

The rehabilitation of posterior atrophic maxilla by using the graftless option of short implant versus conventional long implant with sinus graft: A systematic review and meta-analysis of randomized controlled clinical trial

Sachin Haribhau Chaware, Vrushali Thakare¹, Ritu Chaudhary², Ajit Jankar³, Smruti Thakkar, Sidesh Borse

Departments of Prosthodontics and ¹Public Health Dentistry, MGVs KBH Dental College and Hospital, Nashik, ³Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India, ²Department of Prosthodontics, Royal College of Surgeons England, Britannia Dental Surgery, Newport, UK

Abstract

Aim: The purpose of systematic review and meta-analysis was to compare the efficacy of short implant versus conventional long implant with sinus graft in patients rehabilitated for posterior atrophic maxilla.

Setting and Design: Systematic review and meta analysis.

Materials and Methods: Electronic searches were conducted in Pub Med, Embase, and Medline with supplemented by manual search up to December 2019. The randomized controlled trial (RCTs) comparing short implant (<8.5 mm) and long implant (>8.5 mm) with sinus graft were included. (Prospero CRD42020186972).

Statistical Analysis Used: Random-effect model, fixed-effect model, A funnel plot and the Egger's test.

Results: Twenty-two Randomized controlled trials (RCTs) were assessed with 667 patients and 1595 implants (short implant:767, Long implant:835). No significant difference of implant survival rate was recorded for short and long implant (at patient level: RR: 1.01, 95% CI = 0.52-2.0, $P = 0.87$, $I^2 = 0\%$, at implant level RR = 1.09, 95% CI = 0.6-2.0, $P = 0.7$, $I^2 = 0\%$). Similarly marginal bone resorption was reported no difference for short and long implant (MD = 0.16, 95% CI: -0.23 = -0.08, $P = 0.00$, $I^2 = 74.83\%$). Biological complications were marginally higher for long implant (RR = 0.48, 95% CI = 0.23-0.8, $P = 0.13$, $I^2 = 29.11\%$). and prosthetic complications were marginally higher for short implants (RR=1.56, 95% CI=0.85-3.15, $P = 0.43$, $I^2 = 0\%$).

Conclusion: There was no significance difference in implant survival rate and marginal bone resorption recorded for both the short implant and long implant with sinus graft, in the patients rehabilitated with posterior atrophic maxilla. Hence, short implant is a suitable alternative to long implant with sinus graft, for the rehabilitation posterior atrophic maxilla.

Keywords: Bone augmentation, porous bone, short implant, sinus graft, textured implant

Address for correspondence: Prof. Sachin Haribhau Chaware, Department of Prosthodontics, MGVs KBH Dental College and Hospital, Nashik - 422 001, Maharashtra, India.

E-mail: sac32in@yahoo.in

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INTRODUCTION

Maxillary sinus grafting either by lateral approach or crestal approach is the routine procedure for implant rehabilitation at posterior atrophic maxilla.^[1-5] The sinus grafting accommodates the length of the conventional long implant and increases bone-implant surface contact.^[6-8] The successful healing of the sinus-graft with a minimum reduction of the graft height is the principal determinant of a long-term stability of the sinus-graft implant.^[9] The gold standard of sinus graft is the autograft, due its inherent osteogenic potential^[10,11] The implant osseointegrated with sinus autograft have shown the success rate of 82%–96% with mild to moderate reduction of graft height.^[12-14] The major drawback of sinus autograft is high morbidity at the donor site, due to requirement of the additional surgery which leads to subsequent postoperative pain, tissue scarring, patient discomfort and secondary infection^[9,10,15] Hence, many clinicians preferred to use of an autograft in combination with other bone substitute.^[16] The bony substitutes for instance allograft,^[16] xenograft,^[17,18] bovine graft materials,^[19] platelet-rich fibrin (PRF),^[20] and alloplastic materials as synthetic calcium phosphate (β -tricalcium phosphate),^[16] hydroxyapatite, biphasic calcium phosphate^[16,18] and Bio-glass^[16,18] have shown higher success rate, either used exclusively or as a mixture with autograft than the 100% autogenous bone.^[21]

The most common postgraft complications are sinus membrane perforation, followed by graft infection and inadequate primary stability.^[22-25] However, the Sinus-graft healing period and delayed placement of the implant is the crucial factor, as there is need for the stabilization of the graft for first 6–12-month period because the maximum reduction of the graft height occurs in the first 12 months.^[15,17] Due to prolonged healing period with no contact of prosthesis, perhaps create the problem of mastication and esthetic for the patient rehabilitated with the atrophic maxilla.^[15,16] Similarly, the retrospective analysis (5 years) reported that the higher implant survival rate (ISR) and lower bone resorption for the implant placed in a native bone than the implant placed with sinus graft. Hence many clinicians preferred to select graftless options of implant placement.^[15,25-27] The graftless options of implant placement are zygomatic or pterygoid bone implant placement and short implant. The zygomatic implant has a success rate of 90%–100%.^[15,29] However, the zygomatic bone implant placement is more invasive procedure hence it needs greater clinical skill.^[15,28] The possible complication associated with the zygomatic implant placement is an extra bulk at the palatal area (palatal emergence profile), which creates discomfort to the patient and difficulty in maintaining the oral hygiene.^[29,30]

Recently, the selection and placement of short implant have gained widespread popularity due to its inherent benefit. Any implant with total length is 8 mm or less, completely submerged in bone is considered as a short implant and implant length <6 mm was referred to as an ultra-short implant.^[31] In contrast, few researchers suggested that implant length of 10 mm is consider as a standard length for predictable success and implant below 10 mm considered to be a short implant.^[32,33] The main clinical advantage of short implant that it is noninvasive surgical procedure with no additional grafting procedure required; therefore, it completely eliminates donor site morbidity.^[33] Other clinical advantages are it reduces the surgical time,^[33,34] decreases the time-span of implant placement, no damage to adjacent tooth,^[35] correct positioning of the implant, fewer postinsertion complications and economical.^[36,37] However, the survival of short implant will be questionable when the factors like crown-implant ratio (C/I), initial implant stability particularly type 4 bone, prosthetic complications, reentry to submerged healing implant at the second stage, and distribution of axial or nonaxial stress particularly in steep compensative curve taken into the consideration.^[36,37] The previous systematic review^[36,37] Has covered less number of studies and selected patient as a statistical unit, that creates the problem for recording the ISR as the multiple failures in single patient-reported as one failure. The objective of the present systematic review^[38,39] is to evaluate the effectiveness and predictability of short implant versus conventional long implant with sinus graft for the patient rehabilitated with posterior atrophic maxilla by taking patient and implant as the statistical unit.

MATERIALS AND METHODS

This systematic review was designed according to the guidelines of the preferred reporting item for systematic review (PRISMA) and meta-analysis guidelines.^[40,41] The systematic review was developed and registered (Prospero Registration number database: CRD42020186972).

A systematic search was conducted to retrieve eligible randomized controlled trial (RCT) up to December 2019 of short implant and conventional long implant with sinus graft. The electronic search was conducted in Medline (PubMed), Cochrane Library (The Cochrane Central Register of Controlled Trials), SCOPUS, Embase, CINHALL, web of science, and Google scholar.

The PICOS protocol for the search engine are as: Population (P): Partially edentulous patients reported for the rehabilitation of posterior maxillary ridge (molar and premolar region) with reduced bone height (RBH).

Intervention (I): Simultaneous placement of short implant (<8.5 mm) and conventional long implant (\geq 8.5 mm) with sinus graft. Comparison (C): Short implant versus conventional long implant with sinus graft at posterior atrophic maxilla. Outcome (O): ISR, Marginal bone resorption (MBR), Biological complication, and Prosthetic complication between short and long implant.

To electronic search was supplemented by manual search of journal-specific area: The manual search list of the collected journal is as follows.

European journal of oral implantology, Journal clinical Periodontology, European Journal of Oral science, Clinical oral Implant research, Med Oral Patol Oral Cir Bucal, Journal Korean association of oral maxillofacial surgery, The Journal of Craniofacial surgery, International Journal of oral and maxillofacial implant, Stomatologija, Baltic Dental and Maxillofacial Journal, Clinical Implant Dental Related Research, Journal of Dental Research, Journal of Dentistry, The open dentistry journal, Oral and Maxillofacial Surgery, and Quintessence International.

