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What Is the Most Effective Rehabilitation Method for Posterior Maxillas With 4 to 8 mm of Residual Alveolar Bone Height Below the Maxillary Sinus With Implant-Supported Prosthesis? A Frequentist Network Meta-Analysis

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Purpose: The most effective rehabilitation method for patients with edentulous posterior maxillas with an intermediate (4 to 8 mm) residual bone height (RBH) below the maxillary sinus is unclear. Evidence derived from conventional meta-analysis is limited because of the lack of head-to-head studies. This network meta-analysis (NMA) was performed to identify the most effective method to treat patients with intermediate posterior RBH.

Materials and Methods: An NMA of randomized controlled clinical trials (RCTs) was conducted to assess various rehabilitation methods using implant-supported prostheses for patients with intermediate posterior maxillary RBH (4 to 8 mm). Publications from 1970 through March 2018 in 3 major databases were searched. Parallel and split-mouth RCTs that reported the outcomes of interest with follow-up of at least 6 months from initial loading were included. Predictor variables were short implants (SIs; ≤ 8 mm) alone, SIs in conjunction with osteotome sinus floor elevation (OSFE) with or without bone grafting, long implants (LIs) in conjunction with OSFE with and without bone grafting, and LIs combined with lateral sinus floor elevation (LSFE) with bone grafting. Outcome variables were implant and prosthesis failure rates, marginal bone loss, and complications. Frequentist NMA was performed using STATA software.

Results: Twenty RCTs involving 770 patients with intermediate posterior maxillary RBH and 837 concerned maxillary sinuses who received 1,486 implants using any of the 4 rehabilitation methods were included. There were no statistically significant differences among the 4 groups for implant and prosthesis failure rates and marginal bone loss at follow-up (range, 6 months to 5 years after loading). There was a

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marked decrease in complications for SIs alone compared with LIs combined with LSFE. For implant and prosthesis survival rates, SIs in conjunction with OSFE with or without bone grafting ranked first as the most effective option (77.1%) followed by LIs plus OSFE with or without bone grafting (62%), LIs plus LSFE with bone grafting (43.9%), and SIs alone (24.8%).

Conclusion: There is moderate-quality evidence derived from this NMA showing that OSFE combined with SI or LI placement with or without bone grafting or SI placement alone is superior to LI placement combined with LSFE and bone grafting when used for patients with intermediate maxillary RBH (4 to 8 mm). Furthermore, the results of this study show that LSFE for patients with intermediate RBH is not a suitable treatment option because of unjustified high cost and rate of complications.

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A surgical technique to increase the height of the alveolar bone in the atrophic posterior maxilla was innovated by Boyne and James.¹ The procedure consisted of approaching the maxillary sinus through the lateral sinus wall and augmenting the floor with particulate autogenous bone harvested from the iliac crest. In 1994, Summers² described the osteotome sinus floor elevation (OSFE; crestal approach or internal sinus lift). It was a 1-stage and less invasive technique. In 1995, Summers³ proposed a 2-stage technique for cases with residual bone height (RBH) less than 6 mm in which the implant would not obtain primary stability. Rehabilitation of the atrophic posterior maxilla using either technique had become a predictable procedure.^{4,5}

In 2004, Lundgren et al⁶ suggested the abandonment of grafting materials because the creation of space between the bone and the Schneiderian membrane would allow the generation of bone without the use of graft materials. In their reviews of the literature, Starch-Jensen and Jensen⁵ and Duan et al⁷ found that graft-free sinus floor elevations were a predictable treatment modality that achieved a satisfactory mean implant survival rate.

It is well established that sinus augmentation allows for placement of implants of standard length, although several studies have pointed out the many problems associated with this procedure, such as duration and cost of treatment, graft failure, and postoperative sinusitis. All these problems often cause patients to hesitate to undergo sinus augmentation.⁸⁻¹⁰ Instead, patients might prefer the use of short implants (SIs) as an alternative to sinus augmentation. Placement of SIs simplifies treatment, and some clinical studies^{11,12} and systematic reviews^{13,14} have proposed it is a valid treatment alternative to standard-length implant placement with sinus lift.

Augmentation of the sinus floor has evolved from a simple procedure as described by Boyne and James¹ into a complex assortment of techniques and materials and even the emergence of alternative options. Electing among these treatment options, for the technique or the materials, is becoming mystifying to practi-

tioners. When the bone height is less than 4 mm, the sinus lift is unavoidable. In such cases, one has to choose the approach, whether to use bone grafting, the type of bone graft, and whether to use platelet-rich plasma. In cases in which the bone height is 4 to 8 mm, the practitioner must choose between SI and standard-length implant placement with sinus lift. This leaves a wide range of treatment options.

A comprehensive comparative study of the available knowledge concerning rehabilitation of the atrophied maxilla would be of great value in enhancing the evidence guiding treatment choices. Traditionally, such comparisons have been limited to systematic reviews of clinical trials. Clinical trials provide direct or "head-to-head" comparison only for 2 treatment modalities or interventions. For indirect comparisons, expert opinions are adopted and subsequently lead to several inevitable flaws. Network meta-analyses (NMAs) have emerged as a suitable tool not only for comparing 2 interventions that have not been compared directly in a head-to-head clinical trial but also for allowing a collective assessment of variable interventions in a single study.¹⁵

For rehabilitation of the atrophic posterior maxilla, specifically for patients with 4 to 8 mm of RBH, there are no randomized controlled trials (RCTs) comparing SI placement without sinus lift against SI placement accompanied by crestal sinus lifts with or without bone grafting. In addition, for the same group of patients, there are no RCTs comparing long implant (LI) placement accompanied by lateral sinus lift with or without bone grafting against SI placement accompanied by crestal sinus lift with or without bone grafting. Accordingly, the authors hypothesized there would be no differences in implant and prosthesis failures, marginal bone changes, and intra- and postoperative complications between SI placement without augmentation or with crestal sinus lift with or without bone grafting and LI placement using lateral sinus lift with or without bone grafting for rehabilitation of the posterior maxilla with an intermediate RBH. Hence, the specific aims of this NMA were to challenge this

hypothesis and to identify the best rehabilitation method for patients with a posterior atrophic maxilla with 4 to 8 mm of alveolar ridge in relation to implant and prosthesis failure rates, marginal bone changes, and intra- and postoperative complications.

Materials and Methods

PROTOCOL AND REGISTRATION

An NMA of RCTs was conducted according to the Preferred Reporting Items for the PRISMA Extension Statement for Reporting of Systematic Reviews Incorporating Network Meta Analyses of Health Care Interventions (Appendix 1).¹⁶ This protocol is registered in PROSPERO (systematic review registration CRD42017079866).¹⁷

SEARCH STRATEGY

Relevant RCTs, in any language and with any publication date, were retrieved by a systematic search of Medline, Embase, CINAHL, the Cochrane Central Registry of Controlled Trials (CENTRAL), and SCOPUS from 1970 through March 2018 (Appendix 2).

SELECTION CRITERIA

The following inclusion criteria were adopted based on the PICOTS process:

(P) Patients: Patients had an RBH of 4 to 8 mm in the posterior maxilla and underwent rehabilitation of the atrophic posterior maxilla using implant supported prostheses. (I) Intervention: Patients underwent simultaneous implant placement in the posterior maxilla of the intermediate RBH using and comparing at least 2 of the 3 following rehabilitation methods:

1. SI (4 to 8 mm long) placement with OSFE with or without bone grafting using different bone grafts, such as autogenous bone graft and bone substitute materials (SI-OSFE ± grafting)
2. LI (>8 mm long) placement with OSFE with bone grafting using different bone grafts, such as autogenous bone graft and bone substitute materials (SI-OSFE ± grafting)
3. LI placement with lateral sinus floor elevation (LSFE) and bone grafting (LI-LSFE + grafting)

(C) Comparator: Placement of SIs (4 to 8 mm) without augmentations. (O) Outcomes: Primary outcomes were implant and prosthesis failure rates. Secondary outcomes were marginal bone loss and surgical complications. (T) Time: All included studies should have followed

patients for at least 6 months after initial functional loading. (S) Study design: RCTs including split-mouth and parallel studies that reported the outcomes of interest at least 6 months after initial loading.

EXCLUSION CRITERIA

The following exclusion criteria were applied: 1) studies with a follow-up period shorter than 6 months after loading; 2) studies with no basic data required to perform meta-analysis, such as number of patients, number of events, means, or standard deviations; 3) nonrandomized clinical studies, case series, and cohort studies; 4) review articles; 5) animal or in vitro studies; and 6) publications using duplicated data.

DATA EXTRACTION

A data extraction form was developed for this review and pilot tested independently on 2 randomly selected studies by 2 reviewers (G.A. and B.A.) to ensure consistency in extraction. The extraction form was refined accordingly, and data were extracted in duplicate. Any disagreement was resolved by a third judge (E.A.). The extracted information included characteristics of the studies and participants, specifically authors, study design, age, male-to-female ratio, number of patients, number of implants, number of sinuses, medical and social status, periodontal status, residual ridge height, and partially or completely edentulous, type of sinus surgery, type of bone graft, healing period, length and width of implants, bone osteotomy procedures, use of membrane and growth factors, implant system, and implant surface.

ASSESSMENT OF RISK OF BIAS

The risk of bias of included trials was assessed independently by 2 authors using the modified version of the Cochrane tool for assessing risk of bias.^{18,19} For the surgical intervention, neither surgeon nor patient could be effectively blinded; thus, the domain of blinding of participants and personnel (performance bias) was eliminated. The following domains were applied:

1. Sequence generation (selection bias)
2. Allocation concealment (selection bias)
3. Blinding of outcome assessment (detection bias)
4. Incomplete outcome data (attrition bias)
5. Selective outcome reporting (reporting bias)
6. Other potential sources of bias (including for-profit bias)

DATA SYNTHESIS

Network Geometry

Network geometry was presented by drawing a network plot to assess whether the included studies on various treatments were connected. Potential effect modifiers, such as duration of follow-up and risk of bias, were identified before the NMA was performed.²⁰

Measures of Treatment Effect

Odds ratios (ORs) for dichotomous outcomes and weighted mean difference (WMD) for continuous outcomes were calculated. Results from the NMA were presented as a summary of relative effect sizes (WMD or OR) for each possible pair of treatments. The statistical unit was the number of augmented sinuses in split-mouth RCTs or the number of patients in parallel RCTs.

Assessment of Transitivity Across Treatment Comparisons

Comparing the distribution of the potential effect modifiers was performed to hold the assumption of transitivity and included 1) the amount of RBH below the maxillary sinus, 2) age, 3) gender, 4) type of sinus lift surgery (lateral or crestal approach), 5) characteristic features of patients, and 6) characteristic features of implants.²¹

Methods for Direct Treatment Comparisons

Standard pairwise meta-analyses were performed using a random-effects model in Comprehensive Meta-Analysis Software (available at: <https://www.meta-analysis.com/>) for every treatment comparison with at least 2 studies. For 0 events in all treatment arms, pairwise meta-analysis was not performed.

Methods for Mixed and Network Comparisons

Comparisons were conducted using NMA in STATA 14 (StataCorp, College Station, TX)^{22,23} using the mvmeta command²⁴ and self-programmed STATA routines (available at: <http://www.mtm.uoi.gr>).

ASSESSMENT OF STATISTICAL HETEROGENEITY

Assumptions When Estimating the Heterogeneity

In standard pairwise meta-analyses, different heterogeneity variances for each pairwise comparison were estimated. In the NMA, a common estimate for the heterogeneity variance across all different comparisons was assumed.²⁵

ASSESSMENT OF STATISTICAL INCONSISTENCY

Local Approaches for Evaluating Inconsistency

To evaluate the presence of inconsistency locally, the loop-specific approach was performed to evaluate

the assumption of consistency in each closed loop of the network separately. The difference between direct and indirect estimates for a specific comparison in the loop (inconsistency factor) was estimated. Then, the magnitude of the inconsistency factors and their 95% confidence intervals (CIs) were used to infer the presence of inconsistency in each loop. In addition, the authors assumed a common heterogeneity estimate within each loop.²¹ The results of this approach were presented in a forest plot using the ifplot command in STATA.

Global Approaches for Evaluating Inconsistency

To check the assumption of consistency in the entire network, the “design-by-treatment” model as described by Higgins et al²⁵⁻²⁷ using the mvmeta command in STATA was performed.²⁵⁻²⁷

RELATIVE TREATMENT RANKING

The ranking probabilities for all treatments at each possible rank for each intervention were analyzed. Then, the treatment hierarchy using the surface under the cumulative ranking (SUCRA) curve and mean ranks was computed.²⁸ The SUCRA also can be presented as a percentage of a treatment that can be ranked first without uncertainty. The rank-heat plot to visualize and present the treatment hierarchy across the multiple outcomes of interest was conducted.²⁹

META-REGRESSION ANALYSIS

To identify possible sources of inconsistency and assess association between the follow-up time and implant failure, meta-regression analysis was performed.

SENSITIVITY ANALYSIS

To ensure that the imputations did not bias the NMA results and that sufficient studies were available, the NMA was repeated after excluding 1) studies with high risk of bias and 2) studies with a follow-up shorter than 1 year.

