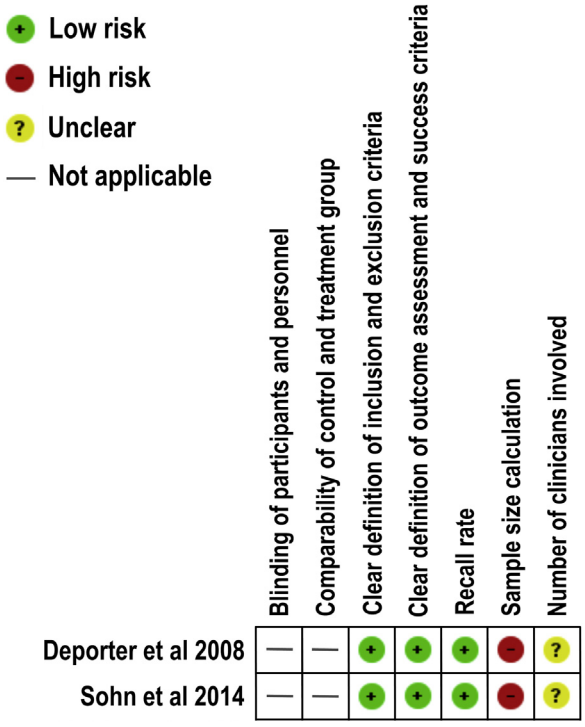

Fig. 2. Risk of bias summary: reviewers' judgements about each risk of bias item for each included study.

implants included in the single-crown groups (Table 4); the confidence intervals seemed to be large (Fig. 3). Hence, it is highly recommended that future studies be conducted to uncover more evidence on the specific question that we proposed.

With most implant companies now offering short and extra-short implant designs, the question of whether these implants can be restored without splinting in the augmented maxillary sinus is critically relevant. A significant number of variables may affect implants and restorations in the augmented maxillary sinus, such as bone quality, patient selection, graft material, bone volume, type of loading, implant form, length and width, among others [14,39,40]. A recent review [16] reported that splinting extra-short implants leads to fewer complications and a lower failure rate than free-standing implants, but these sites did not have sinus augmentation. Another review reported that surface geometry (i.e. machined versus rough) had a significant influence on the clinical outcome of dental implants that are shorter than 7 mm [41]. Additionally, both of the included studies [31,32] were related to a specific implant design, which differs from the more widely used threaded dental implant designs in similar lengths and prosthetic treatments. This is because the Endopore implant relies on osseoconsolidation rather than osseointegration (i.e. three-dimensional bone ingrowth into the surface multilayer of the spherical particles of titanium alloy) [42]. Our included primary studies failed to provide information about PROMs. However, one study has reported excellent patient satisfaction in people receiving short and extra-short implants regardless of the prostheses type [25].

Through previous systematic reviews [43], it is known that sinus augmentation via a lateral window or transalveolar approaches for implant purposes are considered to be predictable interventions. One-stage surgery is attractive because it is less invasive, less costly, and it has a shortened treatment time. However, two-stage surgery may be an option for maturing the graft before an implant installation [44]. A study that reported on 5-year outcomes with the same short implant design that was

Table 3
Characteristics of the included articles: implant characteristics.

Authors, year	Implants, n	Type of implants	Implant size, mm	Surgical technique		Graft material	Healing time, months	Implant success/ survival criteria	Standardization of radiographs	Implant success, n(%)	Failed implants, n(%)	1 year/ final MBL at, mm
				Soft tissues	Hard tissues							
Deporter et al. 2008 [57][1]	14 in Mx (26 in total)	Titanium alloy (Ti-6Al-4 V) as a tapered truncated cone shape	Maximum diameter: 5 Length: 5	Full-thickness mucoperiosteal flap and submerged approach	Osteotomy sites were prepared using rotary burs and/or, hand osteotomes for posterior maxilla (bone type III or IV)	NR	3 to 6	Buser, et al. *Quintessence Int* 1994;25:679–86	No. Therefore, no attempt was made to measure peri-implant crestal bone heights	12 (85.7) in Mx (24 [92.3] in total)	2(14.3) in Mx 2(7.7) in total	NA
Sohn et al. 2014 [58]	92	Tapered cylindric porous-surfaced implants	Diameter: 4.1 and 5 Length: 7, 9, and 12	NR	56 implants with BAOSFE 36 implants placed with lateral window technique. All implants were placed simultaneously	Radiopaque bovine or mineral allograft	6	Albrektsson, et al. I*nt J Oral Maxillofac Implants* 1986;1:11–25 Roos, et al. *Int J Oral Maxillofac Implants* 1997:12:504–514	Yes. Panoramic and periapical radiographs (standardized long-cone paralleling technique) at the first visit, postoperatively, at the time of prosthesis seating, and at a follow-up visit	NA	8 (8.7) [5 BAOSFE, 3 lateral approach]	0.68/1.13

n, number; %, percentage; BAOSFE, bone-added osteotome sinus floor elevation; Mx, maxillary; MBL, marginal bone loss; NA; not applicable; NR; not reported.
[1] Includes data from implants placed in mandible except when indicated otherwise.