The two investigators were searched the articles by screening the title and abstract. The searched analysis based on the following inclusion criteria: the studies included only RCT with no follow-up restrictions. Studies with clear survival rate, failure rate, MBR, and complication associated with implant data. The studies with the comparison of short implant and conventional long implant with graft in a same analysis. The studies with minimum 10 participants in the test and control groups for parallel and split mouth RCT was included in the search. The studies associated with the zygomatic implant, *in vitro* study, case report, animal study was not included. Similarly, the studies of the short implants without comparison, length of the implant was more than 8.5 mm still it was in the list of short implant, and short implant with sinus elevation or grafting procedure was excluded from the search.

The full-text length of the articles of the selected search was evaluated by three investigators (reproducibility 0.87, Cohen's kappa). The data retrieved from each of the selected study assigned to the comparison of short implant and conventional long implant, length and diameter of the short and long implant, and type of sinus graft/sinus surgery. Patient data such as mean age, male/female ratio, and smoking habits. Publication year, and author. Outcome variable such as follow-up period, loading protocol, survival rate, biological complications, MBR and prosthetic complications.

All three investigators discussed all the variant views of the selected search and any disagreement or variant

opinion between three investigators was further resolved by addition of the fourth investigator. Any missing data, author of the study were contacted via E-mail to provide further detail.

Risk of bias was assigned as per the Cochrane collaboration tools^[42] (random sequence generation [selection bias], allocation concealment [selection bias], blinding of participants and personnel [performance bias], blinding of outcome assessment [detection bias], incomplete outcome data [attrition bias], selective reporting [reporting bias], and other bias). The investigators were recorded the risk of bias of each individual study and then across the study. If the study fulfils all seven criteria, then it was notifying as a low risk, sequentially, if the study missed one criteria or unclear, then that study was notifying as a moderate risk, and if the study missed two or more criteria, then it was considered as high risk [Tables 1 and 2].

The meta-analysis from the Data search was conducted by using software NCSS LIC (NCSS statistical software 2019, v19.0.2, version, www.ncss.com). The outcome variables included ISR, biological complication and prosthetic complications evaluated by risk ratio (RRs). The ISR (implant failure) is a dichotomous variable of each implant group; hence, it is pooled and analyzed by RRs and 95% confidence interval (95% CIs). The value of marginal bone loss as a continuous variable recorded as "standardized mean difference" (SMD) with 95% CI were used. The RRs and SMD values were considered significant when $P < 0.05$. To find out the heterogeneity among the studies, Cochrane Q test was performed ($P < 0.001$ /CI 95%). The presence of heterogeneity was assessed by using inconsistency test I^2 (high heterogeneity: $I^2 > 75\%$; low heterogeneity: $I^2 < 25\%$). The random-effect model was used when meta-analysis recorded high heterogeneity ($P < 0.10$).^[43] However, fixed-effect model was adopted, when heterogeneity was not statistically significant. A funnel plot and the Egger's test^[44] were used to assess the presence of the publication bias.

RESULTS

The search process reviewed 68 full-text articles by first and second authors, after the evaluation of the title and abstract (kappa 0.87). The twenty-two articles were evaluated, as per the agreement of the four authors (agreement = 86.6) and proposed inclusion criteria of the review [Figure 1]. The twenty-eight studies were excluded, the reason specified with Figure 1. The twenty-two studies.^[45-66] were further divided as per their follow-up period after the prosthetic component loading. The two

Table 1: Risk of bias summary of individual studies

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participant and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Thoma <i>et al.</i> , 2018							
Felice P <i>et al.</i> , 2019							
Esposito M <i>et al.</i> , 2014							
Taschieri <i>et al.</i> , 2017							
Gastaldi G <i>et al.</i> , 2017							
Bechara S <i>et al.</i> , 2017							
Gastaldi G <i>et al.</i> , 2018							
Felice P <i>et al.</i> , 2018							
Pohl V <i>et al.</i> , 2017							
Esposito M <i>et al.</i> , 2015							
Pistilli R <i>et al.</i> , 2013a							
Pistilli R <i>et al.</i> , 2013b							
Esposito M <i>et al.</i> , 2011							
Felice P <i>et al.</i> , 2015							
Bolle C <i>et al.</i> , 2018							
Gulje FL <i>et al.</i> , 2014							
Schincaglia G <i>et al.</i> , 2018							
Zhang XM <i>et al.</i> , 2017							
Esposito M <i>et al.</i> , 2016							

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Table 1: Contd...

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participant and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Felice P et al., 2012	+	+	+	+	+	+	+
Felice P et al., 2009	+	+	+	+	+	+	+
Felice P et al., 2011	+	+	+	+	+	+	+

Green: Low risk, Yellow: Medium risk, Red: High risk

Table 2: Risk of bias across the studies

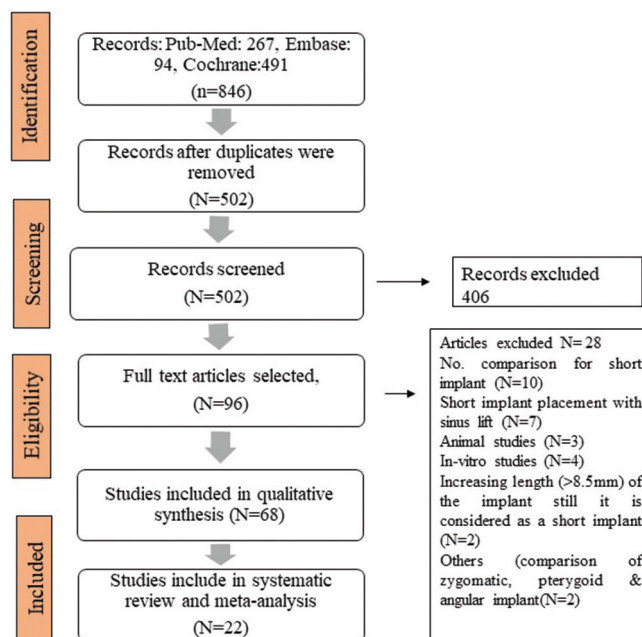
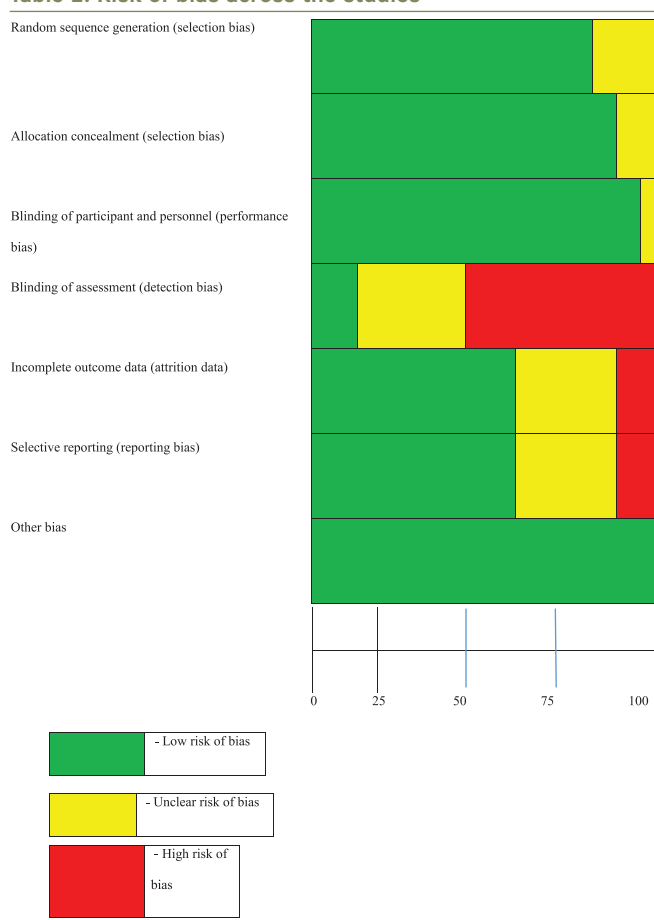