ASSESSMENT OF PUBLICATION BIAS

A comparison-adjusted funnel plot was conducted to assess network-wide publication bias and small study effect for outcomes with at least 10 studies in the network.^{30,31}

CERTAINTY OF THE EVIDENCE AND SUMMARY OF FINDINGS TABLE

To assess the confidence of evidence of direct, and NMA estimates effect for each outcome, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach of network meta-analysis³² was performed. The certainty of evidence of direct and NMA effect estimates for each outcome

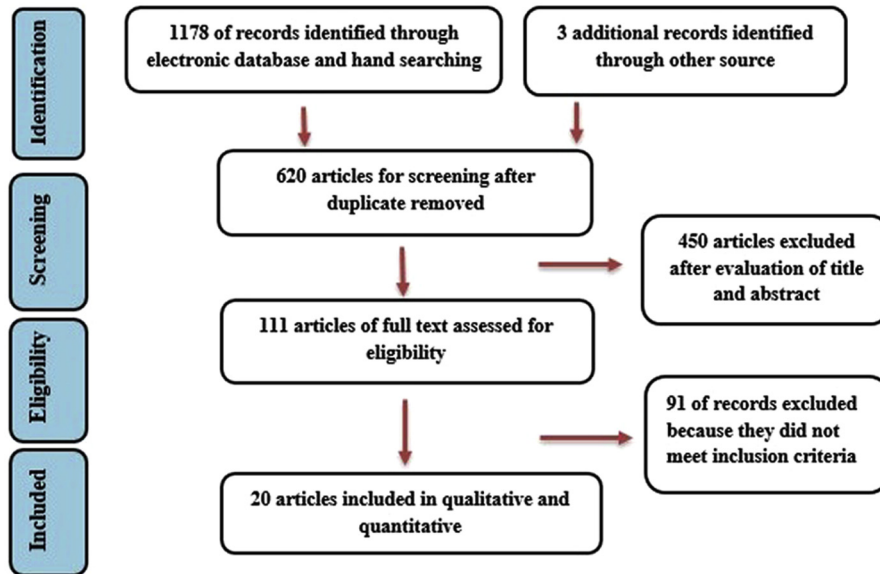


FIGURE 1. Selecting screening process according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

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was rated as high, moderate, low, or very low using the GRADE rating system.³³ In the GRADE system, RCTs start as high-quality evidence but can be downgraded because of limitations in study design, inconsistency, imprecision, indirectness, and publication bias.^{19,34}

Results

STUDY SELECTION

Figure 1 shows the process of evaluating articles for inclusion in the review and NMA. The search strategy yielded 1,178 reports from all databases and 3 additional articles were identified from other sources. Of the 1,181 reports, 620 articles were duplicates, which were removed. Four hundred fifty articles were excluded after reading the titles and abstracts, and the full-text articles of the remaining 111 studies were reviewed by 2 authors for eligibility. At this stage of the analysis, 91 studies were excluded because they did not meet the inclusion criteria. Twenty RCTs met the inclusion criteria and were processed for critical review.³⁵⁻⁵⁴

PRESENTATION OF NETWORK GEOMETRY

Network diagram of all eligible comparisons for the implant failure are presented in Figure 2. Four interventions with 6 comparisons were included in the network diagrams. The 4 rehabilitation methods were SI placement alone, SI-OSFE ± grafting, LI-OSFE ± grafting, and LI-LSFE ± grafting.

SUMMARY OF NETWORK GEOMETRY

A total of 770 patients with 837 concerned maxillary sinuses received 1,486 implants using any of the 4 rehabilitation methods for patients with a posterior atrophic maxilla.³⁵⁻⁵⁴ The rehabilitation methods were SI placement without augmentations (n = 11 trials; 239 patients with 254 sinuses receiving 452 SIs),^{37,39,40,42-44,46,49,52-54} SI-OSFE ± grafting (n = 5 trials; 106 patients with 106 sinuses receiving 142 SIs),^{38,41,48,50,51} LI-OSFE ± grafting (n = 4 trials;

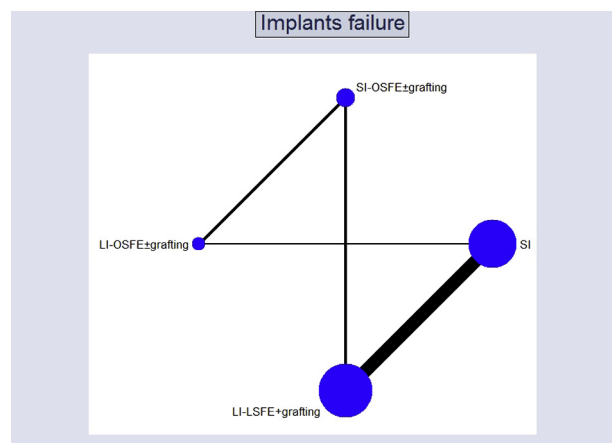


FIGURE 2. Network geometry for outcome of implant failure. LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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		Direct comparisons in the network			
		AvsC	AvsD	BvsC	BvsD
Network meta-analysis estimates	Mixed estimates				
	AvsC	20.3	26.6	26.6	26.6
	AvsD	2.6	92.2	2.6	2.6
	BvsC	17.9	17.9	46.4	17.9
	BvsD	10.2	10.2	10.2	69.4

	Indirect estimates				
	AvsB	7.8	42.2	7.8	42.2
CvsD	20.3	20.3	29.7	29.7	
Entire network		14.3	32.0	21.9	31.8
Included studies		1	10	2	2

FIGURE 3. Contribution of direct, indirect, mixed, and network meta-analysis evidences. A, Short implant placement without augmentation. B, Short implant placement with osteotome sinus floor elevation with and without bone grafting. C, Long implant placement with osteotome sinus floor elevation with and without bone grafting. D, Long implant placement with lateral sinus floor elevation with bone grafting.

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85 patients with 124 sinuses receiving 212 SIs),^{47,50-52} and LI-LSFE + grafting (n = 15 trials; 340 patients with 353 sinuses receiving 680 LIs).^{35-37,39-46,48,49,53,54} SI placement without augmentation (11 studies) was used as the comparator arm. Contributions of direct, indirect, mixed, and NMA evidences are presented in [Figure 3](#).

STUDY CHARACTERISTICS

Characteristics of the studies, patients, and implants of all included studies are presented in [Table 1](#).

RISK OF BIAS WITHIN INCLUDED STUDIES

The studies were generally considered to be of moderate quality. Twelve studies had a low risk of bias,^{26,27,39-43,46,49,52,53} 5 studies had an unclear risk of bias,^{45,47,50,51,53} and 3 studies had a high risk of bias.^{38,44,54} Sixteen studies were adequately randomized,^{26,27,38-46,49,52,53} 1 study was not,⁵⁴ and randomization was unclear in 3 studies.^{47,50,51} Allocation concealment was adequate in all studies.³⁵⁻⁵⁴ Assessment of outcome assessors showed that 2 studies had a high risk of bias,^{44,54} 3 had an unclear risk,^{45,51,53} and 15 studies had a low risk of bias in relation to this domain.^{26,27,35,36,38-43,45,46,49,52} Eighteen studies adequately reported on patient dropout^{35-37,39-53} and 2 studies did not^{38,54} ([Fig 4](#)).

RESULTS OF INDIVIDUAL STUDIES

The online supplementary file ([Appendices 3-6](#)) presents the summary of outcomes data for each of the study's intervention groups: number of events and sample size for outcomes of implant failure, prosthesis failure, and complications. Mean, standard deviation, and sample size for outcome of marginal bone loss are presented.

SYNTHESIS OF RESULTS

Implant Failure

Pairwise meta-analysis. Results of standard pairwise meta-analysis of direct comparisons are fully reported in the supplementary materials ([Appendix 7](#)). Three RCTs were excluded from the analysis because they reported 0 events in all treatment arms.⁵⁵ Seven RCTs comparing SI placement without augmentation with LI placement with maxillary sinus augmentation by LSFE using different bone graft materials were included. There was no statistically significant difference between the 2 groups (OR = 1.2 CI, 0.490-3.34; $P = .614$). This result is similar to results derived from the NMA.

Network meta-analysis. Twenty RCTs concerning the 4 rehabilitation methods were analyzed through NMA in relation to implant failure.³⁵⁻⁵⁴ The NMA showed no relevant differences among the 6 comparisons used for patients with posterior atrophic maxilla and 4 to 8 mm of RBH. There was a

Table 1. PATIENT, STUDY, AND IMPLANT CHARACTERISTICS OF INCLUDED STUDIES

Study	Study Design	Age (yr), Mean	Male/ Female Ratio	Patients, N	Implants, N	Sinuses, N	Medical and Social Status	Residual Ridge Height (mm), Mean
Torres et al, 2009 ³⁵	RCT + RCT split mouth	G4	40/47	87	G4a, 129; G4b, 153	G4a, 70; G4b, 74	medically controlled, smoker (31), diabetes (9), osteoporosis (11), ischemic heart disease (7), hypertension (14)	<7
Esposito et al, 2010 ³⁶	RCT split mouth	G4, 35-60 (50)	2/8	10	48	20	medically controlled, 5 smokers	G4, 3.4 (0.7)
Esposito et al, 2011 ³⁷	pilot RCT in 2 centers, split mouth	G1, G4, 45- 70 (56)	9/6	15	72	30	medically controlled, 3 light smokers, 1 heavy smoker	G1, G4, 4.6
Si et al, 2013 ³⁸	RCT	G2, 19-78 (48.5)	23/18	40	40	40	medically controlled, 25 smokers	G2a, 4.58 (1.47); G2 b, 4.67 (1.18)
Pistilli et al, 2013 ³⁹	RCT in 2 centers	G1, 45-70 (61.1); G4, 45-75 (58.5)	15/25	40	73	40	medically controlled, 7 smokers	G1, G4, 4.6
Pistilli et al, 2013 ⁴⁰	RCT in 2 centers, split mouth	G1, G4, 45- 80 (57.6)	11/9	20	83	40	medically controlled, 3 heavy smokers	G1, G4, 5-7
Cannizzaro et al, 2013 ⁴¹	RCT	G2, 21-70 (47.5); G4, 30-72 (53.3)	19/21	40	82	40	medically controlled, 11 moderate smokers, 7 heavy smokers	G2, 4.46 (0.80); G4, 4.35 (0.57)
Gulje et al, 2014 ⁴²	RCT multicenter	G1, G4, 29- 72 (49)	20/21	40	40	40	medically controlled	G1, G4, 6-8
Esposito et al, 2014 ⁴³	RCT in 2 centers, split mouth	G1, G4, 45- 70 (56)	9/6	14	72	28	medically controlled, 2 moderate smokers, 1 heavy smoker	G1, G4, 4.6
Thoma et al, 2015 ⁴⁴	RCT multicenter	G1, G4, 30- 75 (50.5)	49/52	97	132	97	medically controlled, 43% smokers	G1, G4, 5-7
Meloni et al, 2015 ⁴⁵	RCT	G4	9/7	16	32	20	medically controlled	G4, 1-4
Esposito et al, 2015 ⁴⁶	pilot RCT in 2 centers	G1, 41-65 (56); G4, 29-65 (52)	16/12	28	178	52	medically controlled, 5 light smokers	G1, G4, 5-9
Markovic et al, 2016 ⁴⁷	RCT in 2 centers	G3, 56.7	NM	30	120	30	medically controlled	6.59 (0.45)
Yu et al, 2017 ⁴⁸	RCT	G2, G4, 34- 60 (49.4)	20/18	38	79	38	medically controlled, excluded heavy smokers	G2, 4.5 (0.39); G4, 4.35 (0.36)
Esposito et al, 2016 ⁴⁹	RCT	G1, 25-77 (60.75); G4, 36-71 (56.40)	19/21	40	78	40	medically controlled, 9 moderate smokers, 2 heavy smokers	4-5
Zhang et al, 2017 ⁵⁰	pilot RCT	G1, 37.5; G2, 42.6; G3, 35.5	32/24	56	56	56	medically controlled	6-8
Sahrman et al, 2016 ⁵¹	RCT	G2, 26-76 (52); G3, 36-81 (58)	—	25	25	25	medically controlled included smokers of <10 cigarettes per day	6
Gastaldi et al, 2017 ⁵²	RCT in 2 centers	G2, 43-67 (53.4); G4, 48-70 (58.6)	8/12	18	34	20	medically controlled, 6 moderate and 5 heavy smokers	G2, G4, 5-7
Taschieri et al, 2018 ⁵³	RCT	G1, 31-77 (52.21); G4, 36-68 (51.05)	22/30	52	100	52	medically controlled, 2 former smokers, 4 light smokers, and 6 heavy smokers	G1, 6.08; G4, 5.39
Bechara et al, 2017 ⁵⁴	RCT	G1, G4, NM	20/33	53	90	53	medically controlled	G1, G4, 3-4

Table 1. Cont'd

Study	Partial vs Complete Edentulism	Type of Sinus Surgery	Type of Bone Graft	Healing Period	Loading Time	Implant L + D (mm)
Torres et al, 2009 ³⁵	partial	lateral	G4a, anorganic bovine bone; G4b, anorganic bovine bone + PRP	RBH 4-7 mm, simultaneous; RBH<4 mm, 6 mo	after 4 mo	L, 10-13.0; D, 3.75-5
Esposito et al, 2010 ³⁶	partial	lateral	G4, none; G4, granular Bio-Oss	simultaneous	after 4 mo	L, 11-13; D, 3.8
Esposito et al, 2011 ³⁷	partial	lateral	G1, none; G4, granular Bio-Oss	simultaneous	after 4 mo	G1: L, 5; D, 6; G4: L, 10-13; D, 4
Si et al, 2013 ³⁸	partial	osteotome	G2a, none; G2b, deproteinized bovine bone mineral (DBBM) mixed with autogenous bone chips	simultaneous	after 6 mo	L, 6-10; D, 4.1-4.8
Pistilli et al, 2013 ³⁹	partial	lateral	G1, none; G4, particulate porcine bone	simultaneous	after 4 mo	G1: L, 5; D, 5; G4: L, 10-15; D, 5
Pistilli et al, 2013 ⁴⁰	36 partial, 4 complete	lateral	G1, none; G4, particulate porcine bone	simultaneous	after 4 mo	G1: L, 6; D, 4; G4: L, 10; D, 4
Cannizzaro et al, 2013 ⁴¹	partial	osteotome, lateral	G2, autogenous bone; G4, particulate autogenous bone with anorganic bovine (Bio-Oss)	simultaneous	after 1.5 mo	G2: L, 8; D, 3.7-4.7-6; G4: L, 10-16; D, 3.7-4.7-6
Gulje et al, 2014 ⁴²	partial	lateral	G1, none; G4 autologous bone and Bio-Oss spongiose bone substitute	simultaneous	after 3 mo	G1: L, 6; D, 4; G4: L, 11; D, 4
Esposito et al, 2014 ⁴³	complete	lateral	G1, none; G4, granular Bio-Oss	simultaneous	after 4 mo	G1: L, 5; D, 6; G4: L, 10-13; D, 4
Thoma et al, 2015 ⁴⁴	partial	lateral	G1, none; G4, particulate bovine bone	simultaneous	after 6 mo	G1: L, 6; D, 4; G4: L, 11-15; D, 4
Meloni et al, 2015 ⁴⁵	partial	lateral	G4a, anorganic bovine bone and autologous bone; G4b, anorganic bovine bone	simultaneous	3 mo after implantation	L, 10; D, 4.3 or 5.0
Esposito et al, 2015 ⁴⁶	partial	lateral	G1, none; G4, autogenous	simultaneous	after 4 mo	G1: L, 5-8.5; D, 4-6; G4: L, 10-13; D, 4-5
Markovic et al, 2016 ⁴⁷	partial	osteotome	G3a, none; G3b, deproteinized bovine bone	simultaneous	after 6 mo	L, 10; D, 4.1
Yu et al, 2017 ⁴⁸	partial	osteotome, lateral	G2, none; G4, autogenous bone	simultaneous	G2, after 2 mo; G4, after 4 mo	G2: L, 6.5; D, 4-5; G4: L, 11-12.5; D, 4-5
Esposito et al, 2016 ⁴⁹	partial	lateral	G1, none; G4, particulate porcine bone	simultaneous	after 4 mo	G1: L, 4; D, 4.0, 4.5; G4: L, 10, 11.5, 13; D, 4.0, 4.5
Zhang et al, 2017 ⁵⁰	partial	osteotome	G1, G2, G3, none	simultaneous	after 3 mo	L, 6, 8, and 10; D, 4.1, 4.8
Sahrmann et al, 2016 ⁵¹	partial	osteotome	G2, G3, none	simultaneous	after 10 wk	G2, 6; G3, 10
Gastaldi et al, 2017 ⁵²	partial	osteotome	G2, none; G4, anorganic bovine bone (Endobon)	simultaneous	4 mo	G2: L, 5-6; G4: L, 10
Taschieri et al, 2018 ⁵³	complete	lateral	G1, none; G4, deproteinized anorganic bovine bone (Bio-Oss)	simultaneous	5 mo for short implants and 6-7 mo for long implants	G1, 6.5, 7.5, and 8.5; G4: L, 10-13; D, 3.75-5
Bechara et al, 2017 ⁵⁴	partial	lateral	G1, none; G4, particulate bone graft (Oscobiol, GenOss)	simultaneous	6 mo	G1: L, 6; D, 5d; G4: L, >10; D, 4.5-5

