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Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus (Review)

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[Intervention Review]

Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus

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ABSTRACT

Background

Insufficient bone volume is a common problem encountered in the rehabilitation of the edentulous posterior maxillae with implant-supported prostheses. Bone volume is limited by the presence of the maxillary sinus together with loss of alveolar bone height. Sinus lift procedures increase bone volume by augmenting the sinus cavity with autogenous bone or commercially available biomaterials, or both. This is an update of a Cochrane review first published in 2010.

Objectives

To assess the beneficial or harmful effects of bone augmentation compared to no augmentation when undertaking a sinus lift procedure. Secondly, to compare the benefits and harms of different maxillary sinus lift techniques for dental implant rehabilitation.

Search methods

We searched the Cochrane Oral Health Group's Trials Register (to 17 January 2014), the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2013, Issue 12), MEDLINE via OVID (1946 to 17 January 2014) and EMBASE via OVID (1980 to 17 January 2014). There were no language or date restrictions on the searches of the electronic databases.

Selection criteria

Randomised controlled trials (RCTs) of different techniques and materials for augmenting the maxillary sinus for rehabilitation with dental implants that report the outcome of implant success or failure at least to four months after initial loading.

Data collection and analysis

Screening of eligible studies, assessment of the risk of bias of the trials, and data extraction were conducted independently and in duplicate. Authors were contacted for any missing information. Results were expressed using fixed-effect models as there were either less than four studies or we used Peto odds ratios (ORs) for dichotomous data when there were zero cells in either the treatment or control or both arms and the number of trials was small. The statistical unit of the analysis was the patient.

Main results

Eighteen RCTs out of 64 potentially eligible study reports met the inclusion criteria. They compared undertaking a sinus lift with not doing so, and the use of different sinus lift techniques. There were 650 patients providing data for the outcomes evaluated. Five studies were assessed as low risk of bias, 11 were assessed as high risk of bias, and in two the risk was unclear.

Sinus lift versus no sinus lift
Four trials of moderate quality (three trials at low and one at high risk of bias) with 102 participants evaluated short implants (5 to 8.5 mm long) as an alternative to sinus lift in bone with residual height between 4 and 9 mm. One year after loading there was insufficient evidence to claim differences between the two procedures for prosthesis failure (OR (Peto) 0.37, 95% confidence interval (CI) 0.05 to 2.68; three trials) or implant failure (OR (Peto) 0.44, 95% CI 0.10 to 1.99; four trials). There was however an increase in complications at treated sites when undertaking the sinus lift (OR (Peto) 4.77, 95% CI 1.79 to 12.71, P value = 0.002; four trials).

Different sinus lift techniques
Fourteen trials with 548 participants compared different sinus lift techniques. Only three comparisons included more than one trial (two trials for each). These were bone graft versus no bone graft, autogenous bone versus bone substitute, bone graft with or without platelet-rich plasma (PRP). There was insufficient evidence to claim a benefit for any of these techniques for the primary outcomes of prosthesis and implant failure. For the other reported outcomes, in a single study at high risk of bias, only bone gain was greater for the bone graft site than the site without a graft six months after augmentation, however this was not significant at 18 or 30 months.

The other comparisons with single studies were rotary versus piezosurgery to open a lateral sinus window, two different bone substitutes, use or not of a membrane to seal the lateral window, one- versus two-stage lateral sinus lift, two-stage granular bone versus one-stage autogenous bone blocks, and crestal versus lateral sinus lift; two trials compared three different crestal sinus lifting techniques: rotatory versus hand malleting (patients preferred rotatory instruments over hand malleting) and hand versus electric malleting. There was no evidence of a benefit for any sinus lift procedure compared to any other for the primary outcomes prosthesis or implant failure.

Authors' conclusions

There is moderate quality evidence which is insufficient to determine whether sinus lift procedures in bone with residual height between 4 and 9 mm are more or less successful than placing short implants (5 to 8.5 mm) in reducing prosthesis or implant failure up to one year after loading. However, there are more complications at sites treated with sinus lift procedures. Many trials compared different sinus lift procedures and none of these indicated that one procedure reduced prosthetic or implant failures when compared to the other. Based on low quality evidence, patients may prefer rotary instruments over hand malleting for crestal sinus lift.