Figure 1: PRISMA flow chart

studies.^[45,46] were reported a 5-year follow-up period, seven studies.^[47-53] were reported a follow-up period of 3 years, eight studies.^[54-61] were reported 1-year follow-up, and five studies were reported.^[62-66] Less than 1-year follow-up. Out of 22 trials, five trials were split-mouth design and 18 trials were parallel design with two groups except one article was having three groups. The pooled analysis geometry reported 704 (short implant group: 419, long implant group: 390) patients, out of 37 patients were dropped during follow-up visit due to various reason. The sample

group of Thoma et al.^[45] trial was evaluated sequentially after 1 year by Schincaglia et al. (2015)^[61] and 3 years by Pohl et al.,^[53] hence to eliminate the repetition sample size, the review has selected the sample size of a 5-year evaluation done by Thoma et al.^[45] The review eventually assessed the 667 patients for outcome variables. The review analyzed 1595 (short implant: 767, long implant: 835) implants of the clinical trial. The highest follow-up period was 60 months and the lowest follow-up period was 4 months. The length of the short implant ranged from 4 to 8.5 and whereas the conventional long implant ranged from 10 mm to 15 mm. The diameter of both groups ranged from 3.7 mm to 7 mm. Table 3 describes the methodological aspect of the implant design and the sinus graft and Table 4 discussed the outcome variables of the comparative studies. The studies were used the commercially available standardized implant system by the various manufacturer and in the sinus graft group, the trial were used xenograft except one study used

Table 3: Methodological description of the comparative studies of short implants and long implants with sinus graft

Author, year, country	Design	Sampling	Implant brand dimension	Sinus graft, sinus surgery approach RBH	Follow up
Thoma DS <i>et al.</i> , 2018 RCT Switzerland	Multicentre RCT	$n=101$, SI=50, LI=50 SI: M/F=29/21, LI: M/F=23/28 Smokers: SI=18, LI=28 Mean age/range: 50.4 (20-77) SI=50±14.05 (23-76) LI=51±12.8 (20-77)	ASTRA TECH Implant System sinus was grafted using a xenograft (Bio-Oss™ Sirona Implants, Mölndal, Sweden $n=124$, SI=60, LI=64 SI=Lth/Dia=6/4, LI= 11-15/4 SI: 1 implant=34, multiple=16 LI: 1 implant=36, multiple=15	sinus was grafted using a xenograft (Bio-Oss™ Granules, Geistlich, Switzerland that could be mixed with local bone chips collected during preparation of the lateral sinus approach (Safescraper Twist, CGM S.p.A., Divisione Medical Meta, Italy) RBH=5-7 mm	5 years Patient dropped (implant) $n=11$ (12) SI=6 (6) LI=5 (6)
Felice P <i>et al.</i> , 2019 Italy	RCT split mouth	$n=20$, M/F=11/9, 3 heavy smokers Mean age/range=57.6 (47-80)	Commercially pure titanium implant (southern implants, Irene, South Africa) with external hexagon, roughned blast surface $n=83$, SI=39, LI=44 Lth/Dia SI=6/4 mm Lth/Dia SI=11.8±4 mm Torque <25 Ncm	Particulate bone graft (OseoBiol GenOss) Lateral window technique RBH=5-7 mm	5 years 3 patient dropped
Esposito <i>et al.</i> , 2014 Sweden	RCT, two centre Split mouth	$n=15$ M/F=9/6 Mean age/range 56/47-70 2 moderate smoker 1 heavy smoker	MegaGen implant, Gyeongbuk, South Korea (rescue implant with internal connection). Hydroxyapatite surface coating $n=72$, SI: 34 (5 mm length) LI: 38 (12.4 mm Lth/Dia was 6 mm in both groups Torque >25 N	Bio-Oss granular/lateral window technique, covered with restorable Bio-Gide barrier	3 years 1 patient dropped
Taschieri S <i>et al.</i> , 2018 Milan, Italy	Randomized study with a parallel group design	Total: 52, SI: M/F=11/16, LI=11/14 Mean age SI: 52.21±10.42 LI: 51.05±10.64 heavy/light smokers: 6/6	(Internal, Universal Platform and Universal Plus Platform, BTI Biotechnology Institute) had a sandblasted surface (optima) $n=102$, SI=58, LI=42, Lth/Dia SI=8.05±0.59/3.75, 4.28, 4.5 LI=11.47±0.63/3.75, 4: 38, 4.5 1 implant SI=6, LI=7. Multiunit SI=21, LI=18 Application P-PRP liquid before implant insertion to increases biological activity	Anorganic bovine bone was the material for the control group (Bio-Oss small granules 0.5-1.0 mm particles, Geistlich Pharma AG, Wolhusen, Switzerland) as grafting materials. Finally, a resorbable membrane (Bio-Gide, Geistlich Pharma AG, RBH=5.39 mm. lateral window technique)	3 years $n=3$ LI=1 SI=2
Gastaldi G, <i>et al.</i> , 2017 Italy	RCT multicentre	$n=20$, SI: M/F=3/7, LI: M/F=5/5 Mean age/range: SI: 58.6 (39-80), LI: 52.8 (42-70) Smokers: SI=1 moderate, 3 heavy LI=5 moderate, 2 heavy	LI: osteilit II implant (XFOS5/6XX, Zimmer Biomet) SI: Long external hex implant (NXFOS5/6XX, Zimmer Biomet) $n=34$, SI=16 LI=18, SI with 1 implant=4, a and SI with two implant=6. LI with one implant=2, LI with two implant=8, SI with 4 mm length=10 and SI with 5 mm length=6. LI with 10 mm length=18. Dia for both implant group=5 mm	Cosci sinus advanced sinus kit (Zimmer Biomet Palm beach gardens FL USA). A granular anorganic bone substitute (Endobon, Zimmer Biomet) lateral window technique RBH=5-7 mm	3 years LI=2 Dropped in 1 year
Bechara S <i>et al.</i> , 2017 Qatar	RCT parallel	$n=53$, SI: M/F=10/23, LI: M/F=9/11 Mean age: SI=47.5±16.2, LI=49.2±13.4	Anyridge implants with internal conical morse-taper connection and deep sharp thread design (MegaGen Implant, Gyeongbuk, SouthKorea) $n=90$, SI=45, LI=45 SI: Lth=6 mm, Dia.=4-8 mm LI: Length=10, 11.5, 13, 15 mm Dia=4-8 mm. Torque=35 N	Particulate bone graft (OseoBiol GenOss) RBH=≥4 mm	3 years
Gastaldi G <i>et al.</i> , 2018 Italy	RCT parallel	$n=40$ SI: M/F=3/17, LI: M/F=7/13 Mean age/range SI: 58.6 (39-80) LI: 52.8 (42-70)	LI: osteilit II implant (XFOS5/6XX, Zimmer Biomet) SI: long external hex implant (NXFOS5/6XX, Zimmer Biomet) $n=40$ SI=20, LI=20 SI: Lth/dia=5/5 LI: length=10 mm, 11.5,13, and 15 mm. Dia=5 mm	Particulate bone graft (OseoBiol GenOss) RBH=4-6 mm Lateral window technique	3 years SI=1 LI=2 Dropped out

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Table 3: Contd...