Table 1. Cont'd

Membrane Used	Implant System	Implant Design	Implant Surface	Follow-Up
no	Osseotite (Biomet 3i Inc, Palm Beach, FL)	NM	rough	2 yr
rigid Inion GTR Biodegradable Membrane	Geass, Pozzuolo del Friuli, UD, Italy	Conical Way self-tapping implants	laser treated	1 yr
resorbable barrier (Bio-Gide, Geistlich Pharma)	Rescue (MegaGen) EZ Plus	NM	hydroxyapatite particles	1 yr
no	Straumann Osteotome (KitStraumann AG, Waldenburg, Switzerland)	NM	NM	3 yr
collagen resorbable barrier (OsteoBioR, Tecnos) from equine pericardium	ExFeel (MegaGen Implants, Gyeongbuk, South Korea)	NM	calcium incorporated titanium (Xpeed) sanded with hydroxyapatite particles	1 yr
collagen resorbable barrier (OsteoBioR, Tecnos) from equine pericardium	NM	NM	NM	1 yr
collagen barrier (Biomend Extend, Sulzer Dental Inc, Carlsbad, CA)	Zimmer Dental (Carlsbad, CA)	tapered screw vent	hydroxyapatite-coated Mp-1 ha dual transition selective surface implants	5 yr
no	OsseoSpeed 4.0S (Dentsply Implants, Mölndal, Sweden)	NM	NM	1 yr
resorbable barrier (Bio-Gide, Geistlich Pharma)	Rescue (MegaGen), EZ Plus	NM	hydroxyapatite particles	3 yr
Bio-Gide (Geistlich Pharma AG, Wolhusen, Switzerland)	ASTRA TECH Implant System OsseoSpeed™ 4.0S; Dentsply Implants (Mölndal, Sweden)	NM	NM	1 yr
Bio-Gide (Geistlich Pharma AG)	Nobel Biocare (Goteborg, Sweden)	tapered	NM	1 yr
Inion GTR Biodegradable Membrane System (Tampere, Finland)	ExFeel implants ± Rescue (MegaGen)	NM	NM	1 yr
no	SLActive-BL (Straumann, Basel, Switzerland)	NM	NM	2 yr
double-layer collagen membrane	Thommen Medical AG (Grenchen, Switzerland), Inicell	NM	hydrophilic implant surfaces were subjected to chairside conditioning for hydrophilicity	2 yr
fine 30 × 30 mm, Evolution, OsteoBio, Tecnos	transmucosal tapered implants (TwinKon Universal SA2; Global-D)	tapered	NM	4 mo
no	Straumann (Institute Straumann AG, Basel, Switzerland), Standard Plus implants	NM	NM	6 mo?
no	SLActive standard + soft tissue level implants (Straumann AG, Basel, Switzerland)	NM	NM	3 yr
no	G2, External Hex Implants (NXFOS5/6xx, Zimmer Biomet); G4, External Hex Parallel Walled Osseotite II implants (XFOS5/6xx, Zimmer Biomet)	parallel	NM	3 yr
Bio-Gide (Geistlich Pharma AG) used over graft and lateral window	G1, G4, Interna, Universal Platform and Universal Plus Platform (BTI Biotechnology Institute)	NM	sandblasted (Optima)	3 yr
Ostobiol, Evolution for lateral window	G1, G4, Anyridge MegaGen Implant (Gyeongbuk, South Korea)	tapered	NM	3 yr

Abbreviations: D, diameter; G1, short implants alone; G2, short implants with osteotome sinus floor elevation with and without bone graft; G3, long implants with osteotome sinus floor elevation with and without bone graft; G4, long implants with lateral sinus floor elevation plus bone grafting; L, length; NM, not mentioned; PRP, platelet-rich plasma.

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Author	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Bethara et al, 2017	+	+	+	+	+	+
Cannizzaro et al, 2013	+	+	+	+	+	+
Esposito et al, 2010	+	+	+	+	+	+
Esposito et al, 2011	+	+	+	+	+	+
Esposito et al, 2014	+	+	+	+	+	+
Esposito et al, 2015	+	+	+	+	+	+
Esposito et al, 2016	+	+	+	+	+	+
Gastaldi et al, 2017	+	+	+	+	+	+
Gulje et al, 2014	+	+	+	+	+	+
Markovic et al, 2015	+	+	+	+	+	+
Meioni et al, 2015	+	+	+	+	+	+
Pisilli et al, 2013a	+	+	+	+	+	+
Pisilli et al, 2013b	+	+	+	+	+	+
Sahrmann et al, 2016	+	+	+	+	+	+
Si et al, 2013	+	+	+	+	+	+
Taschieri et al, 2017	+	+	+	+	+	+
Thoma et al, 2015	+	+	+	+	+	+
Torres et al, 2009	+	+	+	+	+	+
Yu et al, 2016	+	+	+	+	+	+
Zhang et al, 2016	?	+	+	+	+	+

FIGURE 4. Summary of risk of bias.

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decrease in the number of implant failures in those who underwent SI-OSFE ± bone grafting (OR = 0.32; CI, 0.05-2.20) and LI-OSFE ± bone grafting (OR = 0.38; CI, 0.3-3.53) compared with SI placement without augmentation. However, these results did not reach the level of statistical relevance. Using OSFE with SI or LI placement decreased the number of lost implants compared with LSFE with LI placement, but this was not statistically relevant. More details about ORs with predictive intervals are presented in Figure 5.

Prosthesis Failure

Pairwise meta-analysis. Pairwise meta-analysis was possible only for the comparison of SI placement alone versus LI placement with LSFE using different bone graft materials. Six RCTs were excluded from the analysis because they reported 0 events in all treatment arms.⁵⁵ Seven RCTs comparing SI placement without augmentations with LI placement with maxillary sinus augmentations by LSFE using different bone graft materials were included in the analysis. There was no statistically significant difference between

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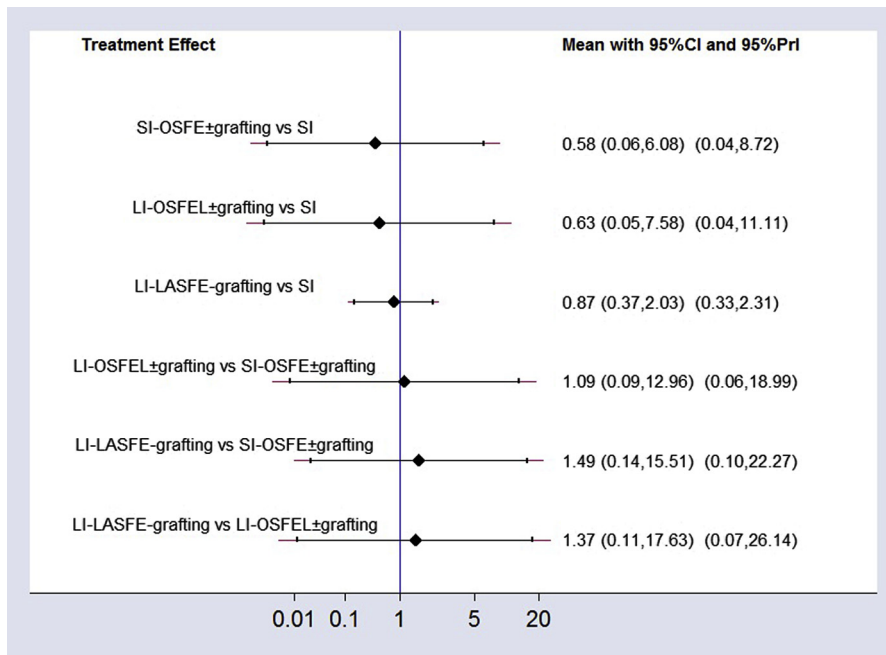


FIGURE 5. Forest plot, network meta-analysis, implant failure, odds ratio, and predictive interval. CI, confidence interval; LI, long implant; LSFE, lateral sinus floor elevation; PrI, predictive interval; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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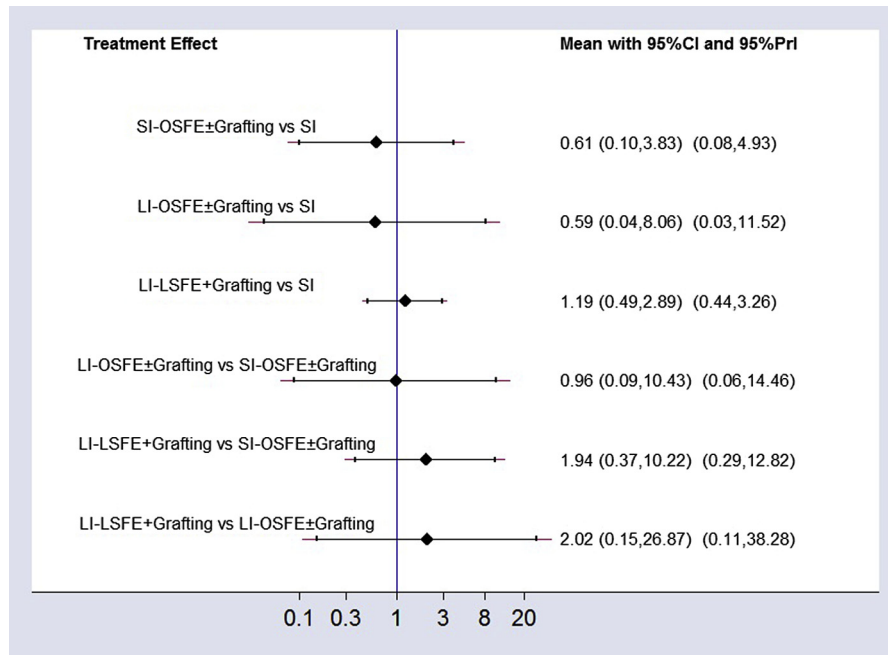


FIGURE 6. Forest plot, network meta-analysis, prosthesis failure, odds ratio, and predictive interval. CI, confidence interval; LI, long implant; LSFE, lateral sinus floor elevation; PrI, predictive interval; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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the 2 groups (OR = 0.846; CI, 0.319-2.24; $P = .737$). This result is similar to results derived from the NMA (Appendix 8).

Network meta-analysis. Twenty RCTs concerning the 4 rehabilitation methods were analyzed through NMA in relation to prosthesis failure.³⁵⁻⁵⁴ The NMA showed no statistically relevant differences among the 6 comparisons used for patients with posterior atrophic maxilla and 4 to 8 mm of RBH. There was a decrease in the number of implant failures in participants who underwent SI-OSFE ± bone grafting (OR = 0.61; CI, 0.10-3.83) and LI-OSFE ± bone grafting (OR = 0.59; CI, 0.04-8.06) compared with SI placement without augmentations. However, these results did not reach the level of statistical relevance. Using OSFE with SI or LI placement decreased the number of lost implants compared with LSFE with LI placement, but this was statistically irrelevant. More details were presented in the interval plot. More details about ORs with predictive intervals are presented in Figure 6.

Marginal Bone Loss

Pairwise meta-analysis. Ten RCTs compared SI placement alone with LI-LSFE with grafting in relation to marginal bone changes.^{37,39,40,42-44,46,49,53,54} There was a significant decrease in marginal bone loss in patients who received SI placement without augmentation (WMD = -0.126; CI, 0.224 to -0.027; $P = .13$). There was significant heterogeneity among

studies; thus, a random-effect model was used ($I^2 = 85$; $P = .00$). These results were similar with results of the NMA (Appendix 9).

Network meta-analysis. Twenty RCTs concerning the 6 rehabilitation methods were analyzed through NMA in relation to marginal bone changes.³⁵⁻⁵⁴ The NMA showed statistically relevant differences between SI placement alone and LI-LSFE + grafting (WMD = 1.41 mm; CI, 1.01-1.26). There was lesser marginal bone change after SI placement alone compared with LI-OSFE ± bone grafting (WMD = 1.18 mm; CI, 0.86-1.61) and an equivalent change compared with SI-OSFE ± bone grafting. However, these results did not reach the level of statistical relevance. There was a small trend in favor of SI-OSFE ± bone grafting compared with LI-OSFE ± bone grafting (WMD = 1.26 mm; CI, 0.88-1.82) and LI-LSFE + bone grafting (WMD = 1.22 mm; CI, 0.93-1.59), but no statistically relevant difference was found. There was no statistically relevant difference between LI-LSFE + bone grafting and LI-OSFE ± bone grafting in relation to marginal bone loss (WMD = 0.96 mm; CI, 0.70-1.33). More details about ORs with predictive intervals are presented in Figure 7.