PLAIN LANGUAGE SUMMARY

Interventions for replacing missing teeth: increasing bone thickness at the base of the natural sinus cavity above the upper jaw (maxillary sinus) to augment the maxillary sinus to enable implants

Review question

This review, carried out by the Cochrane Oral Health Group, seeks to determine whether and when it is necessary to increase the thickness of the bone layer at the base of the natural sinus cavity (maxillary sinus) that lies above the upper jaw in order to successfully insert dental implants onto which artificial teeth will be anchored. Also, to find the most effective techniques for doing this.

Background

Missing teeth may cause problems with eating and speaking, and affect how someone looks. Traditionally they have been replaced by loose false teeth (dentures) or bridges fixed between other teeth. Dental implants offer an alternative way of replacing teeth. Implants look like screws; they are made from materials such as titanium, which can fuse with the bone they are placed in (osseointegration) offering a stable base for artificial teeth to be fixed to. However, there needs to be enough depth of bone to successfully insert the implants. Bone thickness towards the back of the upper jaw can sometimes be too thin because of the natural sinus cavity (maxillary sinus) that lies above it. The cavity can also sometimes become larger following tooth loss.

Where the bone is too thin, there are a number of techniques that are used to create a thicker layer of bone at the base of the sinus cavity which are generally known as 'sinus lift' procedures. These methods involve using either bone taken from the patient (autogenous bone) or other materials known as biomaterials, a combination of the two, or sometimes simply using a blood clot as a base for the body to naturally form additional bone.

An alternative to a sinus lift is to use, where possible, short implants (4 to 8.5 mm long).

Study characteristics

The evidence on which this review is based is correct as of 17 January 2014. Eighteen trials with 650 participants were included. Four of the trials, with a total of 102 participants, compared implant-supported prostheses using a sinus lift with prostheses on short implants (5 to 8.5 mm long) without sinus lift. The remaining 14 trials with a total of 548 participants compared different sinus lift techniques.

Key results

There is not enough evidence to show whether sinus lift techniques are more or less successful in reducing the number of failures of dental prostheses (artificial teeth) or dental implants when compared to simply using short implants, up to one year after loading.

However, there is limited evidence that there are fewer complications when short implants are used without surgical lifts. Complications include sinusitis, infection and bleeding, and when bone grafts are taken from the patient complications can also include nerve injury, problems with walking and infection.

Quality of the evidence

The quality of the evidence for whether or not to use a sinus lift procedure was moderate. The evidence for the 14 comparisons of different sinus lift procedures was based on a maximum of two comparisons for each comparison and was low.

Summary of findings for the main comparison. Long implants with augmentation versus short implants without augmentation for replacing missing teeth

Long implants with augmentation versus short implants without augmentation for replacing missing teeth: augmentation procedures of the maxillary sinus

Patient or population: patients with replacing missing teeth
Settings: general and specialist dental practice
Intervention: sinus lift versus no sinus lift

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Short implants	Long implants with sinus lift				
Prosthesis failures subjective assessment Follow-up: median 1 year	**Study population**		**OR 0.37** (0.05 to 2.68)	109 (3 studies)	⊕⊕⊕⊖ **moderate** [1]	
	55 per 1000	**21 per 1000** (3 to 134)				
	Moderate					
	50 per 1000	**19 per 1000** (3 to 124)				
Implant failures Follow-up: median 1 year	**Study population**		**OR 0.44** (0.1 to 1.99)	137 (4 studies)	⊕⊕⊕⊖ **moderate** [1]	
	71 per 1000	**33 per 1000** (8 to 133)				
	Moderate					
	50 per 1000	**23 per 1000** (5 to 95)				
Complications Follow-up: median 1 year	**Study population**		**OR 4.77** (1.79 to 12.71)	137 (4 studies)	⊕⊕⊖⊖ **low** [1,2]	
	43 per 1000	**176 per 1000** (74 to 363)				
	Moderate					

	50 per 1000	**201 per 1000** (86 to 401)

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI)
CI: confidence interval; **OR:** Peto odds ratio

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate
Very low quality: We are very uncertain about the estimate

[1] Downgraded for imprecision (small number of events)
[2] Downgraded for inconsistency (statistical heterogeneity present P value = 0.04, I^2= 64%)