Author, year, country	Design	Sampling	Implant brand dimension	Sinus graft, sinus surgery approach RBH	Follow up
Felice P <i>et al.</i> , 2018 Italy	RCT split mouth	n=20, M/F=11/9, Mean age/range: 57.6 (45-80)	LI: osteilit II implant (XFOS5/6XX, Zimmer Biomet) SI: Long external hex implant (NXFOS5/6XX, Zimmer Biomet) n=83, SI=39 LI=44 SI: Lth=6 mm, Dia=4 mm LI: Lth=10 mm, 11.5 mm, 13 and 15 mm. Dia=4 mm	A resorbable collagen membrane (Osseo Guard Flex, Zimmer Biomet) RBH=5-7 mm RBH=5-7 mm, lateral window technique	3 years 2 patients dropped
Pohl V <i>et al.</i> , 2017	Multicentre RCT	n=101, SI=50, LI=50 SI: M/F=29/21, LI: M/F=23/28 Smokers: SI=18, LI=28 Mean age/range: 50.4 (20-77) SI=50±14.05 (23-76) LI=51±12.8 (20-77)	ASTRA TECH Implant System sinus was grafted using a xenograft (Bio-Oss™ Sirona Implants, Mölndal, Sweden n=124, SI=60, LI=64 SI=Lth/Dia=6/4, LI=11-15/4 SI: 1 implant=34, multiple=16 LI: 1 implant=36, multiple=15	Sinus was grafted using a xenograft (Bio-Oss™ Granules, Geistlich, Switzerland that could be mixed with local bone chips collected during preparation of the lateral sinus approach (Safescraper Twist, CGM S.p.A., Divisione Medical Meta, Italy) RBH=5-7 mm	3 years LI=2 SI=1
Esposito M <i>et al.</i> , 2015 Sweden	Pilot RCT multicentre	n=28, SI: M/F=11/4, LI: M/F=5/8/mean age/range SI=52 (29-65), LI=56 (41-65) SI=4 moderate smoker, LI=1 moderate smoker	ExFeel (MegaGen Implants, Gyeongbuk, South Korea). n=178, SI=86, LI=92 SI=Lth/Dia=7.6/4.44 mm LI=Lth/Dia=11.6/4.07 mm	Collagen resorbable barrier (OsteoBioIR, Tecnos) from equine pericardium: lateral window technique RBH=5-9 mm	1 year LI=2
Pistilli R <i>et al.</i> , 2013 Italy	RCT Spilt mouth, multicentre	n=20, M/F=11/9, Mean age/range: 57.6 (45-80)	LI: osteilit II implant (XFOS5/6XX, Zimmer Biomet) SI: Long external hex implant (NXFOS5/6XX, Zimmer Biomet) n=83, SI=39 LI=44 SI: Lth=6 mm, Dia=4 mm LI: Lth=10 mm, 11.5 mm, 13 mm, and 15 mm. Dia=4 mm	A resorbable collagen membrane (Osseo Guard Flex, Zimmer Biomet) RBH=5-7 mm RBH=5-7 mm, lateral window technique	1 year LI=1
Pistali R <i>et al.</i> , 2013 Italy	RCT parallel multicentre	n=40, SI=20, LI=20 Mean age/range: SI=61.1/45-70 LI=58.5/44-75 moderate smoker=7	ExFeel (MegaGen Implants, Gyeongbuk, South Korea) n=73, SI=36, LI=37, SI=length 5 mm, Dia=6 mm, and LI=length=10-13 mm, Dia=4 mm	Collagen resorbable barrier (OsteoBioIR, Tecnos) from equine pericardium: lateral window technique RBH=4-6 mm	1 year
Esposito M <i>et al.</i> , 2011 Sweden	Pilot RCT split mouth	n=15 M/F=9/6 Mean age/range=56 (45-70) Moderate smoker=2, heavy smoker 1	Megagen rescue n=72, SI=34, LI=38, Length: SI=5 mm, LI=12.4, Dia=6 mm for both implant Torque <25 Ncm	Granular Bio-Oss with Bio-glide barrier. Lateral window technique RBH=4-6 mm	1 year
Felice P <i>et al.</i> , 2015 Italy	RCT parallel	n=20, SI: M/F=3/7, LI: M/F=5/5 Mean age/range: SI: 53.4 (43-67), LI: 58.6 (48-70) Smokers: SI=1 moderate 3 heavy LI=5 moderate	LI: osteilit II implant (XFOS5/6XX, Zimmer Biomet) SI: Long external hex implant (NXFOS5/6XX, Zimmer Biomet) n=36, SI=16, LI=18 SI with 1 implant=4, a and SI with two implant=6. LI with one implant=2, LI with two implant=8. SI with 5 mm length=10 and SI with 6 mm length=6. LI with 10 mm length=18. Dia for both implant group=5 mm	A resorbable collagen membrane (Osseo Guard Flex, Zimmer Biomet) RBH=5-7 mm	1 year LI=3 SI=1
Bolle C <i>et al.</i> , 2018 France	RCT parallel	n=40, M/F=19/21 SI: M/F: 7/13 LI: M/F: 12/8 Mean age/range LI: 56.40 (36-71) SI: 60.75 (25-77)	Twinkon, universal SA2, global ID: long tapered transmucosal implant n=78 SI: 37, LI: 41 SI Lth: 4 mm Dia (4 mm=31, 4.5=6). LI: Lth (10 mm=15, 11.5 mm=24, 13 mm=2) Dia (4 mm=41) torque <25 Ncm	Osteo-Biol, Gen -os, Tecnos: A mixture of cancellous and cortical collagenated porcine-derived granular bone Osteotomy approach RBH=4-5 mm	1 year
Gulje FL <i>et al.</i> , 2014 The Netherlands	RCT Multicentre	n=41, M: 20 F: 21 SI: 21, LI: 20 Mean age/range SI: 50/30-71 LI: 48/29-72	Osseospeed 4.0 s, Dentsply implants, Moindal, Sweden SI=21, L=6 mm, LI=19, L=11 mm Dia was 4 mm for both groups	Bio-Oss granular Geistlich, Wolhusen, Switzerland/ lateral window RBH=6-8 mm	1 year LI=1

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Table 3: Contd...

Author, year, country	Design	Sampling	Implant brand dimension	Sinus graft, sinus surgery approach RBH	Follow up
Schincaglia G <i>et al.</i> , 2018 Switzerland	Multicentre RCT	$n=101$, SI=50, LI=50 SI: M/F=29/21, LI: M/F=23/28 Smokers: SI=18, LI=28 Mean age/range: 50.4 (20-77) SI=50±14.05 (23-76) LI=51±12.8 (20-77)	ASTRA TECH Implant System sinus was grafted using a xenograft (Bio-Oss™ Sirona Implants, Mölndal, Sweden) $n=124$, SI=60, LI=64 SI=Lth/Dia=6/4, LI=11-15/4 SI: 1 implant=34, multiple=16 LI: 1 implant=36, multiple=15	sinus was grafted using a xenograft (Bio-Oss™ Granules, Geistlich, Switzerland that could be mixed with local bone chips collected during preparation of the lateral sinus approach (Safescraper Twist, CGM S.p.A., Divisione Medical Meta, Italy) RBH=5-7 mm	1 year LI=2 SI=1
Zhang XM <i>et al.</i> , 2017 China	A pilot RCT parallel	$n=56$, SI: 6 mm, M: 6, F: 12 SI: 8 mm, M: 7 F: 8 LI: 10 mm, M: 13, F: 10 Mean Age SI: 6/8:37.5/42.6 LI: 33.5	Straumann AG, Basel Switzerland $n=56$ SI (6 mm): Dia=4.1/4.8=7/6 SI (8 mm): Dia=4.1/4.8=6/9 LI (8 mm): Dia=4.1/4.8=16/7	No ridge augmentation Implant placement done by using modifies summers OSEF technique	9 months
Esposito <i>et al.</i> , 2016 Sweden	RCT parallel	$n=40$, SI/LI=19/21 Mean age/range SI=60.75 (20-75), LI=56.70 (36-71)	Twinkon Universal SA2 (Global D) $n=78$, SI=37, LI=41 Lth/Dia: SI=4/4 mm, LI=10,11.5,13/4 mm	Porcine particulate bone graft Lateral window approach RBH=4-5 mm	4 months
Felice P <i>et al.</i> , 2012 Italy	RCT parallel	$n=40$, SI: M/F=5/15, LI=10/10 Mean age/range LI=58.5 (45-75), SI=61.1 (45-70) Smoker: SI/LI=6/1	ExFeel, MegaGen Implant Co., Gyeongbuk, South Koreaa, a novel nanostructured calcium incorporated titanium surface (Xpeed) sanded with hydroxyapatite particles $n=73$, SI=36, LI=37 Lth/Dia: SI=5/5 mm, LI=11.9/5 mm	Collagenated porcine bone, lateral window approach RBH=4-6 mm	4 months
Felice P <i>et al.</i> , 2009 Italy	Split-mouth RCT	$n=15$, M/F=9/6 Mean age/range=56 (45-70) 1 heavy and 2 light smoker	ExFeel, MegaGen Implant Co., Gyeongbuk, South Korea $n=72$, SI=34, LI=38 Lth/Dia: SI=5/5, 10.4/5 mm Implant surface blasted with hydroxyapatite particles	Granular Bio-Oss with restorable Bio glade barrier Lateral window approach RBH=4-6 mm	4 months
Felice P <i>et al.</i> , 2011 Italy	RCT parallel	$n=28$, SI: M/F=11/4, LI=5/8 Mean age/range SI=52 (29-65), LI=56 (41-65) Smokers: SI=4, LI=1	ExFeel, MegaGen Implant Co., Gyeongbuk, South Korea $n=178$, SI=86, LI=92 Lth/Dia: SI=5, 6, 7, 8, 8.5/4, 5, 6, 7 mm LI=10, 11.5, 13/4, and 5 mm	Autogenous bone graft from iliac crest with rigid restorable barrier (Llion GTR Biodegradable Membrane System, Llion, Tampere, Finland). Lateral window approach RBH=5-9 mm	4 months

SI: Short implant, LI: Long implant, Lth: Length, Dia: Diameter, RBH: Reduced bone height, RCT: Randomized controlled trial, M/F: Male/female

the autogenous bone graft (iliac crest). Three studies.^[45,53,61] has reported the C/I ratio.