Complications

Pairwise meta-analysis. Pairwise meta-analysis was possible only for the comparison of SI placement alone with LI placement with LSFE using different bone graft materials. Four RCTs were excluded from the analysis

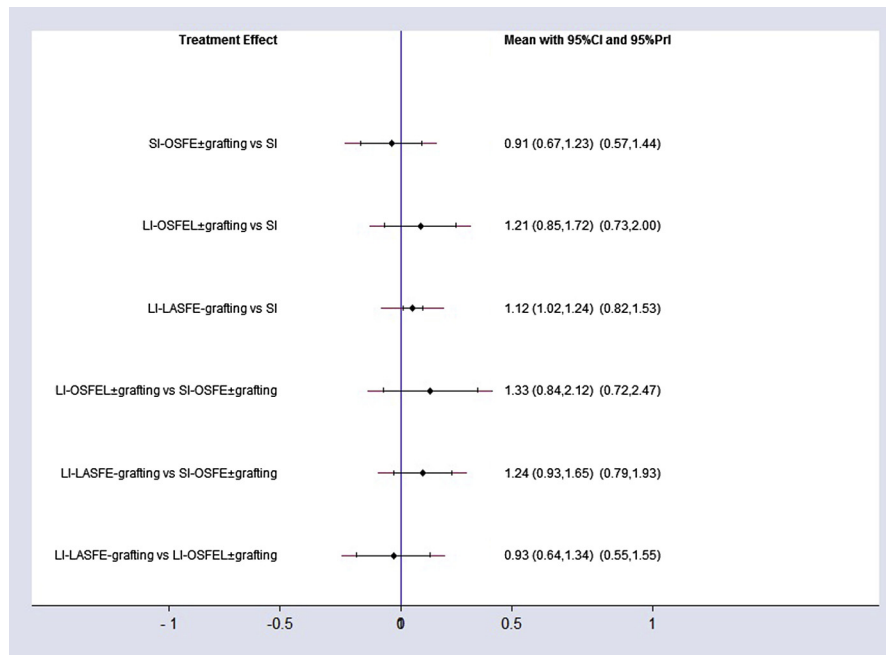


FIGURE 7. Forest plot, network meta-analysis, marginal bone loss in millimeters, and predictive interval. CI, confidence interval; LI, long implant; LSFE, lateral sinus floor elevation; PrI, predictive interval; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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because they reported 0 events in all treatment arms. There was a statistically significant decrease of intraoperative and postoperative complications in favor of SI placement alone compared with LI-LSFE + grafting using different bone graft materials (OR = 0.34; CI, 0.156-0.761; $P = .008$). This was in agreement with results of the NMA. No significant heterogeneity was found among the included studies; thus, the fixed-effect model was used ($I^2 = 37$; $P = .133$; Appendix 10).

Network meta-analysis. Twenty RCTs concerning the 6 rehabilitation methods were analyzed through NMA in relation to intraoperative and postoperative complications.³⁵⁻⁵⁴ The NMA showed a marked decrease in the incidence of intra- and postoperative complications after SI placement without augmentation compared with LI placement with augmentation using LSFE (OR = 2.29; CI, 1.08-4.87). In addition, there was a decrease in the incidence of intra- and postoperative complications for SI placement alone compared with SI (OR = 1.03; CI, 0.26-4.01) or LI (OR = 1.49; CI, 0.24-9.35) placement combined with OSFE with and without augmentation. However, the statistical difference was not established. SI-OSFE ± grafting had a lower rate of complications compared with LI-OSFE ± grafting (OR = 1.45; CI, 0.21-9.68) and SI-OSFE ± grafting (OR = 2.23; CI, 0.67-7.49), but the results were statistically irrelevant. Although LI-OSFE ± grafting lowered the incidence of intra- and postoperative complications compared with LI-LSFE + grafting (OR = 1.45; CI, 0.23-10.12), this decrease was not

statistically relevant. More details about ORs with predictive intervals are presented in Figure 8.

EXPLORATION FOR INCONSISTENCY

Loop-specific tests did not detect any statistical inconsistency between direct and indirect evidences. All CIs for ratio of two odds ratios (RoRs) were compatible, with 0 inconsistency (RoR = 1) for all study outcomes (Appendices 11-14). Based on the design-by-treatment interaction model, no significant inconsistency between direct and indirect evidences was identified within the evidence network as a whole ($P > .05$).

TREATMENT RANKING

Implant Failure

According to the SUCRA curve, the probability of being the most effective rehabilitation method that had the fewest implant failures for the posterior atrophic maxilla with 4 to 8 mm of RBH was SI-OSFE ± bone grafting followed by LI-OSFE ± bone grafting, LI-LSF + bone grafting, and SI placement alone (77.1, 63.2, 34.9, and 24.8%, respectively; Fig 9, Appendix 15).

Prosthesis Failure

According to the SUCRA curve, the probability of being the most effective rehabilitation method that had the fewest prosthesis failures for the posterior atrophic maxilla with 4 to 8 mm of RBH was SI-

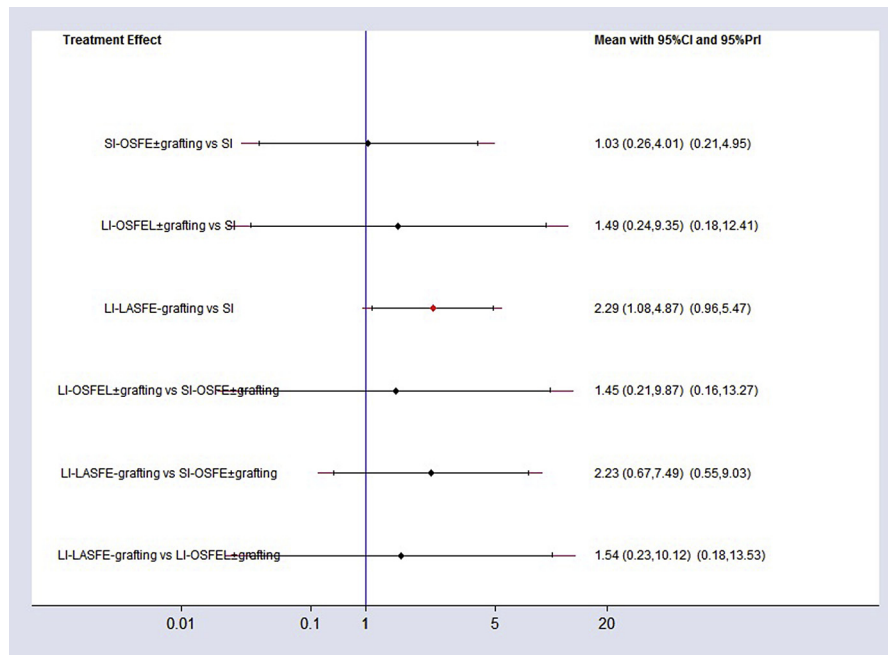


FIGURE 8. Forest plot, network meta-analysis, complications, odds ratio, and predictive interval. CI, confidence interval; LI, long implant; LSF, lateral sinus floor elevation; PrI, predictive interval; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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OSFE ± bone grafting followed by LI-OSFE ± bone grafting, SI placement alone, and LI-LSF + bone grafting (65.6, 62.2, 43.3, and 28.7%, respectively; Fig 9, Appendix 16).

Marginal Bone Loss

According to the SUCRA curve, the probability of being the most effective rehabilitation method that had the least marginal bone change after functional loading for the posterior atrophic maxilla with 4 to 8 mm of RBH was SI-OSFE ± bone grafting followed by SI placement alone, LI-OSFE ± bone grafting, and LI-LSF + bone grafting (83.5, 72.2, 22.2, and 22.2%, respectively; Fig 9, Appendix 17).

Intra- and Postoperative Complications

The SUCRA curve showed that the probability of being the most effective rehabilitation method that had the fewest intra- and postoperative complications after rehabilitation of the posterior atrophic maxilla with 4 to 8 mm of RBH was SI placement alone followed by SI-OSFE ± bone grafting, LI-OSFE ± bone grafting, and LI-LSF + bone grafting (72.6, 64.8, 50.5, and 12.4%, respectively; Fig 9, Appendix 18).

META-REGRESSION ANALYSIS

To assess whether follow-up time after functional loading had an effect on implant failure rate, meta-

regression analysis was performed between the reported number of lost implants and follow-up time for each RCT. Meta-regression analysis from the fixed-effect model confirmed a positive relation between the pooled event rate of implant failures and follow-

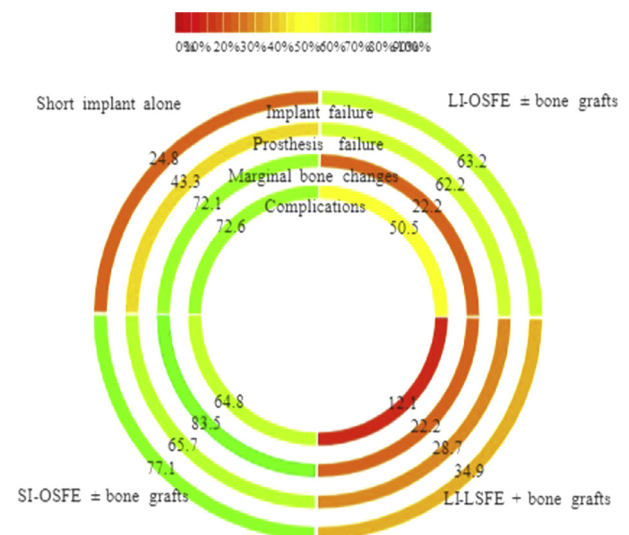


FIGURE 9. Rank-heat plot identifies hierarchy of multiple treatments for all outcomes. LI, long implant; LSF, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation.

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up time in the included studies (slope = 0.133; CI, -0.084 to 0.351 ; $P = .230$). Thus, the regression model fit (Appendix 19).

CONFIDENCE OF EVIDENCE

Because there is no standardized format for a summary table of findings for NMA, quality of evidence was presented through a summary table of findings for conventional pairwise NMA using GRADEpro software (available at: <https://grade.pro.org/>). Moderate-quality evidence was graded for implant and prosthesis failure rates, marginal bone loss, and complications and later downgraded 1 level for indirectness and imprecisions.

RISK OF BIAS ACROSS STUDIES

The assessment for risk of bias was conducted according to the Cochrane assessment tools. Twelve RCTs (most included studies) had a low risk of bias, 5 RCTs had an unclear risk of bias, and 3 RCTs showed a high risk of bias. More details are presented in Figure 4.

FUNNEL PLOT AND PUBLICATION BIAS

The funnel plot for outcomes of implant and prosthesis failure is shown in Appendix 20. Scatterplots in the funnel plot were almost symmetrical visually, indicating the absence of small size effect and publication bias.

SENSITIVITY ANALYSIS

After excluding studies with a high risk of bias^{38,42,54} and studies with shorter follow-up,^{49,50} the overall results of this NMA did not change.

Discussion

SUMMARY OF EVIDENCE

Currently, there is still controversy on what is the most effective rehabilitation method with the lowest rates for implant and prosthesis failure, marginal bone loss, and complications for the atrophic posterior maxilla having 4 to 8 mm of residual alveolar bone. There were several main key findings of this study. First, OSFE with SI or LI placement was associated with a smaller number of lost implants and prostheses compared with LSFE with LI placement. However, these differences were not statistically relevant. Second, there were no statistically relevant differences in marginal bone changes among the 6 rehabilitation methods. Third, SI placement without augmentation showed a marked decrease in surgical complications compared with augmentation through LSFE. OSFE with SI or LI placement was a superior method in preventing surgical complications

compared with LSFE with LI placement, but these results did not achieve statistical relevance.

SI PLACEMENT WITHOUT AUGMENTATIONS VERSUS SI-OSFE ± BONE GRAFTING

One RCT that compared SI placement alone with SI-OSFE ± bone grafting for patients with 6 to 7 mm of RBH reported 100% implant and prosthesis survival rates.⁵⁰ Thus, direct pairwise meta-analysis was not preformed. After a loading time of 1 to 5 years, SI-OSFE ± bone grafting had lower implant and prosthesis failure rates compared with SI placement alone. Although this finding remains statistically irrelevant, one can assume that using SI-OSFE ± bone grafting would increase the gain in endo-sinus bone, which in turn would increase primary stability and implant and prosthesis survival rates.

These results were in accord with previous studies that reported comparable prosthesis and implant survival rates (follow-up, 16 to 18 months) between SI placement without augmentation (99%^{37,39,42,44}) and SI placement combined with OSFE with bone grafting (91.9,⁵⁶ 95.2,³⁸ 79.3,⁴¹ and 98.89%⁵⁷) or without bone grafting (95,³⁸ 100,⁴⁸ 97.30,⁵⁷ and 98%⁵⁸). Based on the SUCRA value, SI-OSFE ± grafting had the highest probability of being the most effective rehabilitation method for atrophic posterior maxilla with 4 to 8 mm of RBH in relation to implant failure (77.1%) and prosthesis failure (65.7%) compared with SI placement alone. Findings on the incidence of marginal bone changes and operative complications were equivalent for SI placement alone and SI-OSFE ± grafting.

SI PLACEMENT WITHOUT AUGMENTATION VERSUS LI-OSFE ± BONE GRAFTING

Although there were 3 head-to-head RCTs comparing SI placement alone with LI-OSFE ± grafting, direct pairwise meta-analysis was impossible because 0 events were reported in all treatment arms.^{47,50-52} The NMA showed trends in favor of LI-OSFE ± grafting over SI placement alone for implant and prosthesis failure rates at a follow-up of 1 to 3 years. These results were consistent with those of other studies that reported that no relevant differences between SI and LI placement after OSFE.^{45,47,50-52,58} Another systematic review showed a considerably low implant survival rate for SI placement (<8 mm),⁵⁷ which contradicts the present study. This disagreement could be explained by the fact that these studies⁵⁷⁻⁵⁹ included all clinical studies, even retrospective studies and studies with an RBH less than 4 mm, whereas the present study included only RCTs with 4 to 8 mm of RBH.