Summary of findings 2. Different sinus lift procedures

Comparison between different sinus lift procedures	
Patient or population: patients with insufficient bone below maxillary sinus **Settings:** dental practice **Intervention:** sinus lift procedure **Comparison:** sinus lift procedure	
Outcomes	**Comments**
Prosthesis failures (at 5 months to 5 years)	Data for prosthetic failures were present for 5 comparisons (all only including 1 small study). There is insufficient evidence to conclude that 1 sinus lift procedure leads to fewer prosthetic failures than another. The comparisons for this outcome were: bone graft versus no bone graft, 2 different bone substitutes, 1- versus 2-stage lateral sinus lift, 2-stage granular bone versus 1-stage autogenous bone blocks, and crestal versus lateral sinus lift
Implant failures (at 5 months to 5 years)	Data for implant failures were present for 8 comparisons (including 1 or 2 small studies). There is insufficient evidence to conclude that 1 sinus lift procedure leads to fewer implant failures than another. The comparisons for this outcome were: bone graft versus no bone graft, autogenous bone versus bone substitute, bone graft with or without platelet-rich plasma (PRP), 2 different bone substitutes, 1- versus 2-stage lateral sinus lift, 2-stage granular bone versus 1-stage autogenous bone blocks, crestal versus lateral sinus lift, and hand versus electric malleting for crestal sinus lifting

BACKGROUND

Description of the condition

Missing teeth may result in a functional and aesthetic deficit and have traditionally been replaced with dentures or fixed prostheses. Dental implants offer an alternative; they are inserted into the jawbones and used to support dental prostheses. Dental implants rely on the maintenance of a direct structural and functional connection between living bone and the implant surface. This is termed osseointegration and was first described by Brånemark (Brånemark 1977). Osseointegration has undoubtedly been one of the most significant scientific breakthroughs in dentistry over the past 50 years.

Insufficient bone volume is a common problem encountered in the rehabilitation of the edentulous posterior maxilla with implant-supported prostheses. The bone available for implant placement may be limited by the presence of the maxillary sinus together with loss of alveolar bone height. Bone volume may be increased by augmentation. Commonly the sinus cavity is augmented with autogenous bone or biomaterials, or both. Procedures are variously described in the literature as sinus lift, sinus augmentation, sinus floor elevation or augmentation of atrophic maxillary sinus.

Implant placement may be combined with sinus augmentation as a 'one-stage' technique. Alternatively sinus augmentation may be carried out some time prior to implant placement as a 'two-stage' technique, which requires an additional surgical episode.

Description of the intervention

Techniques of sinus augmentation (sinus lift)

Boyne described the surgical technique of retrograde sinus augmentation, where in some cases blade implants were placed (Boyne 1980). The technique required a window to be prepared in the vestibular wall of the sinus, and the sinus epithelium was elevated to create a space into which particulate bone from the iliac crest was placed and allowed to heal for about six months or more before placing the implants.

Tatum described five tissue incisions (crestal, palatal, split thickness palatal, vertical and horizontal vestibular), three types of bone access (crestal, buccal wall and Le Forte I), and the use of autogenous bone, allograft and alloplast. In addition, Tatum described sinus augmentation and implant placement as a one-stage and a two-stage technique (Tatum 1986). The technique, known as a lateral window sinus lift, is widely used today and is considered reliable, particularly when autogenous bone is used (Wallace 2003; Del Fabbro 2004).

Summers described a less invasive one-stage technique for sinus floor elevation with simultaneous implant placement, called the osteotome sinus floor elevation. Summers considered it necessary to have at least 6 mm of residual bone to ensure primary stability of the implant. Concave tipped osteotomes of increasing diameter applied via a crestal approach advanced a mass of bone beyond the level of the original sinus floor, elevating the sinus epithelium. Summers combined this procedure with the addition of a bone graft material (Summers 1994). For cases with less than 6 mm residual bone height, Summers proposed a two-stage approach. A bone plug is defined with a trephine and displaced superiorly with the use of a broad osteotome. Hydrostatic pressure elevates the mucosal lining of the sinus. The resultant osteotomy is filled with a bone graft material and the implant placed after a period of healing (Summers 1995).

Cosci modified the crestal approach technique utilising an atraumatic lifting drill to reduce the risk of perforation of the mucosa lining of the sinus and using a one-stage technique with as little as 3 mm of residual bone (Cosci 2000). Bone can be collected with a trephine directly from the osteotomy site, to be used as grafting material; a bone substitute can be used, or the implant tip can hold up the sinus membrane to work as a natural barrier for bone regeneration. While the crestal approach is less invasive, and is a one-stage technique, there are some disadvantages associated with it. The amount of bone which can be gained using a crestal approach is usually less than that obtained with the lateral window technique, and a minimum of 3 mm crestal bone height is generally recommended to stabilize the implant at placement (Cosci 2000).