Table 4
Single versuss splinted crowns implant and prosthetic outcomes.

Authors and year	Implant failures, n (%)		P-value	Restoration failures, n (%)		P-value	Results	Conclusions	Authors and year	Implant failures, n (%)
	Single	Splinted				Single	Splinted			
Deporter et al. 2008 [57] *	0 (0)	2 (18.2)	NR			NR	NR	NA	2 Mx implants failed (4.3%), and none Mn implant failed (0%)	5 × 5 mm dental implants should further be investigated to manage highly resorbed posterior sites in partial edentulism
Sohn et al. 2014 58]	2 (8.5)	6 (12.5)	0.65			NR	NR	NA	No statistical differences were found regarding location of implants, C/I ratio, or type of prosthesis. Statistical differences found in implants size	The cumulative survival rate of sintered porous-surfaced implants in the maxillary sinus augmented sites show satisfactory results

n, number; %, percentage; Mn, mandibular; Mx, maxillary; NA; not applicable; NR; not reported.
* Data other than posterior maxillary implants was excluded otherwise indicated.

Table 5
Weighted arithmetic mean of the total implant failures and total implants according to the type of prostheses.

	Implants, failures n/total n (failure %)		P-value*
	Single	Splinted	
Implant failures, n(%)	2/20 (10)	8/86 (10.8)	.923
Implants total, n(%)	20/106 (18.9)	86/106 (81.1)	< .001

n, number; %, percentage.
* x^2 statistic.

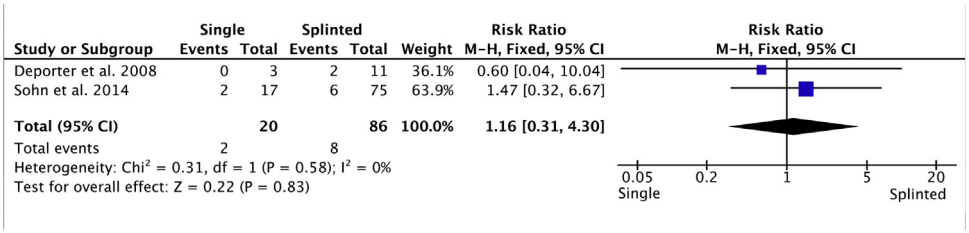

Fig. 3. Forest plot comparing the adverse events of single and splinted implants in sinus lift sites.

presented in the present review, certainly supported its use in conjunction with osteotome sinus elevation [45]. A review has reported that bone quality is particularly important for short implants that are to be placed in the maxillae [46]. Moreover, since bone density in the posterior maxilla is often low, it has always been maintained the short implants are more likely to fail in the posterior maxilla than in the posterior mandible [41]. However, a recent network meta-analysis reported that short implants with simultaneous osteotome sinus floor elevation with or without bone grafting were the most effective option (implant and prosthesis survival rates = 77.1%) for restoring the posterior maxillae with less than 8 mm of bone height below the maxillary sinus [9]. At the moment, there are only 5 trials concerning 142 short implants (106 patients, 106 sinuses lifts) placed with osteotome sinus floor elevation with and without bone grafting [47–50]. However, none of these trials provided sufficient data or included both types of prostheses.

It has been suggested that the more implants and abutments used to support a fixed reconstruction, the lesser the risk of prosthesis failure [14]. Splinting adjacent implants has been recommended in cases where the posterior maxillary bone residual height is less than 5 mm; it is believed that this will prevent implant mobility and failure [51]. Moreover, immediate loading of splinted implants in maxillary sinus augmented sites has been considered to be a predictable procedure [52]. Consequently, when short implants are placed in maxillary sinus augmented sites, they are generally splinted to longer implants to reduce occlusal overload [53]. The rationale for this is that splinting may reduce the bone-implant interface stresses. For instance, it is recommended to place extra-short implants in low-quality bone only when the minimum diameter is 4 mm in order to maximize bone-surface contact and progressive occlusal load during the prosthetic phase [53]. However, it has been reported that the type of prosthesis does not influence implant failure in maxillary sinus augmented sinus sites [54]. Additionally, a recent review found similar peri-implant marginal bone loss regardless of the type of prosthesis [55].

5. Conclusions

Within the limitations of the present study, the clinical outcomes up to 9 years were similar for single and splinted short and extra-short press-fit, sintered porous-surfaced implants in the augmented maxillary sinus. There are no studies directly comparing splinted and non-splinted short implants with a rough surface in sinus lifted scenarios. High-quality long-term prospective studies with larger sample sizes are needed to provide more solid clinical recommendations for whether the type of prosthesis is a concern with short implants in the augmented maxilla.

Conflicts of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jormas.2020.08.013.

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