Concerning the impact of RBH on implant survival rates, previous systematic reviews showed a positive correlation.⁵⁷⁻⁵⁹ The survival rate of implants placed in an RBH less than 5 mm was 92.7 versus 96.9% for implants inserted in an RBH higher than 5 mm.⁵⁷⁻⁵⁹ There was no relevant variation between SI placement alone and LI-OSFE \pm bone grafting for marginal bone changes after functional loading from 1 to 3 years. This is similar to previous reports.^{47,50-52,57-59} SI placement alone seems to have small trends for surgical complications compared with OSFE.

SI PLACEMENT ALONE VERSUS LI PLACEMENT COMBINED WITH LSFE WITH BONE GRAFTING

The NMA of the 20 RCTs showed no relevant differences between SI placement alone and standard implant placement combined with LSFE for implant and prosthesis survival rates at 1- to 5-year follow-up. This is similar to the results of a direct meta-analysis of 7 RCTs. Results derived from the NMA and direct meta-analysis coincided with the previous literature.^{36,37,39-44,48,49,52-54} Direct pairwise meta-analysis showed a marked decrease in marginal bone changes when SI placement alone was compared with LSFE combined with standard implant placement. However, the NMA showed no substantial difference between the 2 groups. These contradictory results might be due to the fact that only 9 RCTs were included in the direct pairwise meta-analysis, whereas 20 RCTs were included in the NMA. Concerning surgical complications, the direct and NMA evidence indicated that SI placement alone was a superior method in decreasing intraoperative complications compared with LI-LSFE.

SI-OSFE \pm BONE GRAFTING VERSUS LI-OSFE \pm BONE GRAFTING

Although 2 RCTs direct head-to-head comparing SI and LI placement in combination with OSFE with and without bone grafting were included, pairwise meta-analysis was not performed because they reported a 0-event outcome.^{50,51} The NMA indicated no relevant differences among SI, LI, and standard implant placement when used with OSFE in an intermediate atrophic maxilla (RBH, 4 to 8 mm) in relation to implant and prosthesis survival rates and marginal bone loss. These results confirm the fact that there is no influence of implant length on implant survival rate. The results of the present study were in accord with studies that reported that using SI placement plus OSFE with or without bone grafting yielded a predictable outcome at 3-year follow-up.^{51,52,56,59} The present results showed that when implants were inserted with OSFE, implant length had no influence on implant survival rate. Another systematic review concluded that SIs had a

lower implant survival rate (83.33%) compared with LIs (96.28%).⁵⁸ These discrepancies might be due to the lack of consensus on the length at which an implant is considered short. In the present study, an SI was no longer than 8 mm and an LI or standard implant was longer than 8 mm. Using less invasive procedures, such as OSFE plus SI placement, will require less elevation of the maxillary sinus membrane and subsequently produce fewer complications, such as mucosal perforation, pain, swelling, or bleeding. This was confirmed by the NMA, which showed some trends favoring SI-OSFE against complications after crestal sinus lift.

SI-OR LI-OSFE \pm BONE GRAFTING VERSUS LI-LSFE IN CONJUNCTION WITH BONE GRAFTING

The NMA showed some trends in favor of SI-OSFE \pm bone grafting over LI-LSFE with bone grafting for implant and prosthesis survival rates, marginal bone loss, and complications at the follow-up time of 1 to 5 years. This is similar to previous studies in the literature.^{8,37,41,44,50-52,60} OSFE using LI or SI placement provided better trends over LI placement in combination with LSFE for patients with 4 to 8 mm of RBH.

Choosing the most effective rehabilitation method for an intermediate atrophic maxilla with 4 to 8 mm of RBH using an implant-supported prosthesis should be an evidence-based decision. The 3 main components of evidence-based decision making are scientific evidence, clinical experience, and patients' preferences and needs. Based on the results of this NMA, moderate-quality evidence (based on the GRADE system) suggests that SI or LI placement in conjunction with OSFE with or without bone grafting seems to be the most effective method for implant and prosthesis survival rates and marginal bone loss for patients with posterior maxillas having 4 to 8 mm of RBH. There is scientific evidence stating that there are no statistically relevant differences for implant survival rate and marginal bone loss among the 6 comparisons for treatment of intermediate posterior maxillary residual bone 1 to 5 years after functional loading. These comparisons include SI placement alone, SI or LI placement in combination with OSFE with and without bone grafts, and LI placement in conjunction with LSFE plus bone grafting. However, one must consider the needs and preference of patients. Such considerations are definitely not limited to implant survival and marginal bone loss but also include surgical and postsurgical complications, duration of surgery, and cost of treatment.^{60,61} When taking all these considerations into account when opting for implant rehabilitation, SI placement without augmentation would be the most suitable treatment option for

patients with 4 to 8 mm of RBH. SI placement alone satisfied the 3 main criteria for clinical decision making, which are scientific evidence, fulfillment of patients' demands (minimum complications and cost), and no requirement for refined training and experience.

The most important clinical question that requires an answer is whether lateral sinus lift is still necessary to treat atrophic posterior maxillas with intermediate RBH (4 to 8 mm). Based on the results derived from this NMA, LSFE in combination with bone grafting did not provide any advantages for implant survival rate and marginal bone loss. Furthermore, intraoperative and postoperative complications, longer treatment time, and higher financial cost associated with LSFE made it a less desirable option compared with less invasive approaches such as SI placement alone or OSFE.

This study has limitations. First, direct meta-analysis and NMA were performed based on study-level data, because the included studies did not report individual patient data to control confounding factors. Second, as a consequence, the included studies contained certain influencing factors that could affect the results of the present study, such as implant diameter, membrane usage, type of bone graft, implant system, implant design, implant surface, loading time, partial or complete edentulism, and the inclusion of smokers. Therefore, because of these limitations, the results of this study should be interpreted with caution. Third, more RCTs assessing OSFE \pm bone grafting with SI or LI placement are required before a definitive conclusion can be drawn. Fourth, because an NMA should be performed only if there is homogeneity among included studies, the authors explored whether the transitivity assumption was dependent mainly on the following modifiers: amount of RBH, only included intermediate residual bone below the maxillary sinus floor that ranged from 4 to 8 mm, and immediate implant placement in combination with OSFE or LSFE. Nevertheless, a statistically inconsistency model was fitted through loop-specific testing and a design-by-treatment interaction model. In addition, similarity between direct pairwise meta-analysis and NMA indicating transitivity assumption was maintained. Fifth, pooling data from parallel and split-mouth studies could act as confounding factor because of the carryover effect within split-mouth studies. However, no outcome of interest in this study would be influenced by this bias because they are objective outcomes in nature. Furthermore, the number of augmented sites was used as the statistical unit for analysis to overcome this problem and to facilitate interpretation of the results.⁶² In the same context, a meta-epidemiologic study showed that there was no difference in effect estimates derived

from split-mouth and parallel-arm RCTs. Those investigators recommended that authors of systematic reviews should include split-mouth RCTs in their meta-analyses with suitable and appropriate analysis.⁶³ Sixth, another potential limitation was variation of follow-up time within included studies; thus, a meta-regression analysis between implant failure rate and follow-up time was performed. The scatterplot showed a positive correlation between follow-up time and implant survival rate. In other words, when follow-up time increases, implant loss also increases.

This study has strengths. First, to the best of the authors' knowledge, this is the first NMA of RCTs investigating a precise clinical question about the most effective rehabilitation method for patients with intermediate maxillary residual bone. Second, this systematic review included the application of novel NMA methods, which simultaneously pooled direct and indirect evidence. Third, this study included a large number of RCTs with a comprehensive literature search and identification of inconsistency. Fourth, to assess certainty of confidence derived from results of this study, the GRADE rating system was performed. Fifth, sensitivity analysis was performed after excluding those studies with short follow-up times and high risk of bias; however, no substantial change was found.

There is moderate-quality evidence derived from this NMA showing that OSFE combined with SI or LI placement with and without bone grafting or SI placement alone seems superior to LI placement with LSFE and bone grafting for patients with intermediate maxillary RBH (4 to 8 mm). The result of this study shows that LSFE for patients with intermediate RBH is not a suitable treatment because of the unjustified increase in complications and financial cost.

References

1. Boyne PJ, James RA: Grafting of the maxillary sinus floor with autogenous marrow and bone. *J Oral Surg* 38:613, 1980
2. Summers RB: A new concept in maxillary implant surgery: The osteotome technique. *Compendium* 15:152, 1994
3. Summers RB: The osteotome technique: Part 4—Future site development. *Compend Contin Educ Dent* 16:1090, 1995
4. Simion M, Gionso L, Grossi GB, et al: Twelve-year retrospective follow-up of machined implants in the posterior maxilla: Radiographic and peri-implant outcome. *Clin Implant Dent Relat Res* 17(suppl 2):e343, 2015
5. Starch-Jensen T, Jensen JD: Maxillary sinus floor augmentation: A review of selected treatment modalities. *J Oral Maxillofac Res* 8:e3, 2017
6. Lundgren S, Andersson S, Gualini F, Sennerby L: Bone reformation with sinus membrane elevation: A new surgical technique for maxillary sinus floor augmentation. *Clin Implant Dent Relat Res* 6:165, 2004
7. Duan DH, Fu JH, Qi W, et al: Graft-free maxillary sinus floor elevation: A systematic review and meta-analysis. *J Periodontol* 88:550, 2017
8. Esposito M, Felice P, Worthington HV: Interventions for replacing missing teeth: Augmentation procedures of the maxillary sinus. *Cochrane Database Syst Rev* 5:CD008397, 2014

9. Lee HW, Lin WS, Morton D: A retrospective study of complications associated with 100 consecutive maxillary sinus augmentations via the lateral window approach. *Int J Oral Maxillofac Implants* 28:860, 2013
10. Pommer B, Mailath-Pokorny G, Haas R, et al: Patients' preferences towards minimally invasive treatment alternatives for implant rehabilitation of edentulous jaws. *Eur J Oral Implantol* 7(suppl 2):S91, 2014
11. Mangano FG, Shibli JA, Sammons RL, et al: Short (8-mm) locking-taper implants supporting single crowns in posterior region: A prospective clinical study with 1- to 10-years of follow-up. *Clin Oral Implants Res* 25:933, 2014
12. Pohl V, Thoma DS, Sporniak-Tutak K, et al: Short dental implants (6 mm) versus long dental implants (11-15 mm) in combination with sinus floor elevation procedures: 3-Year results from a multicentre, randomized, controlled clinical trial. *J Clin Periodontol* 44:438, 2017
13. Lee SA, Lee CT, Fu MM, et al: Systematic review and meta-analysis of randomized controlled trials for the management of limited vertical height in the posterior region: Short implants (5 to 8 mm) vs longer implants (>8 mm) in vertically augmented sites. *Int J Oral Maxillofac Implants* 29:1085, 2014
14. Atieh MA, Zadeh H, Stanford CM, Cooper LF: Survival of short dental implants for treatment of posterior partial edentulism: A systematic review. *Int J Oral Maxillofac Implants* 27:1323, 2012
15. Kanters S, Ford N, Druyts E, et al: Use of network meta-analysis in clinical guidelines. *Bull World Health Organ* 94:782, 2016
16. Hutton B, Salanti G, Caldwell DM, et al: The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: Checklist and explanations. *Ann Intern Med* 162:777, 2015
17. National Institute for Health Research: PROSPERO. Published 2017, https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=79866
18. Higgins JPT, Green S (eds): *Cochrane Handbook for Systematic Reviews of Interventions*. Version 5.1.0. Available at: <http://handbook-5-1.cochrane.org/>. Updated March 2011
19. Guyatt GH, Oxman AD, Vist GE, et al: GRADE: An emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 336:924, 2008
20. Salanti G, Kavvoura FK, Ioannidis JP: Exploring the geometry of treatment networks. *Ann Intern Med* 148:544, 2008
21. Salanti G, Marinho V, Higgins JP: A case study of multiple-treatments meta-analysis demonstrates that covariates should be considered. *J Clin Epidemiol* 62:857, 2009
22. StataCorp. *Stata Statistical Software: Release 13*. College Station, TX, StataCorp LP, 2013
23. White IR: Network meta-analysis. *Stata J* 15:951, 2015
24. Harbord RM, Higgins JPT: Meta-regression in Stata. *Stata J* 8:493, 2008
25. Higgins J, Whitehead A: Borrowing strength from external trials in a meta-analysis. *Stat Med* 15:2733, 1996
26. Higgins J, Jackson D, Barrett J, et al: Consistency and inconsistency in network meta-analysis: Concepts and models for multi-arm studies. *Res Synth Methods* 3:98, 2012
27. White IR, Barrett JK, Jackson D, Higgins J: Consistency and inconsistency in network meta-analysis: Model estimation using multivariate meta-regression. *Res Synth Methods* 3:111, 2012
28. Salanti G, Ades A, Ioannidis JP: Graphical methods and numerical summaries for presenting results from multiple-treatment meta-analysis: An overview and tutorial. *J Clin Epidemiol* 64:163, 2011
29. Veroniki AA, Straus SE, Fyraridis A, Tricco AC: The rank-heat plot is a novel way to present the results from a network meta-analysis including multiple outcomes. *J Clin Epidemiol* 76:193, 2016
30. Macaskill P, Walter SD, Irwig L: A comparison of methods to detect publication bias in meta-analysis. *Stat Med* 20:641, 2001
31. Chaimani A, Higgins JP, Mavridis D, et al: Graphical tools for network meta-analysis in STATA. *PLoS One* 8:e76654, 2013
32. Puhan MA, Schünemann HJ, Murad MH, et al: A GRADE Working Group approach for rating the quality of treatment effect estimates from network meta-analysis. *BMJ* 349:g5630, 2014
33. Atkins D, Best D, Briss PA, et al: Grading quality of evidence and strength of recommendations. *BMJ* 328:1490, 2004
34. Guyatt GH, Oxman AD, Santesso N, et al: GRADE guidelines: 12. Preparing summary of findings tables—Binary outcomes. *J Clin Epidemiol* 66:158, 2013
35. Torres J, Tamimi F, Martinez PP, et al: Effect of platelet-rich plasma on sinus lifting: A randomized-controlled clinical trial. *J Clin Periodontol* 36:677, 2009
36. Esposito M, Piattelli M, Pistilli R, et al: Sinus lift with guided bone regeneration or anorganic bovine bone: 1-Year post-loading results of a pilot randomised clinical trial. *Eur J Oral Implantol* 3:297, 2010
37. Esposito M, Pellegrino G, Pistilli R, Felice P: Rehabilitation of posterior atrophic edentulous jaws: Prostheses supported by 5 mm short implants or by longer implants in augmented bone? One-year results from a pilot randomised clinical trial. *Eur J Oral Implantol* 4:21, 2011
38. Si MS, Zhuang LF, Gu YX, et al: Osteotome sinus floor elevation with or without grafting: A 3-year randomized controlled clinical trial. *J Clin Periodontol* 40:396, 2013
39. Pistilli R, Felice P, Piattelli M, et al: Posterior atrophic jaws rehabilitated with prostheses supported by 5 x 5 mm implants with a novel nanostructured calcium-incorporated titanium surface or by longer implants in augmented bone. One-year results from a randomised controlled trial. *Eur J Oral Implantol* 6:343, 2013
40. Pistilli R, Felice P, Cannizzaro G, et al: Posterior atrophic jaws rehabilitated with prostheses supported by 6 mm long 4 mm wide implants or by longer implants in augmented bone. One-year post-loading results from a pilot randomised controlled trial. *Eur J Oral Implantol* 6:359, 2013
41. Cannizzaro G, Felice P, Minciarelli AF, et al: Early implant loading in the atrophic posterior maxilla: 1-Stage lateral versus crestal sinus lift and 8 mm hydroxyapatite-coated implants. A 5-year randomised controlled trial. *Eur J Oral Implantol* 6:13, 2013
42. Gulje FL, Raghoobar GM, Vissink A, Meijer HJ: Single crowns in the resorbed posterior maxilla supported by either 6-mm implants or by 11-mm implants combined with sinus floor elevation surgery: A 1-year randomised controlled trial. *Eur J Oral Implantol* 7:247, 2014
43. Esposito M, Pistilli R, Barausse C, Felice P: Three-year results from a randomised controlled trial comparing prostheses supported by 5-mm long implants or by longer implants in augmented bone in posterior atrophic edentulous jaws. *Eur J Oral Implantol* 7:383, 2014
44. Thoma DS, Haas R, Tutak M, et al: Randomized controlled multicentre study comparing short dental implants (6 mm) versus longer dental implants (11-15 mm) in combination with sinus floor elevation procedures. Part 1: Demographics and patient-reported outcomes at 1 year of loading. *J Clin Periodontol* 42:72, 2015
45. Meloni SM, Jovanovic SA, Lolli FM, et al: Grafting after sinus lift with anorganic bovine bone alone compared with 50:50 anorganic bovine bone and autologous bone: Results of a pilot randomised trial at one year. *Br J Oral Maxillofac Surg* 53:436, 2015
46. Esposito M, Barausse C, Pistilli R, et al: Short implants versus bone augmentation for placing longer implants in atrophic maxillae: One-year post-loading results of a pilot randomised controlled trial. *Eur J Oral Implantol* 8:257, 2015
47. Markovic A, Mistic T, Calvo-Guirado JL, et al: Two-center prospective, randomized, clinical, and radiographic study comparing osteotome sinus floor elevation with or without bone graft and simultaneous implant placement. *Clin Implant Dent Relat Res* 18:873, 2016
48. Yu H, Wang X, Qiu L: Outcomes of 6.5-mm hydrophilic implants and long implants placed with lateral sinus floor elevation in the atrophic posterior maxilla: A prospective, randomized controlled clinical comparison. *Clin Implant Dent Relat Res* 19:111, 2017
49. Esposito M, Zucchelli G, Barausse C, et al: Four mm-long versus longer implants in augmented bone in atrophic posterior jaws: 4-Month post-loading results from a multicentre randomised controlled trial. *Eur J Oral Implantol* 9:393, 2016
50. Zhang XM, Shi JY, Gu YX, et al: Clinical investigation and patient satisfaction of short implants versus longer implants with