In order to obtain simultaneous vertical bone augmentation with a sinus lift procedure, Cannizzaro proposed a technique that is a combination of a sinus lift and an onlay graft. Implants are placed in the ulna and bone blocks containing the implants are retrieved with a trephine, inserted into the sinus via a crestal approach, and left protruding occlusally for some millimetres in order to obtain simultaneous vertical bone gain (Cannizzaro 2007).

Materials used in sinus lift procedures

Autogenous bone has long been considered the gold standard (Palmer 2000). Intra-oral donor sites (chin and ramus) are convenient but yield limited volume. Extra-oral donor sites (iliac crest, tibia, ulna, rib and calvarium) increase surgical complexity and are associated with significant (and under-reported) morbidity and scarring. Therefore, alternative grafting materials (bone substitutes) have been developed.

Allografts consist of 'same species' tissue. Cadaveric bone is harvested and various techniques (freeze drying and irradiation) reduce antigenicity. The grafts are then sterilised and supplied by specially licensed tissue banks.

Xenografts consist of 'different species' tissue. Bovine, swine and equine bone predominate. Complete or partial thermo-chemical removal of the organic component eventually creates a mineral scaffold with residual collagen, depending on the preparation procedures used (anorganic).

Alloplasts are synthetic bone substitutes. There are many types classified in terms of porosity as dense, macro-porous, micro-porous, and either crystalline or amorphous. The structure influences performance. Some examples are beta tri-calcium phosphate, bio-active glass, calcium sulphate, etc.

All these graft materials can be delivered in various convenient forms such as bone particles (eventually in streaky gels) or large blocks, can be mixed with autogenous bone, and can be very stable over time or are highly resorbable, depending on their physical characteristics.

Urist discovered that cell-free, decalcified bone implanted into extra-skeletal sites stimulated new bone formation (Urist 1965). The biologically active molecules that are responsible belong to the growth factor B family and are called bone morphogenetic proteins (BMPs) (Valentin-Opran 2002). A number have been discovered

and include growth factors, platelet-rich plasma (PRP) and other molecules. Their use requires a delivery system that mimics the physical properties and release kinetics of bone.

Some authors have proposed sinus augmentation without the use of a graft material, with coagulated blood acting as a scaffold for bone formation. Lundgren proposed maintaining a space by suturing the sinus lining to the lateral wall (Lundgren 2004). The implant apex may be used to support the sinus membrane (Nedir 2006; Hatano 2007; Thor 2007; Sohn 2008; Gabbert 2009; Pjetursson 2009). Some bone regeneration does occur as a result of this procedure though the actual clinical benefit is in doubt since this method was not evaluated against appropriate control procedures.

Alternative techniques to sinus lift

There are some alternative techniques to sinus augmentation that may be possible. Onlay bone grafts may be used for horizontal or vertical augmentation. These procedures are evaluated in another Cochrane systematic review (Esposito 2009).

Implants can also be placed with an angulated direction in order to avoid the maxillary sinus (Aparicio 2001), or even placed trans-sinus (Maló 2013). These implants are called 'tilted' or 'angulated' implants and they can only be used when anatomical conditions permit.

Zygomatic implants offer an alternative to sinus augmentation. Long implants pass through the sinus (Brånemark 2004) or laterally to the sinus into the zygomatic process and can also be loaded immediately (Davò 2013). Zygomatic implants are evaluated in another Cochrane review (Esposito 2013).

Another interesting and simple alternative to sinus lift procedures is the use of short implants (4 to 8 mm long). Current ongoing research is focused on evaluating short implants placed without augmentation, offering the opportunity of a less complex, cheaper and faster alternative to augmentation. There are few randomised controlled trials evaluating the efficacy of short implants both in upper and lower jaws (Cannizzaro 2009; Felice 2009a; Esposito 2011; Felice 2011; Esposito 2012; Felice 2012).