Risk of bias is specified with Tables 1 and 2. The eleven studies^[45,49-54,57-60] were assigned as a high risk and seven studies^[46-48,50,55,61,62] were assigned as an unclear risk for detection bias because the investigator who has given the responsibility to do clinical and radiographic analysis could be easily identified the augmented site due to different implant length and rest of the seven studies show unclear bias as independent examiner perform the clinical and radiological assessment. Two studies^[50,62] show the unclear selection bias as not clearly mentioned about the random sequence generation. Two studies^[50,62] were reported for allocation concealment bias as the studies did not mention the eligible patient consent, opening of opaque sealed

envelope and allocation of the patient to the respective surgeon. One study^[46] shows a high risk for attrition bias as 11 patients dropped during follow up period and five studies show unclear bias as dropped of 2-3 patients per study. The reporting bias specifically related to two studies^[48,53] in that one study reported selectively the implant thread geometry^[50] and other study explained selectively the significance of platelet rich plasma.^[48] Remaining five studies^[56,63-66] were reported low risk for all bias. Funnel plot shows the symmetrical distribution of the studies, indicating the absence of publication bias [Figures 2-4].

Outcome variables

ISR was calculated as a failure rate of the implant within the specified follow-up period mentioned with the individual study. Two studies^[45,46] with 5 years follow-up period

Table 4: Outcome variables of comparative studies of short implant and long implant with sinus graft

Comparative studies	Survival rate (%)	Marginal bone resorption (mean±SD)	Biological complication (n)	Prosthetic complication	Patient satisfaction	C/I ratio
Thoma <i>et al.</i> , 2018	SI=98.5 LI=100	SI=0.54±0.87 mm LI=0.46±1.00	SI=5 LI=9	SI=6 LI=7	Equal satisfaction to SI and LI	SI=1.86±0.23 LI=0.99±0.17
Felice P <i>et al.</i> , 2019	SI=94.87 LI=100	SI=1.93 (±0.54) LI=2.28 (±0.46)	SI=1 LI=5	SI=1 LI=0	For short implant	NM
Esposito M <i>et al.</i> , 2014	SI=91.2 LI=97.3	SI=1.36 (±0.53) LI=1.74 (±0.37)	SI=4 LI=1	SI=3 LI=0	NM	NM
Taschieri S <i>et al.</i> , 2017	SI=100 LI=100	SI (MD)=0.91 (±1.22)/0.94 (±1.43) LI=1.15 (±0.68)/1.06 (±0.70)	SI=0 LI=0	SI=0 LI=0	For short implant	NM
Gastaldi G, <i>et al.</i> , 2017	SI=100 LI=100	SI=0.89 (±0.25) LI=1.08 (±0.29)	SI=0 LI=1	SI=2 LI=0	NM	NM
Bechara S <i>et al.</i> , 2017	SI=100 LI=95.5	S=0.20 mm (±0.28) L=0.27 mm (±0.38)	SI=0 LI=19	SI=0 LI=0	For short implant	NM
Gastaldi G <i>et al.</i> , 2018	SI=94.73 LI=100	SI=1.04 (±0.34) LI=1.43 (±0.53)	SI=2 LI=6	SI=0 LI=0	For short implant	NM
Felice P <i>et al.</i> , 2018	SI=94.8 LI=100	SI=1.28 (±0.37) LI=1.50 (±0.37)	SI=1 LI=5	SI=1 LI=0	NM	NM
Pohl <i>et al.</i> , 2017	SI=100 LI=100	SI=0.44 (±0.44) LI=0.45 (±0.55)	SI=0 LI=0	SI=10 LI=3	NM	SI=1.86±0.23 LI=0.99±0.17
Esposito M <i>et al.</i> , 2015	SI=98.83 LI=97.82	SI=1.05 (±0.20) LI=1.01 (±0.16)	SI=0 LI=3	SI=0 LI=0	Short implant	NM
Pistilli R <i>et al.</i> , 2013 Italy	SI=97.2 LI=100	SI=1.16 (±0.30) LI=1.53 (±0.59)	SI=0 LI=5	SI=1 LI=0	NM	NM
Pistali R <i>et al.</i> , 2013	SI=100 LI=100	SI=1.41 (±0.31) LI=1.53 (±0.55)	SI=0 LI=4	SI=0 LI=0	NM	NM
Esposito M <i>et al.</i> , 2011	SI=98.33 LI=98.33	SI=0.79 (±0.56) LI=1.16 (±0.46)	SI=3 LI=1	NA	NM	NM
Felice P <i>et al.</i> , 2015	SI=100 LI=100	SI=0.78 (±0.16) LI=0.95 (±0.24)	SI=0 LI=0	SI=0 LI=0	For short implant	NM
Bolle C <i>et al.</i> , 2018	SI=91.89 LI=82.92	SI=0.51 (±0.04) LI=0.72 (±0.04)	SI=4 LI=9	SI=1 LI=5	NM	NM
Gulje FL <i>et al.</i> , 2014	SI=100 LI=100	SI=0.1 (±0.2) LI=0.1 (±0.3)	SI=0 LI=0	NM	Equal for SI and LI	NM
Schincaglia G <i>et al.</i> , 2018	SI=98.6 LI=97	SI=-0.22 (±0.3) LI=0.59 (±0.37)	NM	NM	NM	SI=1.86±0.23 LI=0.99±0.17
Zhang XM <i>et al.</i> , 2017	SI=100 LI=100	NM	SI=0 LI=0	SI=0 LI=0	Equal for SI and LI	NM
Esposito <i>et al.</i> , 2016	SI=85 LI=75	SI=0.48 (±0.12) LI=0.50 (±0.13)	SI=0 LI=0	SI=0 LI=0	NM	NM
Felice P <i>et al.</i> , 2012	SI=97.22 LI=100	NM	SI=0 LI=5	SI=1 LI=0	NM	NM
Felice P <i>et al.</i> , 2009	SI=97.05 LI=100	NM	SI=3 LI=1	SI=0 LI=0	NM	NM
Felice P <i>et al.</i> , 2011	SI=97.67 LI=98.91	NM	SI=0 LI=8	SI=0 LI=0	NM	NM

SI: Short implant, LI: Long implant, NM: Not mentioned, MD: Mean difference, C/I: Crown-implant

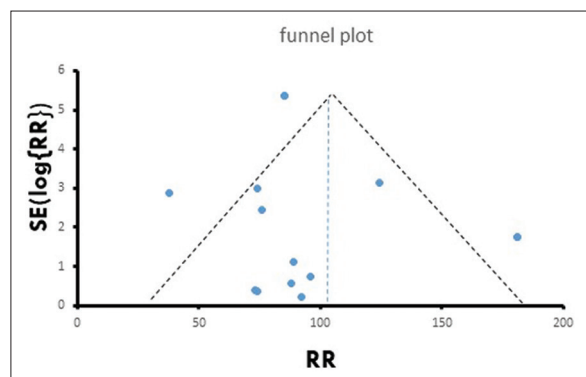


Figure 2: Funnel plot for implant survival rate at patient level

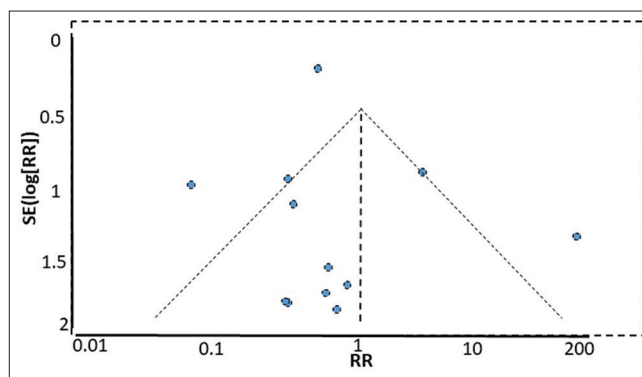


Figure 3: Funnel plot of implant survival rate at implant level

reported 100% survival rate for conventional long implant. In contrast, short implant reported marginally lower

ISR for the same group (at patient level: RR = 2.8 95% CI = 0.3–29.78 P = 0.3, I² = 0%, at implant level: RR = 4.1,