- osteotome sinus floor elevation in atrophic posterior maxillae: A pilot randomized trial. *Clin Implant Dent Relat Res* 19:161, 2017
51. Sahrman P, Naenni N, Jung RE, et al: Success of 6-mm implants with single-tooth restorations: A 3-year randomized controlled clinical trial. *J Dent Res* 95:623, 2016
 52. Gastaldi G, Felice P, Pistilli R, et al: Short implants as an alternative to crestal sinus lift: A 3-year multicentre randomised controlled trial. *Eur J Oral Implantol* 10:391, 2017
 53. Taschieri S, Lolato A, Testori T, et al: Short dental implants as compared to maxillary sinus augmentation procedure for the rehabilitation of edentulous posterior maxilla: Three-year results of a randomized clinical study. *Clin Implant Dent Relat Res* 20:9, 2018
 54. Bechara S, Nimcenko T, Kubilius R: The efficacy of short (6 mm) dental implants with a novel thread design. *Stomatologija* 19:55, 2017
 55. Felice P, Pistilli R, Piattelli M, et al: 1-Stage versus 2-stage lateral sinus lift procedures: 1-Year post-loading results of a multicentre randomised controlled trial. *Eur J Oral Implantol* 7:65, 2014
 56. Nedir R, Nurdin N, Khoury P, Bischof M: Short implants placed with or without grafting in atrophic sinuses: The 3-year results of a prospective randomized controlled study. *Clin Implant Dent Relat Res* 18:10, 2016
 57. Yan M, Liu R, Bai S, et al: Transalveolar sinus floor lift without bone grafting in atrophic maxilla: A meta-analysis. *Sci Rep* 8:1451, 2018
 58. Shi JY, Gu YX, Zhuang LF, Lai HC: Survival of implants using the osteotome technique with or without grafting in the posterior maxilla: A systematic review. *Int J Oral Maxillofac Implants* 31:1077, 2016
 59. Del Fabbro M, Corbella S, Weinstein T, et al: Implant survival rates after osteotome-mediated maxillary sinus augmentation: A systematic review. *Clin Implant Dent Relat Res* 14(suppl 1):e159, 2012
 60. Thoma DS, Zeltner M, Hüsler J, et al: EAO Supplement Working Group 4-EAO CC 2015. Short implants versus sinus lifting with longer implants to restore the posterior maxilla: A systematic review. *Clin Oral Implants Res* 26(suppl 11):154, 2015
 61. Fan T, Li Y, Deng WW, et al: Short Implants (5 to 8 mm) versus longer (>8 mm) with sinus lifting in atrophic posterior maxilla: A meta-analysis of RCTs. *Clin Implant Dent Relat Res* 19:207, 2017
 62. Lesaffre E, Philstrom B, Needleman I, Worthington H: The design and analysis of split-mouth studies: What statisticians and clinicians should know. *Stat Med* 28:3470, 2009
 63. Smail-Faugeron V, Fron-Chabouis H, Courson F, Durieux P: Comparison of intervention effects in split-mouth and parallel-arm randomized controlled trials: A meta-epidemiological study. *BMC Med Res Methodol* 14:64, 2014

Appendix 1. PRISMA CHECKLIST OF ITEMS TO INCLUDE WHEN REPORTING A SYSTEMATIC REVIEW INVOLVING A NETWORK META-ANALYSIS

Section and Topic	Item Number	Checklist Item	Page Reported
Title			
Title	1	Identify the report as a systematic review <i>incorporating a network meta-analysis (or related form of meta-analysis)</i> .	1
Abstract			
Structured summary	2	Provide a structured summary including, as applicable: Background: main objectives Methods: data sources; study eligibility criteria, participants, and interventions; study appraisal; and <i>synthesis methods, such as network meta-analysis</i> . Results: number of studies and participants identified; summary estimates with corresponding confidence and credible intervals; <i>treatment rankings may also be discussed. Authors may choose to summarize pairwise comparisons against a chosen treatment included in their analyses for brevity</i> . Discussion and Conclusions: limitations; conclusions and implications of findings Other: primary source of funding; systematic review registration number with registry name	1-2
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known, <i>including mention of why a network meta-analysis has been conducted</i> .	4
Objectives	4	Provide an explicit statement of questions being addressed, with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
Methods			
Protocol and registration	5	Indicate whether a review protocol exists and if and where it can be accessed (eg, web address); and, if available, provide registration information, including registration number.	4
Eligibility criteria	6	Specify study characteristics (eg, PICOS, length of follow-up) and report characteristics (eg, years considered, language, publication status) used as criteria for eligibility, giving rationale. <i>Clearly describe eligible treatments included in the treatment network, and note whether any have been clustered or merged into the same node (with justification)</i> .	5
Information sources	7	Describe all information sources (eg, databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for ≥ 1 database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (ie, screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5 and Fig 1
Data collection process	10	Describe method of data extraction from reports (eg, piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5-6
Data items	11	List and define all variables for which data were sought (eg, PICOS, funding sources) and any assumptions and simplifications made.	5-6

Appendix 1. Cont'd

Section and Topic	Item Number	Checklist Item	Page Reported
Geometry of the network	S1	Describe methods used to explore the geometry of the treatment network under study and potential biases related to it. This should include how the evidence base has been graphically summarized for presentation, and what characteristics were compiled and used to describe the evidence base to readers.	6
Risk of bias within individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (eg, risk ratio, difference in means). <i>Also describe the use of additional summary measures assessed, such as treatment rankings and surface under the cumulative ranking curve (SUCRA) values, as well as modified approaches used to present summary findings from meta-analyses.</i>	7
Planned methods of analysis	14	Describe the methods of handling data and combining results of studies for each network meta-analysis. This should include, but not be limited to: <i>Handling of multi-arm trials;</i> <i>Selection of variance structure;</i> <i>Selection of prior distributions in Bayesian analyses; and</i> <i>Assessment of model fit.</i>	7
Assessment of Inconsistency	S2	Describe the statistical methods used to evaluate the agreement of direct and indirect evidence in the treatment network(s) studied. Describe efforts taken to address its presence when found.	7-8
Risk of bias across studies	15	Specify any assessment of risk of bias that could affect the cumulative evidence (eg, publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses if done, indicating which were prespecified. This can include, but is not be limited to, the following: Sensitivity or subgroup analyses; Meta-regression analyses; <i>Alternative formulations of the treatment network; and</i> <i>Use of alternative prior distributions for Bayesian analyses (if applicable).</i>	8
Results*			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9 and Fig 1
Presentation of network structure	S3	Provide a network graph of the included studies to enable visualization of the geometry of the treatment network.	9
Summary of network geometry	S4	Provide a brief overview of characteristics of the treatment network. This can include commentary on the abundance of trials and randomized patients for the different interventions and pairwise comparisons in the network, gaps of evidence in the treatment network, and potential biases reflected by the network structure.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (eg, study size, PICOS, follow-up period) and provide the citations.	9
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment.	10

Appendix 1. Cont'd

Section and Topic	Item Number	Checklist Item	Page Reported
Results of individual studies	20	For all outcomes considered (benefits or harms), present for each study: 1) simple summary data for each intervention group and 2) effect estimates and confidence intervals. <i>Modified approaches may be needed to deal with information from larger networks.</i>	10
Synthesis of results	21	Present results of each meta-analysis done, including confidence and credible intervals. <i>In larger networks, authors may focus on comparisons versus a particular comparator (eg, placebo or standard care), with full findings presented in an appendix. League tables and forest plots may be considered to summarize pairwise comparisons.</i> If additional summary measures were explored (such as treatment rankings), these also should be presented.	10-13
Exploration for inconsistency	S5	Describe results from investigations of inconsistency. This can include such information as measures of model fit to compare consistency and inconsistency models, <i>P</i> values from statistical tests, or summary of inconsistency estimates from different parts of the treatment network.	13-14
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies for the evidence base being studied.	15
Results of additional analyses	23	Give results of additional analyses, if done (eg, sensitivity or subgroup analyses, meta-regression analyses, <i>alternative network geometries studied, alternative choice of prior distributions for Bayesian analyses, and so forth</i>).	15
Discussion			
Summary of evidence	24	Summarize the main findings, including the strength of evidence for each main outcome; consider their relevance to key groups (eg, health care providers, users, and policy-makers).	15-16
Limitations	25	Discuss limitations at study and outcome level (eg, risk of bias) and at review level (eg, incomplete retrieval of identified research, reporting bias). <i>Comment on the validity of the assumptions, such as transitivity and consistency. Comment on any concerns regarding network geometry (eg, avoidance of certain comparisons).</i>	19-20
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	20
Funding			
Funding	27	Describe sources of funding for the systematic review and other support (eg, supply of data) and the role of funders for the systematic review. This also should include information regarding whether funding has been received from manufacturers of treatments in the network and whether some of the authors are content experts with professional conflicts of interest that could affect use of treatments in the network.	21

Note: Text in italics indicates wording specific to reporting of network meta-analyses that has been added to guidance from the PRISMA statement.

Abbreviations: PICOS, population, intervention, comparators, outcomes, study design; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

* Authors might wish to plan for the use of appendices to present all relevant information in full detail for items in this section.

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Appendix 2. PICOS CRITERIA AND SEARCH STRATEGY FOR SYSTEMATIC REVIEW

PICOS Criteria

Population	1) intermediate posterior maxilla OR posterior maxillary alveolar crest OR edentulous maxillary alveolar ridge OR atrophic posterior maxilla
Intervention	2) short implants OR osteotome floor sinus floor elevation OR crestal sinus lift OR lateral sinus floor elevation OR long implants OR standard implants OR short implants without augmentations OR short implants alone OR maxillary sinus augmentations
Comparisons	3) same as 2
Outcomes	4) implant failure OR implant loss OR prosthesis failure OR complications OR implant survival rate
Time	5) 6 mo OR 1 yr OR 3 yr OR >1 yr
Study design	6) split-mouth randomized controlled trial OR parallel randomized controlled trial OR RCT
Search combination	1 AND 2 AND 3 AND 4 AND 5 AND 6
Language	no language restriction
Electronic database	PubMed, EMBASE, and Cochrane CENTRAL
Focused question	What is the most effective rehabilitation method for posterior maxillas with 4 to 8 mm of residual alveolar bone height below the maxillary sinus with implant-supported prostheses?

Abbreviations: PICOS, population, intervention, comparators, outcomes, study design; RCT, randomized controlled trial.