A review of longitudinal studies suggested a failure rate of approximately 10% for implants 7 mm long (das Neves 2006). However, the design of the studies on which this estimate is based suggests that this figure should be viewed with caution as it may represent a gross underestimation. Nevertheless, these figures suggest that shorter implants may have a poorer prognosis than longer ones. Since it is commonly believed that shorter implants (8 mm or less) have a poorer prognosis than longer implants, clinicians place longer implants if bone allows. When bone height is 4 to 8 mm, clinicians must decide whether to augment or place short implants. It is possible that improved implant surface modifications and designs, together with improved surgical techniques, may shift the balance in favour of short implants when the alternative is a more complex augmentation procedure. No reliable evidence of the superiority of currently available surface modifications or designs has been documented so far (Esposito 2007).

Why it is important to do this review

Insufficient bone volumes are a common problem encountered when replacing missing teeth in the maxilla with implant-supported prostheses. Bone volumes are limited by the presence of the maxillary sinuses together with loss of alveolar bone height. If effective, sinus lift procedures will increase bone volume by augmenting the sinus cavity with autogenous bone or commercially available biomaterials, or both. This will allow patients who cannot be rehabilitated with conventional implants due to insufficient bone volumes to receive fixed implant-supported prostheses, improving their quality of life. However, it is still unclear what the minimal bone heights are under which a sinus lift procedure will improve the prognosis of implant-supported prostheses, and there is the risk that augmenting sinuses that do not require it would increase morbidity with no actual benefits for the patients. This is an update of a Cochrane review first published in 2010 (Esposito 2010) that originates from a previous larger review evaluating all types of augmentation procedures for dental implant placement (Coulthard 2003; Esposito 2006a; Esposito 2008).

OBJECTIVES

To assess the beneficial or harmful effects of bone augmentation compared to no augmentation when undertaking a sinus lift procedure. Secondly, to compare the benefits and harms of different maxillary sinus lift techniques for dental implant rehabilitation.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs) including split-mouth studies.

Types of participants

Patients with missing teeth and an atrophic posterior maxilla who may require augmentation of the maxillary sinus prior to or at placement of dental implants.

Types of interventions

Any bone augmentation technique, active agent (such as bone morphogenetic proteins, platelet-rich plasma, stem cells) or biomaterials used together with osseointegrated, root-formed dental implants. When comparing sinus lift procedures with no augmentation procedures, implants can have different dimensions (for instance be shorter and wider), can be placed in an angulated direction, and can be trans-sinus. The use of zygomatic implants is evaluated in another Cochrane review (Esposito 2013).

For trials to be considered in this review, implants had to be placed and the success or failure of the implant therapy had to be reported at least at the endpoint of four months after initial loading of the implant-supported prostheses. The following time points were considered: between four months to one year, three and five years after loading.

Types of outcome measures

Primary outcomes

- Prosthesis failure: planned prosthesis that could not be placed due to implant failure(s), loss of the prosthesis secondary to implant failure(s), and any replacement of prosthesis.
- Implant failure: implant mobility and removal of stable implants dictated by progressive marginal bone loss or infection

(biological failures) and any mechanical complication such us implant fractures or platform deformations rendering the implant not usable (mechanical failure). Biological failures were grouped as early (failure to establish osseointegration) and late failures (failure to maintain the established osseointegration). Failures that occurred before prosthesis placement were considered early failures. Implant mobility could be assessed manually or with instruments such as the Periotest (Siemens AG, Benshein, Germany) or resonance frequency (Osstell, Integration Diagnostics, Göteborg, Sweden).

Secondary outcomes

- Augmentation procedure failure: failure of the augmentation procedure, not affecting the success of the implant.
- Complications at treated sites (e.g. sinusitis, infection, haemorrhage, etc.) including, when appropriate, complications at bone donor sites (e.g. nerve injury, gait disturbance, infection, etc.).
- Patient satisfaction.
- Patient preference (only in split-mouth trials).
- Bone gain expressed in millimetres or as a percentage.
- Duration of the treatment time starting from the first intervention to the functional loading of the implants.
- Treatment costs.

Trials evaluating only histological outcomes were not considered in this review.

Search methods for identification of studies

For the identification of studies to be included or considered for this review, detailed search strategies were developed for each database searched. These were based on the search strategy developed for MEDLINE (OVID) but revised appropriately for each database. The search strategy used a combination of controlled vocabulary and free text terms and was run with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials in MEDLINE: sensitivity maximising version (2009 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of the *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (Higgins 2011). Details of the MEDLINE search are provided in Appendix 1.