95% CI = 0.4–39.64 $P = 0.1$, $I^2 = 0\%$). Studies^[47-53] with 3 years follow-up period were reported no significant difference between short and long implant (at patient level: RR = 1.3, 95% CI: 0.3–5.6, $P = 0.6$, $I^2 = 0\%$, at implant level: RR = 1.8, 95% CI = 0.5–7.1, $P = 0.3$, $I^2 = 0\%$). Three studies^[48,49,53] were reported 100% ISR for both short and long implant group. The two studies^[51,52] showed 100% ISR for long implant and one study^[50] showed 100% ISR for short implant. The three studies^[48,51,52] reported marginally lower ISR for short implant except one study showed marginally lower ISR for long implant.^[50] Similarly,

there is no significant difference between short and long implant for the studies^[54-61] with 1 year follow-up period (at patient level: RR = 0.83, 95% CI = 0.3–1.8 $P = 0.6$, $I^2 = 0\%$, at implant level: RR = 0.8 95% CI = 0.4–1.7 $P = 0.6$, $I^2 = 0\%$). Two studies reported^[58,60] 100% ISR for both short and long implant, three studies^[54,59,61] reported marginally lower ISR for long implant, except, one study^[56] showed marginally lower ISR for short implant, and one more study^[57] however, reported equal survival rate for both short and long implant group. In <1 year, only one study^[62] showed 100% ISR for both groups, three studies^[64-66] reported marginally lower ISR for short implant and one study^[63] showed lowest survival rate among the all the groups, however ISR was lower for long implant. Eventually, the meta-analysis [Tables 5 and 6] reported statistically no significant difference in ISR for both short and conventional long implant with sinus augmentation placed for the rehabilitation of posterior atrophic maxilla (at patient level: RR: 1.01, 95% CI = 0.52–2.0, $P = 0.87$, $I^2 = 0\%$, at implant level RR = 1.09, 95% CI = 0.6–2.0, $P = 0.7$, $I^2 = 0\%$). There is no significant difference in ISR for both short and long implant in relation to small to wider diameter of implant (>5 mm).

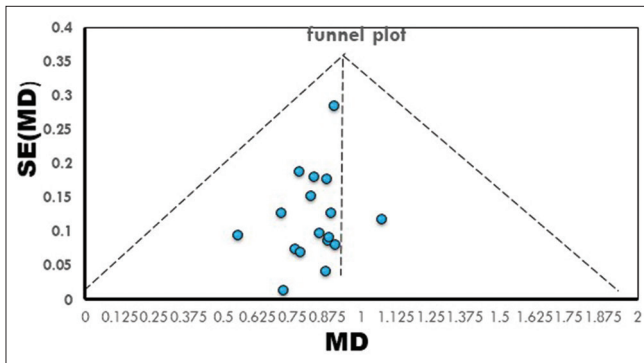


Figure 4: Funnel plot marginal bone resorption

Table 5: Forest plot of implant survival rate of short implant and long implant at patient level

Studies	RR	95% CI (lower-upper)	Effect weight
Thoma 2018	3.1452	0.1278-80.0305	3.4733
Felice 2019	5.3571	0.2624-120.9129	3.8293
Esposito 2014	2.4561	0.3642-18.6182	9.3051
Bechara 2017	0.2087	0.0093-4.2828	3.8353
Gastaldi 2018	2.8636	0.1153-78.0416	3.391
Felice 2018	5.3571	0.2624-120.9129	3.8293
Esposito 2015	1.7603	0.2305-13.7804	8.607
Pistilli 2013a	3	0.1216-78.1422	3.4452
Esposito 2011	1.1111	0.1108-11.2351	6.7517
Bolle 2018	0.5577	0.1348-1.9791	19.9514
Esposito 2016	0.7295	0.1718-2.8875	18.085
Average	0.3514	0.0135-8.6825	3.4452
Felici 2012	0.3514	0.0135-8.6825	3.4452
Felici 2011	1.7603	0.2305-13.7804	8.607
Felici 2009	0.381	0.0147-9.4358	3.4

RR: Relative risk, CI: Confidence interval

Table 6: Forest plot of implant survival rate of short implant versus long implant at implant level

Studies	RR	95% CI (lower-upper)	Effect weight
Thoma 2018	3	0.1219-0.1216	3.4773
Felice 2019	5.3571	75.9904-78.1422	3.8288
Esposito 2014	2.4561	0.2624-0.0971	9.3039
Bechara 2017	0.2087	120.9129-9.783	3.8348
Gastaldi 2018	2.7143	0.3642-0.1348	3.381
Felice 2018	5.3571	18.6182-1.9791	3.8288
Esposito 2015	1.7603	0.0093-0.1718	8.6059
Pistilli 2013a	3	4.2828-2.8875	3.4447
Esposito 2011	0.9756	0.1089-0.0135	6.7688
Bolle 2018	0.5577	74.3793-8.6825	19.9489
Esposito 2016	0.7295	0.2624-0.2305	18.0827
Average	0.3514	120.9129-13.7804	3.4447
Felici 2012	0.3514	120.9129-13.7804	3.4447
Felici 2011	1.7603	0.2305-0.0147	8.6059
Felici 2009	0.381	13.7804-9.4358	3.4436

RR: Relative risk, CI: Confidence interval

Marginal bone resorption

There are 18 studies^[46-61,63] included for MBR, as the four studies^[62,64-66] did not report the MBR due to follow up period was <9 months except one study^[63] showed MBR with follow-up period was <6 months. The reported mean difference of MBR for the studies^[43-46] with 5 years follow-up period was higher for long implant (MD: = 3.5, 95% CI: -0.57-0.27, $P = 0.1$, $I^2 = 61.53\%$). The reported mean of MBR for the studies with 5 years follow-up was 0.54 mm and 1.93 mm for short implant and 0.46 mm and 2.28 mm for long implant. The mean difference for 3 years follow up study was reported no significant difference for short implant and long implant (MD = 0.15, 95% CI = -0.24-0.06, $P = 0.00$, $I^2 = 91.30\%$) The average of the means of MBR for the studies^[47-53] with 3 years follow up is 1.01 mm (range 0.20 mm-1.36 mm) for short implant and long implant 1.08 mm (range 0.27-1.74 mm). Similarly, marginally lower MBR for short implant (MD = 0.16, 95% CI = 0.27-0.05, $P = 0.00$, $I^2 = 86.09\%$) the average of means of the studies^[54-61] with 1 year follow-up is 0.75 mm (range 0.1-1.16) for short implant and long implant 0.94 mm (range 0.1-1.53 mm). There are five studies with follow-up <1 year, but only one study^[63] reported the MBR, i.e., 0.48 mm for short implant and 0.50 for long implant, remaining four studies do not report the MBR due to follow-up was <6 months. The combined result of 18 studies [Table 7] reported no significant difference in MBR for both short implant and conventional long implant (MD = 0.16. 95% CI: -0.23--0.08, $P = 0.00$, $I^2 = 74.83\%$).

Biological complication

Fourteen studies^[45-47,49-52,54-57,59,64-66] reported the biological complications and among them, seven studies showed biological complications associated only with long implant.

Short-term complications are pain, swelling, infection hematoma, and bad taste breath. Long-term complications are bleeding on probing, graft failure, peri-implant mucositis, and implant failure. Nine studies reported the sinus membrane perforation, and two studies reported implant dislodged into the maxillary sinus, four studies show long-term peri-implant mucositis and three studies reported bleeding on probing, pocket depth, and plaque control record. The augmented group with long implant shows more complications than short implant without augmentation [Table 8] (RR = 0.48, 95% CI = 0.23-0.8, $P = 0.13$, $I^2 = 29.11\%$).

Prosthetic complications

Nine studies^[45-47,49,52,53,55,59,64] reported the prosthetic complications. The listed prosthetic complications are abutment screw fracture, screw loosening, ceramic veneer fracture, debonding, or de-cementation of crown. Short implant reported higher prosthetic complications than conventional long implant [Table 9], (RR = 1.56, 95%CI = 0.85-3.15, $P = 0.43$, $I^2 = 0\%$).