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Appendix 3. RESULTS OF INDIVIDUAL STUDIES—IMPLANT FAILURE

Study	SI Only		SI + OSFE ± Bone Grafting		LI + OSFE ± Grafting		LI + LSFE + Bone Grafting	
	Event	Count	Event	Count	Event	Count	Event	Count
Gastaldi et al, 2017 ⁵²	1	10			1	8		
Esposito et al, 2016 ⁴⁹	3	20					8	20
Pistilli et al, 2013 ³⁹	0	20					5	19
Pistilli et al, 2013 ⁴⁰	0	20					4	20
Esposito et al, 2010 ³⁶							2	9
Esposito et al, 2011 ³⁷	3	15					1	15
Esposito et al, 2014 ⁴³	3	14					1	14
Esposito et al, 2015 ⁴⁶	0	15					5	13
Si et al, 2013 ³⁸			2	22				
Si et al, 2013 ³⁸			1	22				
Yu et al, 2016 ⁴⁸			0	20			1	18
Cannizzaro et al, 2013 ⁴¹			4	20			7	20
Thoma et al, 2015 ⁴⁴	2	47					7	50
Gulje et al, 2014 ⁴²	0	20					0	20
Taschieri et al, 2018 ⁵³	0	25					0	24
Bechara et al, 2017 ⁵⁴	0	33					1	20
Meloni et al, 2015 ⁴⁵							0	10
Torres et al, 2009 ³⁵							2	57
Zhang et al, 2017 ⁵⁰			0	15	1	23		
Markovic et al, 2016 ⁴⁷					0	30		
Sahrman et al, 2016 ⁵¹			0	10	0	15		
Markovic et al, 2016 ⁴⁷					0	9		
Meloni et al, 2015 ⁴⁵							1	10

Abbreviations: LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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Appendix 4. RESULTS OF INDIVIDUAL STUDIES—PROSTHESIS FAILURE

Study	SI Only		SI + OSFE ± Bone Grafting		LI + OSFE ± Bone Grafting		LI + LSFE + Bone Grafting	
	Event	Count	Event	Count	Event	Count	Event	Count
Gastaldi et al, 2017 ⁵²	0	10			0	8		
Esposito et al, 2016 ⁴⁹	1	20					3	20
Si et al, 2013 ³⁸			2	22				
Si et al, 2013 ³⁸			3	22				
Yu et al, 2017 ⁴⁸			1	20			2	18
Markovic et al, 2016 ⁴⁷					0	30		
Sahrmann et al, 2016 ⁵¹			0	10	0	15		
Zhang et al, 2017 ⁵⁰			0	15	0	23		
Meloni et al, 2015 ⁴⁵							0	10
Pistilli et al, 2013 ³⁹	1	19					1	20
Pistilli et al, 2013 ⁴⁰	0	20					1	20
Esposito et al, 2010 ³⁶							0	9
Esposito et al, 2011 ³⁷	1	15					0	15
Esposito et al, 2014 ⁴³	2	14					0	14
Esposito et al, 2015 ⁴⁶	0	15					0	13
Thoma et al, 2015 ⁴⁴	3	47					3	50
Gulje et al, 2014 ⁴²	0	20					0	20
Cannizzaro et al, 2013 ⁴¹			1	20			2	20
Bechara et al, 2017 ⁵⁴	0	33					1	20
Taschieri et al, 2018 ⁵³	0	25					0	24
Meloni et al, 2015 ⁴⁵							0	10
Markovic et al, 2016 ⁴⁷					0	9		

Abbreviations: LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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Appendix 5. RESULTS OF INDIVIDUAL STUDIES—MARGINAL BONE LOSS

Study	SI Only			SI + OSFE ± Bone Grafting			LI + OSFE ± Bone Grafting			LI + LSFE + Bone Grafting		
	Mean	SD	Size	Mean	SD	Size	Mean	SD	Size	Mean	SD	Size
Gastaldi et al, 2017 ⁵²	0.89	0.25	10				1.08	0.29	8			
Esposito et al, 2016 ⁴⁹	0.47	0.12	20							0.50	0.13	20
Pistilli et al, 2013 ³⁹	0.87	0.07	20							1.15	0.12	19
Pistilli et al, 2013 ⁴⁰	1.02	0.06	20							1.09	0.05	20
Esposito et al, 2010 ³⁶										1.01	0.16	9
Esposito et al, 2011 ³⁷	0.79	0.56	15							1.16	0.46	15
Esposito et al, 2014 ⁴³	1.02	0.47	13							1.54	0.35	14
Esposito et al, 2015 ⁴⁶	1.05	0.2	15							1.01	0.16	13
Si et al, 2013 ³⁸				1.38	0.23	22						
Si et al, 2013 ³⁸				1.33	0.46	22						
Yu et al, 2017 ⁴⁸				0.35	0.6	20				0.4	0.71	18
Cannizzaro et al, 2013 ⁴¹				0.41	0.42	20				0.71	0.41	19
Gulje et al, 2014 ⁴²	0.1	0.3	20							0.1	0.3	20
Taschieri et al, 2018 ⁵³	0.91	1.22	25							1.15	0.68	24
Bechara et al, 2017 ⁵⁴	0.201	0.284	33							0.273	0.384	20
Meloni et al, 2015 ⁴⁵										1.19	0.53	10
Sahrman et al, 2016 ⁵¹				0.16	0.62	10	0.33	0.71	15			
Meloni et al, 2015 ⁴⁵										1.06	0.61	10

Abbreviations: LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SD, standard deviation; SI, short implant without augmentation.

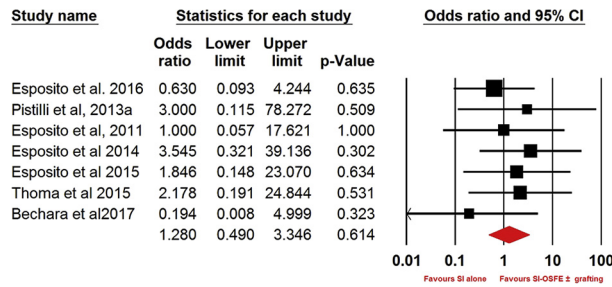
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Appendix 6. RESULTS OF INDIVIDUAL STUDIES—COMPLICATIONS

Study	SI Only		SI + OSFE ± Bone Grafting		LI + OSFE ± Bone Grafting		LI + LSFE + Bone Grafting	
	Event	Count	Event	Count	Event	Count	Event	Count
Bechara et al, 2017 ⁵⁴	0	33					1	20
Cannizzaro et al, 2013 ⁴¹			1	20			3	19
Esposito et al, 2014 ⁴³	3	14					1	14
Esposito et al, 2015 ⁴⁶	2	15					1	13
Esposito et al, 2010 ³⁶							0	9
Esposito et al, 2011 ³⁷	1	15					1	15
Esposito et al, 2016 ⁴⁹	2	20					3	20
Gastaldi et al, 2017 ⁵²	0	10			0	8		
Gulje et al, 2014 ⁴²	0	20					0	20
Markovic et al, 2016 ⁴⁷					0	9		
Markovic et al, 2016 ⁴⁷					0	30		
Meloni et al, 2015 ⁴⁵							0	10
Meloni et al, 2015 ⁴⁵							0	10
Pistilli et al, 2013 ⁴⁰	0	20					0	20
Pistilli et al, 2013 ³⁹	1	20					0	19
Sahrman et al, 2016 ⁵¹			0	10	0	15		
Si et al, 2013 ³⁸			2	22				
Si et al, 2013 ³⁸			3	22				
Taschieri et al, 2018 ⁵³	0	25					0	24
Thoma et al, 2015 ⁴⁴	2	47					1	50
Torres et al, 2009 ³⁵							2	57
Yu et al, 2017 ⁴⁸			0	20			1	18
Zhang et al, 2017 ⁵⁰			0	15	0	23		

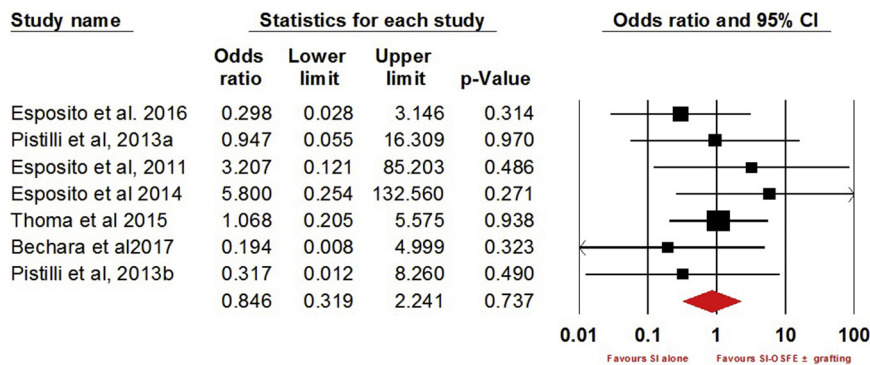
Abbreviations: LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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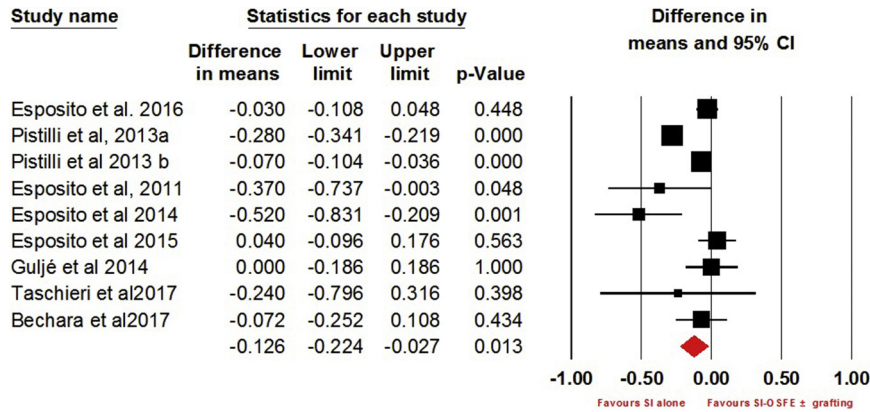
APPENDIX 7. Direct pairwise meta-analysis of implant failure for short versus long implants combined with lateral sinus floor elevation. CI, confidence interval; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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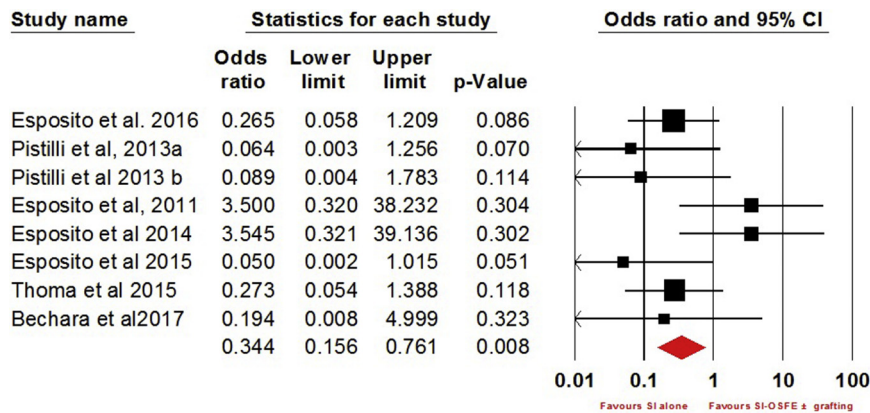
APPENDIX 8. Direct pairwise meta-analysis of prosthesis failure for short versus long implants combined with lateral sinus floor elevation. CI, confidence interval; OSFE, osteotome sinus floor elevation; SI, short implant.

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APPENDIX 9. Direct pairwise meta-analysis of marginal bone loss for short versus long implants combined with lateral sinus floor elevation. CI, confidence interval; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

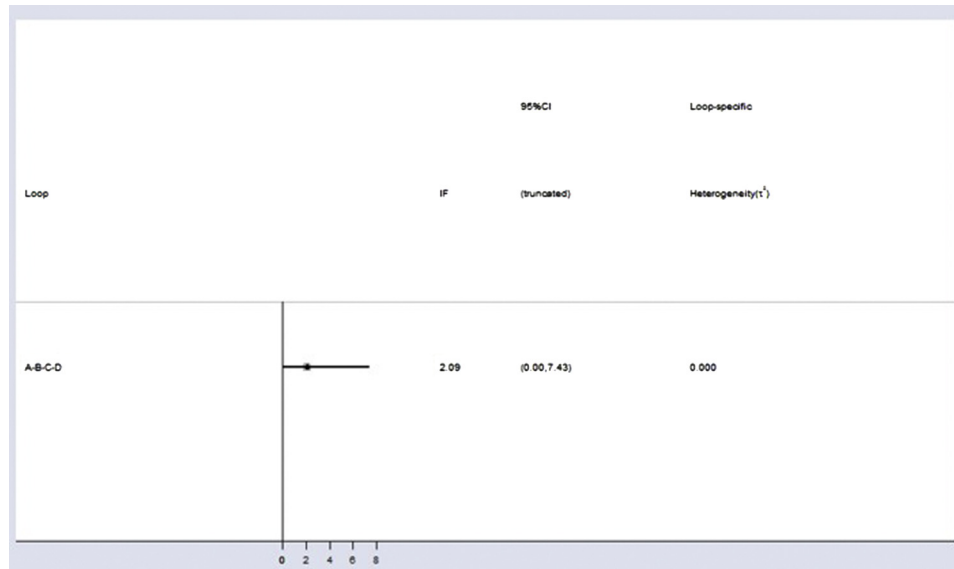
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APPENDIX 10. Direct pairwise meta-analysis of complications for short versus long implants combined with lateral sinus floor elevation. CI, confidence interval; OSFE, osteotome sinus floor elevation; SI, short implant without augmentation.

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web 4C/FPO



APPENDIX 11. Irfplot showing inconsistency model of implant failure. A, Short implant placement without augmentation. B, Short implant placement with osteotome sinus floor elevation with and without bone grafting. C, Long implant placement with osteotome sinus floor elevation with and without bone grafting. D, Long implant placement with lateral sinus floor elevation with bone grafting. CI, confidence interval.