Searched databases

We searched the following electronic databases:

- the Cochrane Oral Health Group's Trials Register (17 January 2014) (Appendix 2);
- the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2013, Issue 12) (Appendix 3);
- MEDLINE via OVID (1946 to 17 January 2014) (Appendix 1);
- EMBASE via OVID (1980 to 17 January 2014) (Appendix 4).

We did not place any restrictions on language or date of publication when searching the electronic databases.

Unpublished studies

We wrote to all the authors of the identified RCTs, checked the bibliographies of all identified RCTs and relevant review articles, and used personal contacts in an attempt to identify unpublished or ongoing RCTs. In the first version of this review we also wrote to more than 55 oral implant manufacturers and we requested information on trials through an Internet discussion group (implantology@yahoogroups.com), however we discontinued these approaches due to poor yield.

Handsearching

Only handsearching done as part of the Cochrane Worldwide Handsearching Programme and uploaded to CENTRAL was included (*see* the Cochrane Masterlist for details of journal issues searched to date).

Data collection and analysis

Selection of studies

The titles and abstracts (when available) of all reports identified through the electronic searches were scanned independently by two review authors. For studies appearing to meet the inclusion criteria, or for which there were insufficient data in the title and abstract to make a clear decision, the full report was obtained. The full reports obtained from all the electronic and other methods of searching were assessed independently by two review authors to establish whether the studies met the inclusion criteria or not. Disagreements were resolved by discussion. Where resolution was not possible, a third review author was consulted. All studies meeting the inclusion criteria then underwent risk of bias assessment and data extraction. Studies rejected at this or subsequent stages were recorded in the 'Characteristics of excluded studies' table and the reasons for exclusion were recorded.

Data extraction and management

Data were extracted independently by two review authors using specially designed data extraction forms. The data extraction forms were piloted on several papers and modified as required before use. Any disagreement was discussed and a third review author or the Cochrane Oral Health Group consulted where necessary. All authors were contacted for clarification of details or missing information. Data were excluded until further clarification was available if agreement could not be reached.

For each trial the following data were recorded.

- Year of publication, country of origin and source of study funding.
- Details of the participants including demographic characteristics, source of recruitment and criteria for inclusion.
- Details of the type of intervention.
- Details of the outcomes reported, including method of assessment, and time intervals.

Assessment of risk of bias in included studies

An assessment of the risk of bias in the included studies was undertaken following the recommendations as described in Chapter 8 of the *Cochrane Handbook for Systematic Reviews of Interventions* 5.1.0 (Higgins 2011). Two review authors independently and in duplicate assessed the risk of bias of all included studies. In the case that the paper to be assessed had one or more review authors in the authors list, it was independently evaluated only by those review authors not involved in the trial and by Philip Riley from the Cochrane Oral Health Group editorial

base. Any disagreement was discussed and where necessary a third review author was consulted to achieve consensus. Authors were contacted directly for clarification.

A specific tool was adopted for assessing risk of bias in each included study. This comprised a description and a judgement for each entry in a risk of bias table, where each entry addressed a specific feature of the study:

- random sequence generation (selection bias);
- allocation concealment (selection bias);
- blinding (of outcome assessor) (detection bias);
- incomplete outcome data addressed (attrition bias);
- free of selective reporting (reporting bias);
- free of other bias.

The judgement for each entry involved an assessment of: low risk of bias, high risk of bias, or unclear indicating either lack of information or uncertainty over the potential for bias.

After taking into account the additional information provided by the authors of the trials, the overall risk of bias in included studies was assessed. Studies were grouped into the following categories. We assumed that the risk of bias was the same for all outcomes and each study was assessed as follows.

Risk of bias	Interpretation	Within a study	Across studies
Low risk of bias	Plausible bias unlikely to seriously alter the results	Low risk of bias for all key domains	Most information is from studies at low risk of bias
Unclear risk of bias	Plausible bias that raises some doubt about the results	Unclear risk of bias for one or more key domains	Most information is from studies at low or unclear risk of bias
High risk of bias	Plausible bias that seriously weakens confidence in the results	High risk of bias for one or more key domains	The proportion of information from studies at high risk of bias is sufficient to affect the interpretation of results

Further quality assessment was carried out to assess sample size calculations, definitions of exclusion and inclusion criteria, and comparability of control and test groups at entry.