Patient satisfaction (additional analysis)

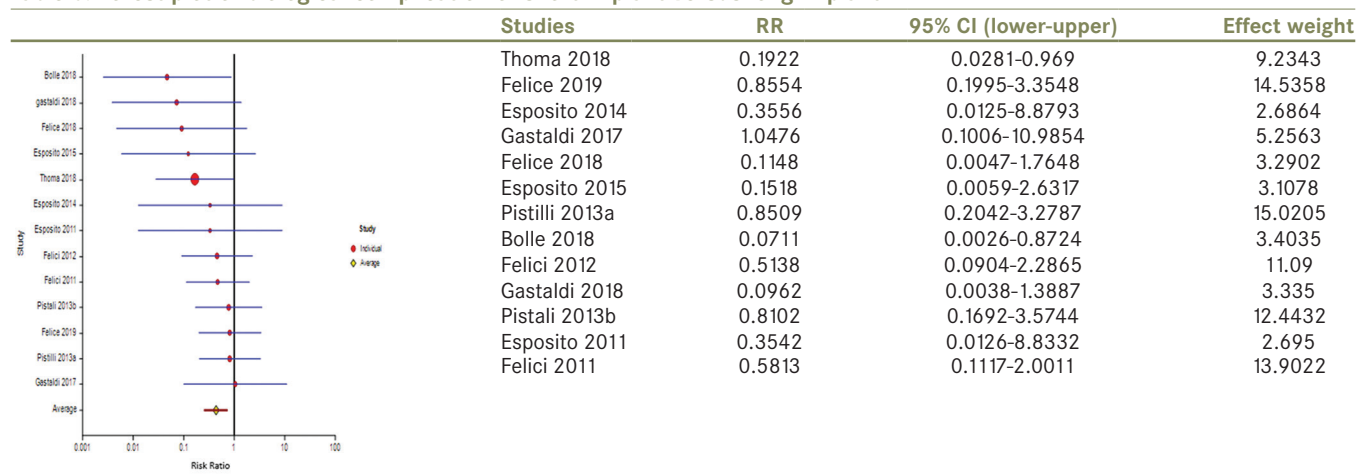
There were Nine studies^[45,46,48,50,51,54,58,60,62] that reported the patient satisfaction, out of that three studies^[45,60,62] reported the patient satisfaction for both short and long implant and six studies^[46,48,50,51,54,58] reported satisfaction for short implant. Thoma *et al.*^[45] used patient-reported outcome measures to record patient satisfaction and equal satisfaction for both short and long implant. Felice *et al.*^[46] reported that 15 patients were satisfied for short implant and five patients showed equal satisfaction for both short and long implant. Taschieri *et al.*,^[48] Bechara *et al.*,^[50] and Guljé *et al.*,^[60] performed questionnaire survey and proposed more satisfaction for short implant. Gastaldi *et al.*^[51]

Table 7: Forest plot of marginal bone resorption of short implant and long implant

Studies	MD	95% CI (lower-upper)	Effect weight
Thoma 2018	0.08	-0.3146-0.4746	2.7787
Felice 2019	-0.35	-0.7122-0.0122	3.2567
Esposito 2014	-0.38	-0.75--0.01	3.209
Taschieri 2017	-0.24	-0.811-0.331	1.5814
Gastaldi 2017	-0.19	-0.4597-0.0797	4.8555
Bechara 2017	-0.072	-0.2596-0.1156	6.3868
Gastaldi 2018	-0.19	-0.3633--0.0167	6.7905
Felice 2018	-0.22	-0.4775-0.0375	4.8764
Pohl 2017	-0.01	-0.2436-0.2236	5.2535
Esposito 2015	0.04	-0.1111-0.1911	7.4518
Pistilli 2013a	-0.37	-0.678--0.062	3.9768
Gulje 2014	-0.12	-0.3181-0.0781	6.175
Esposito 2011	-0.37	-0.7533-0.0133	3.0242
Felici 2015	-0.17	-0.3616-0.0216	6.501
Bolle 2018	-0.26	-0.2864--0.2336	10.0179
Gulje 2014	0	-0.1618-0.1618	7.0923
Schincaglia 2018	-0.37	-0.5062--0.2338	7.6985
Esposito 2016	-0.03	-0.1147-0.0547	9.0741

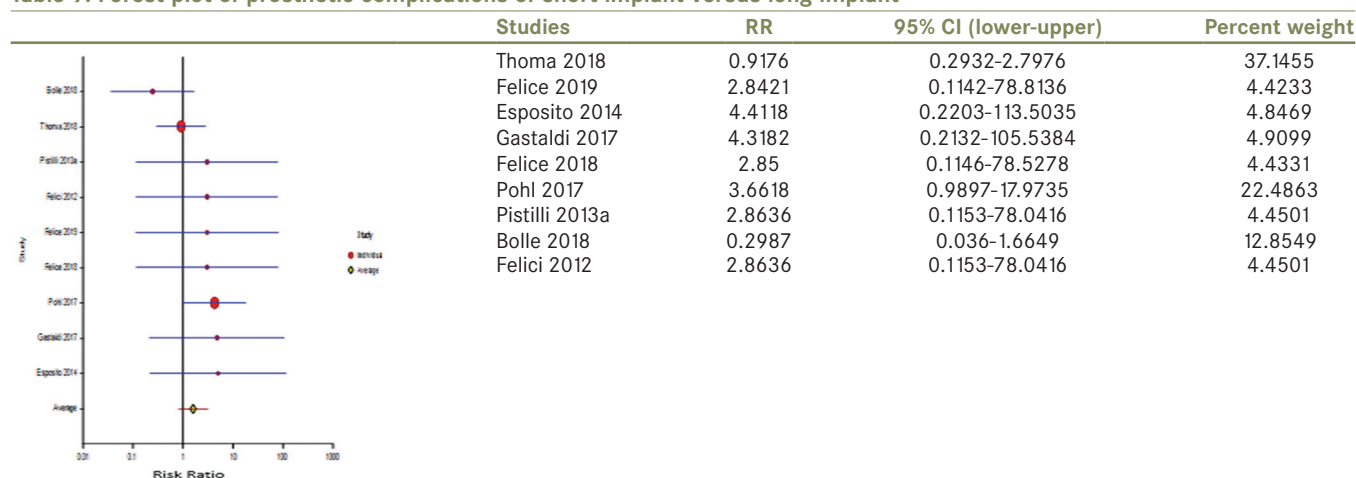
MD: Mean difference, CI: Confidence interval

Table 8: Forest plot of biological complication of short implant versus long implant



RR: Relative risk, CI: Confidence interval

Table 9: Forest plot of prosthetic complications of short implant versus long implant



RR: Relative risk, CI: Confidence interval

used functional and esthetic criteria and reported equal satisfaction for both short and long implant and Zhang *et al.*, evaluated by using postoperative clinical symptoms and reported more satisfaction for short implant.

DISCUSSION

The present review combined the results of 22 RCTs (maximum follow-up is 60 months and minimum follow-up is 120 days) with 704 participants and 1595 implants and synthesized the information of outcome variables. There was no difference of outcome variables between short and conventional long implants with sinus graft. The synthesized information derived from outcome variables are discussed in the following way.

Implant survival rate

The analysis (patient level and implant level) of ISR reported that out of 22 trial 7 studies showed 100% survival

rate. There was 21 (36.52%) short implant and 20 (41.75%) long implant failed to osseointegrate. At the patient level, 15 (27.93%) patients with short implant and 14 (27.85%) patient with long implant showed failure. It is concluded that there is no significant difference of ISR in both short and long implant. The finding of the present review was similar to the previous systematic review.^[36,37] However, the previous review recorded the ISR at the patient level, but the multiple failure of implant in one patient was recorded as a one.^[67] Hence, the present review implemented both the methods to calculate ISR.