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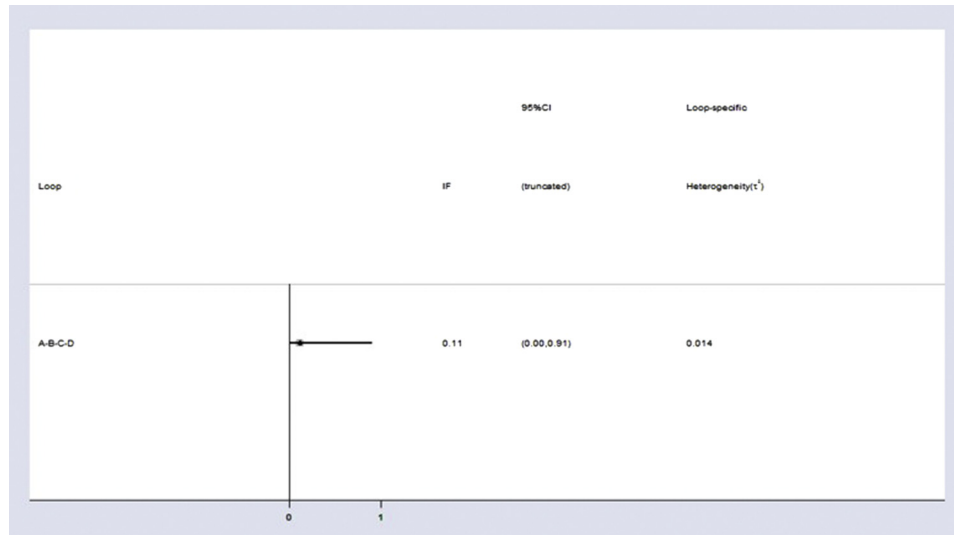
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APPENDIX 12. Irfplot showing inconsistency model of prosthesis failure. A, Short implant placement. B, Short implant placement with osteotome sinus floor elevation with and without bone grafting. C, Long implant placement with osteotome sinus floor elevation with and without bone grafting. D, Long implant placement with lateral sinus floor elevation with bone grafting. CI, confidence interval.

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APPENDIX 13. Irfplot showing inconsistency model of marginal bone loss. *A*, Short implant placement without augmentation. *B*, Short implant placement with osteotome sinus floor elevation with and without bone grafting. *C*, Long implant placement with osteotome sinus floor elevation with and without bone grafting. *D*, Long implant placement with lateral sinus floor elevation with bone grafting. CI, confidence interval.

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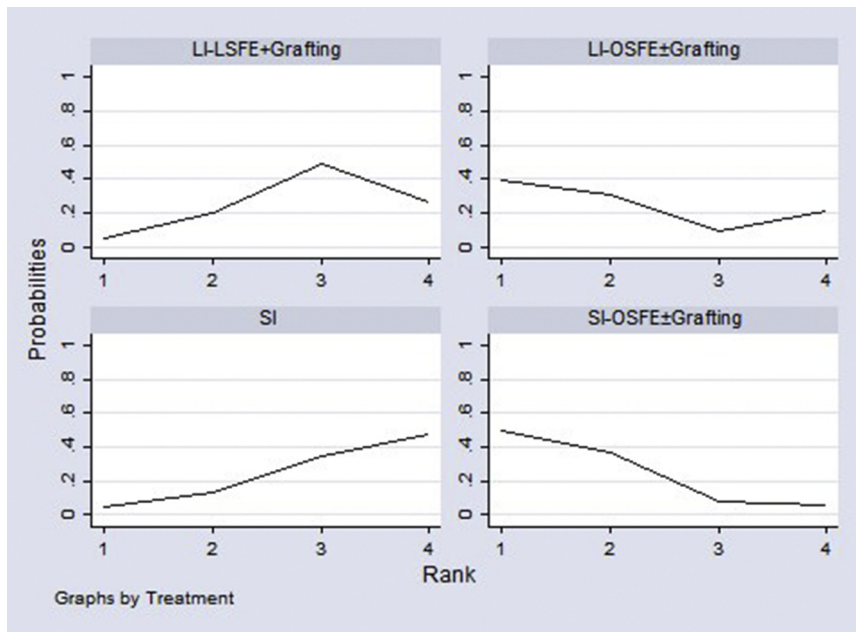
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APPENDIX 14. Irfplot showing inconsistency model of complications. *A*, Short implant placement without augmentation. *B*, Short implant placement with osteotome sinus floor elevation with and without bone grafting. *C*, Long implant placement with osteotome sinus floor elevation with and without bone grafting. *D*, Long implant placement with lateral sinus floor elevation with bone grafting. CI, confidence interval.

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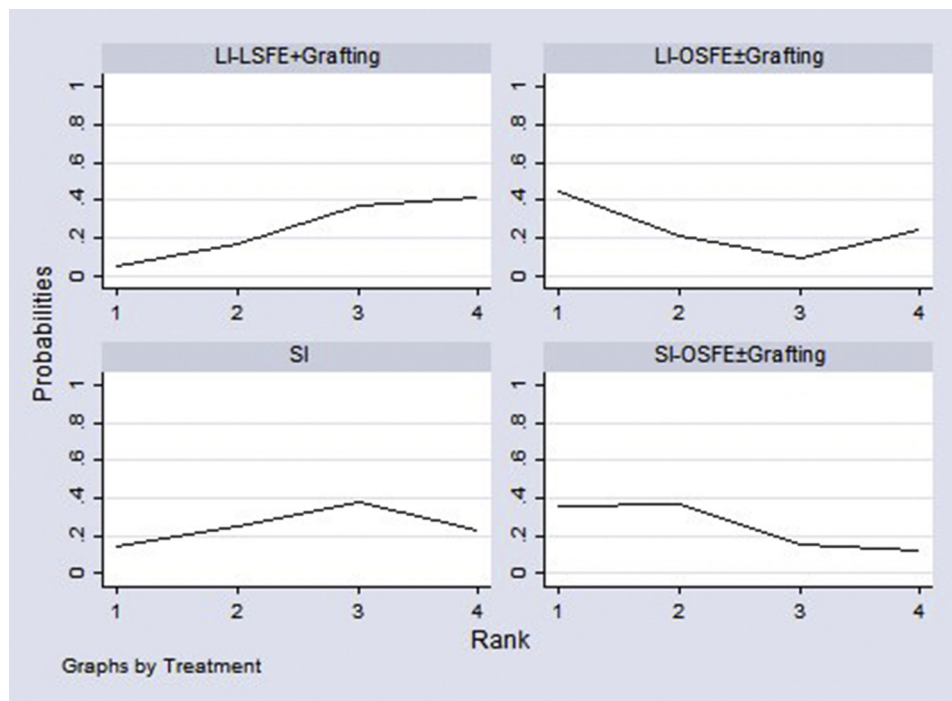
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APPENDIX 15. Surface under the cumulative ranking curve showing ranking for implant failure. LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant placement without augmentation.

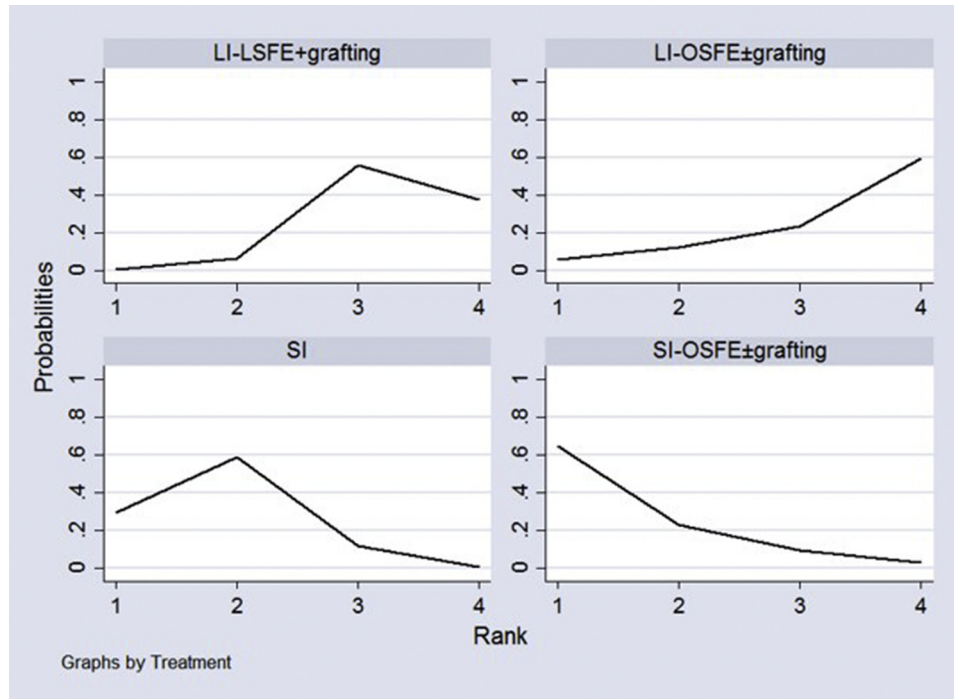
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APPENDIX 16. Surface under the cumulative ranking curve showing ranking for prosthesis failure. LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant placement without augmentation.

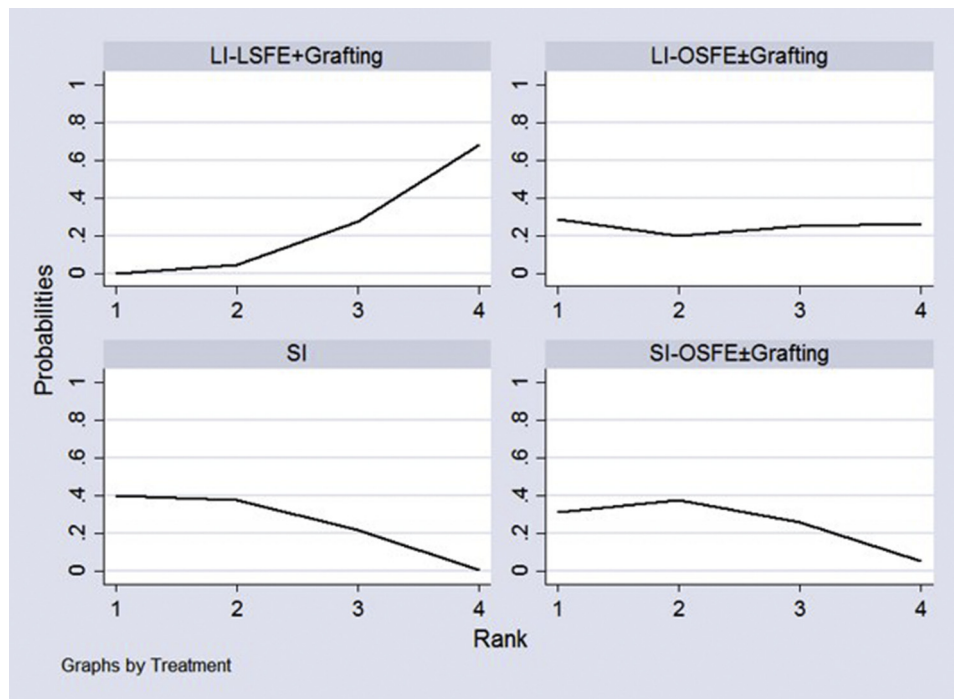
Al-Moraissi et al. Rehabilitation of Atrophic Posterior Maxilla. J Oral Maxillofac Surg 2018.



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APPENDIX 17. Surface under the cumulative ranking curve showing ranking for marginal bone loss. LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant.

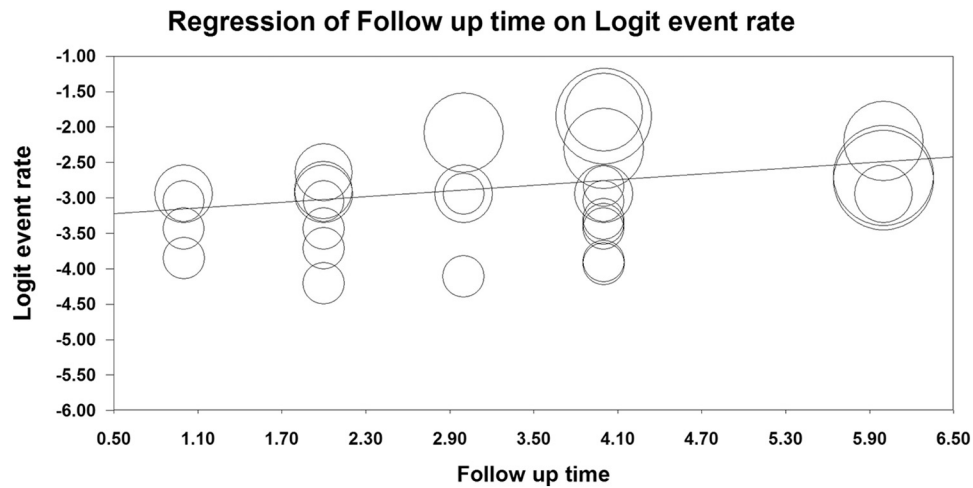
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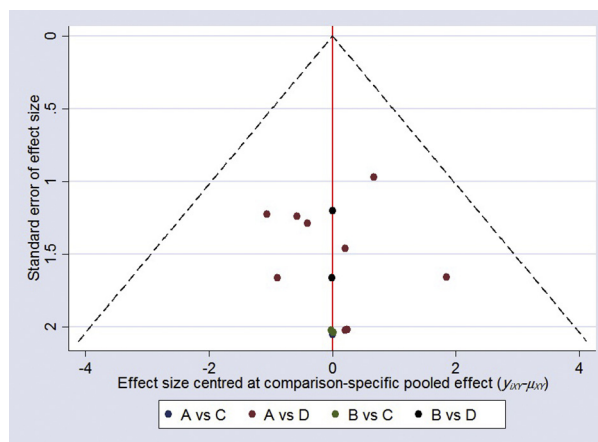
APPENDIX 18. Surface under the cumulative ranking curve showing ranking for complications. LI, long implant; LSFE, lateral sinus floor elevation; OSFE, osteotome sinus floor elevation; SI, short implant placement without augmentation.

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APPENDIX 19. Scatterplot of meta-regression between duration of follow-up and implant failure.

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APPENDIX 20. Funnel plot of publications bias for implant failure rate. *A*, Short implant placement without augmentation. *B*, Short implant placement with osteotome sinus floor elevation with and without bone grafting. *C*, Long implant placement with osteotome sinus floor elevation with and without bone grafting. *D*, Long implant placement with lateral sinus floor elevation with bone grafting.

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