It is kind to measure the factors that improve the survival rate of short implant. In the past, Misch^[68] and Lekholm *et al.*^[69,70] reported that high failure of short implant <10 mm in posterior maxilla due to the porous bone and greater biting strength. The significant factor noticed by the present review is the surface coating or textured surface of the implant. The surface coating

on the implant is vary from the roughened grit-blasted surface.^[46] Sandblasted surface (optima),^[47,48] sand-blasted and acid-etched surface, hydroxyapatite coating, calcium incorporated hydroxyapatite coating, nanostructured calcium incorporated titanium surface (Xpeed)^[64] sanded with hydroxyapatite particles. Straumann (SLActive).^[62] The remarkable feature of rough surface implant that it increases the bone-implant contact and initial stability,^[71] thereby, it promotes the osteoconduction,^[72] contact osteogenesis, and rapid osseo-integration.^[73] It offers greater torque resistance.^[74] and the stress transformation from implant to bone is influenced by surface roughness.^[75] The combination of nanostructured calcium surface and hydroxyapatite surface enhances rapid protein adhesion and subsequent osteoprogenitor cell attachment, proliferation, differentiation, and spreading.^[64] The hydrophilic implant (SL active Straumann) increases the bone-implant contact and achieved initial stability during the healing period.^[62,76] Implant hydrophilic surface possess high surface energy that improves bone regeneration and clot stabilization.^[62,76] Bechara *et al.*^[50] proposed in his investigation that implant thread geometry influences the primary stability as it increases the surface area and bone-implant contact. The thread depth distance has a partial impact on the surface area. The sharp – square-shaped thread deigned used in the study offers greater resistance to compressive and minimize share force. Taschieri *et al.*^[48] investigated Platelet-rich fibrin (PRF) as a liquid form applied before the placement of short implant, which was already sandblasted. The author assumed that it increases the biological activity and proliferation and differentiation of osteoprogenitor cells as well as osteoblast. Bechara *et al.*^[50] reported that both short and long implants achieved acceptable implant stability (>58 IQ). A similar observation was also made by Zhang *et al.*,^[62] in that implant stability was measured 69.76 + 6.24 mean/standard deviation (SD) implant stability quotient (ISQ) for short implant (6 mm), 66.99 + 5.93 mean/SD ISQ for short implant (8 mm) with osteotome sinus floor elevation (OSFE) and 77.72 + 4.95 mean/SD ISQ for long implant (10 mm) with OSFE at initial implant placement. There was no significant difference between short and long implant at initial implant stability. Eventually, the review observed that the reason of the failure of earlier short Brenamark type implant was due to minimally rough surface of pure titanium machined turned implant, that does not produce even and less bone-implant contact and offers less resistance to horizontal forces.^[77-79] The long-term data proposed by Thoma *et al.* (2018)^[45] and Felice P (2019)^[46] reported a predictable survival rate of the short implant. The review observation was further supported by a Lee *et al.*,^[80] the

author claimed that a sand-blasted, large-grit, acid-etched surface of the implants, submerged subcrestally produces excellent survival rate of 98.3% at posterior maxilla. Similarly, Hagi *et al.*^[81] was also highlighted the implant thread geometry and its significance to the primary stability of the implant. The survival rate reported by Resonance frequency testing does not show a significant difference between short and long implant. Eventually, it has been proved histologically, that bone implant contact was more favourable on the rough surface implant in contrast to the smooth surface implant.^[82]

Marginal bone resorption

It is second criterion that predicts valid alternative approach to long conventional implant for the rehabilitation of posterior atrophic maxilla. There were 18 studies^[45-61,63] included for the meta-analysis. There was no significant difference in MBR for both short and long implant. However, the MBR was less for short implant marginally. Esposito *et al.*^[47] and Esposito *et al.*^[57] reported higher bone resorption for long implant. The factors which influence on MBR are implant diameter and crown implant ration at implant level and bone density, submerged healing at the tissue level and patient smoking habit. The implant diameter mentioned in the review was ranged from 3.7 mm to 8 mm, majority of the studies were used the diameter between 4 and 6 mm except Bechara *et al.*^[50] was used 8 mm diameter implant. The present review, findings of MBR between short diameter implant and long diameter implant does not show any significant difference. Bechara *et al.*^[50] reported the negative correlation between implant diameter and MBR. The proportionate increase in the diameter to compensate the length of the implant does not show much benefit as the osseointegration already occurred before the prosthetic loading.^[83]

The C/I ration in the present review only three studies^[45,53,61] recorded C/I ratio. However, the radiographic appearance presented in the studies observed more C/I ratio for short implant, but there was no significant difference in bone resorption between short and long implant. A similar observation was also mentioned by the studies^[45,53,61] that recorded C/I ratio. Hence, both the short and long implant satisfy the Albrektsson criteria of bone resorption.^[84] The retrospective cohort findings regarding C/I ratio reported the range of C/I was 0.5:1–3:1. The mean C/I ratio of implants in function was 1,3:1 and the mean C/I ratio on failed implants was 1,4:1.^[85] Increasing the length of the implant to compensate the crown height does not show much influence on stress distribution, as the angle of the implant generates the magnitude of the stress at the peri-implant crest area, more the pronounced

implant angle, greater will be the bone resorption and the diminishing toward the implant apex.^[86] Photo-elastic analysis reveals that crown space is more significant than C/I ratio.^[87] Moreover, increase implant length corresponds to increase crown height result will be more prosthetic complications, due to increase lever arm.^[88]

Bone density is the well-established evidence for primary implant stability. However, the bone at posterior maxillary ridge has more cancellous marrow and less trabecular portion of bone.^[89] The review mentioned the height of the remaining bone was ranges from 4 to 9 mm. The justification of short implant is more viable in type IV bone density^[90] as the cancellous bone offers rapid modeling, due to highly vascularized and less fatty marrow.^[91] The rough surface implant along with adaptive remodelling of cancellous bone produces radiographic density and achieved implant initial stability.^[92,93] Finite element analysis observations confirm the fact that short implant induces more stress on trabecular bone; therefore, more density changes occurred at short implant.^[94] Increasing the length of the implant generate more off the vertical force and produces more bone resorption.^[89]

Submerged healing of the implant is the contributing factor to prevent the crestal bone resorption. In the present review all the short implants were placed subcrestally along with surface textured collar produces more thickening of the crestal collar and significantly less bone resorption than the implant placed at crestal level or machined turned polished collar of past implant.^[95] Bechara *et al.*^[50] mentioned that maximum stress at implant neck level, hence widens diameter of the implant should contact with (approximately fourth thread) bone crest. In the past, it has been reported that subcrestal placement of the implant reduces crestal bone resorption.^[96] However, 2 mm buccal bone should be there to improve the overall effect of submerged healing.^[97] there is a need of an instrumental method to determine RBH, as current imaging option does not show buccolingual width or angulation of the implant.^[98]

Smoking is a presequel of MBR. The present review reported the participant (101 participants in both groups,) with heavy smoking (>10 cigrate) and moderate smoking (<10 cigrate). However, the studies does not specify the ISR or MBR in the patients with smoking group versus nonsmoking group. Nevertheless, smoking produces avascular necrosis as the nicotine is the potent vasopressin.^[99] Other effect of smoking is compromised the implant healing at first stage. The low survival rate of implant in smokers than nonsmokers.^[100]

The biological complications were highlighted that the placement of short implant is less invasive as compared to long implant, therefore complications reported by the review is less for short implant. However, meta-analysis reported no difference in complications between short and long implant. The more pronounced immediate postoperative complication reported with present review is sinus membrane perforation in long implant with sinus graft. Other self-limiting complications are pain, infection, swelling, hematoma, and bad taste breath. However, few studies reported short implant dislodgement into sinus cavity. The long-term complications are bleeding-on-probing, plaque control, peri-implant mucositis, and graft failure.

Prosthetic complications are slightly higher for short implants. Nine studies reported the prosthetic complications. Minor chairside complications are ceramic veneer chipping or fracture, debonding or decementation of crown. Abutment screw loosening or fracture was more troublesome complication.

Biological and prosthetic complications are not significant while determining the status of short implant. It was difficult to calculate baseline scores for complications, since the complications differ with individual patients.

Patient satisfaction was prominently associated with short implant. Since, the less surgical time required for the placement of short implant, low cost, less time required for the placement short implant and prosthetic loading as compared to long implant with sinus graft, moreover, there should be no contact of prosthesis during graft healing period again create the problem of mastication and aesthetic.

The present review covers maximum number of RCTs. The many studies are head-to head RCT that compared the short implant versus long implant with sinus graft. The review comprises maximum number of implant analysis. All the authors were participated to evaluate the risk of bias within and across the study and outcome variables. The evidence proposed by the review is moderate quality. The selection of short implant at posterior atrophic maxilla when RBH show radiographically 4–8 mm is the predictable alternative to sinus graft. The surface treatment or moderately textured short implant with submerged healing enhances the implant stability, increase ISR and decrease MBR. However, long-term follow-up with high number of participant is needed to evaluates the ISR and MBR of ultrashort implant (4 mm).

CONCLUSION

The systematic review and meta-analysis proposed following conclusion, within the limitation of the study included in the review.

1. There is no statistically significant difference between short and conventional long implant with sinus graft in relation to implant survival rate, MBR, biological complications and prosthetic complications
2. The surface treatment and topography (rough surface) of short implant improves the stability in type 4 bone and implant survival rate
3. Submerged healing with rough implant collar reduces the MBR with short implant
4. Biological and prosthetic complications are self-limiting and can be eliminated by proper planning.

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Conflicts of interest

There are no conflicts of interest.

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