Measures of treatment effect

For dichotomous outcomes, the estimate of effect of an intervention was expressed as odds ratios (ORs) together with 95% confidence intervals (CIs). For continuous outcomes, mean differences (MDs) and standard deviations were used to summarise the data for each group with 95% CIs. Appropriate data were extracted from the split-mouth studies (Lesaffre 2009) and the generic inverse variance method was used to enter the data into Review Manager (RevMan).

Unit of analysis issues

In parallel group studies the statistical unit was the patient and not the augmentation procedure or the implants. In split-mouth studies the augmentation procedures or the prostheses within each pair were the unit of analysis (Lesaffre 2009).

Dealing with missing data

All authors were contacted to retrieve missing data from trials. Methods for estimating missing standard deviations, in section 7.7.3 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011), were used.

Assessment of heterogeneity

The significance of any variations in the estimates of the treatment effects from the different trials was to be assessed by means of Cochran's test for heterogeneity, and heterogeneity would have been considered significant if P value < 0.1. The I^2 statistic, which describes the percentage total variation across studies that is due to heterogeneity rather than chance, was used to quantify heterogeneity. with I^2 over 50% being considered moderate to high heterogeneity.

Assessment of reporting biases

If there had been sufficient numbers of trials (more than 10) in any meta-analysis, publication bias would have been assessed according to funnel plot asymmetry (Egger 1997) as described in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). If asymmetry was identified we would have examined possible causes.

Data synthesis

Meta-analysis was undertaken where studies of similar comparisons reported the same outcome measures. ORs were combined for dichotomous data, and MDs were to be combined for continuous data, using random-effects models provided there were more than three studies in the meta-analysis. When there were up to three studies in the meta-analyses they were combined using fixed-effect models. Peto ORs, from fixed-effect models, were used when there were zero events in the control or treatment arms, or both. Data from split-mouth studies were to be combined with data from parallel group trials by the method outlined by Elbourne (Elbourne 2002), using the generic inverse variance method in RevMan.

Subgroup analysis and investigation of heterogeneity

Clinical heterogeneity was to be assessed by examining the types of participants and interventions for all outcomes in each study. It was decided not to formulate any hypotheses to be investigated for subgroup analyses since no significant meta-analysis was

expected. However, this may be done in future updates of this review.

Sensitivity analysis

It was planned to undertake sensitivity analyses to examine the effect of the study overall risk of bias assessments on the overall estimates of effect by removing from the analyses studies at unclear and high risk of bias. In addition, the effect on the review's findings of including unpublished literature was also to be examined. There were too few trials to undertake these analyses.

Presentation of main results

We produced summary of findings tables for the main outcomes of this review using GRADEpro software. We assessed the quality of the body of evidence by considering the overall risk of bias of the included studies, the directness of the evidence, the inconsistency of the results, the precision of the estimates, the risk of publication bias and the magnitude of the effect. We categorised the quality of the body of evidence for each of the primary outcomes as high, moderate, low or very low.

RESULTS

Description of studies

Results of the search

The search for this review was part of a wider search for all eligible trials for the series of Cochrane reviews on dental implants. This search is conducted every six months and has so far included about 8700 records.

Included studies

See Characteristics of included studies table.

Eighteen trials were identified to be included in the review (Wannfors 2000; Hallman 2002; Raghoebar 2005; Cannizzaro 2009; Felice 2009a; Felice 2009b; Torres 2009; Checchi 2010; Felice 2011; Crespi 2012: Esposito 2012; Felice 2012; Lindgren 2012; Felice 2013; Merli 2013; Rickert 2013; Si 2013; Torres 2013).

Characteristics of the trial setting and investigators

- Of the 18 included trials, 10 were conducted in Italy (Cannizzaro 2009; Felice 2009a; Felice 2009b; Checchi 2010; Felice 2011; Crespi 2012; Esposito 2012; Felice 2012; Felice 2013; Merli 2013), three in Sweden (Wannfors 2000; Hallman 2002; Lindgren 2012), two in the Netherlands (Raghoebar 2005; Rickert 2013), two in Spain (Torres 2009; Torres 2013), and one in China (Si 2013).
- Seven trials had a parallel group study design (Wannfors 2000; Cannizzaro 2009; Felice 2011; Felice 2012; Felice 2013; Merli 2013; Si 2013), nine trials had a split-mouth design (Hallman 2002; Raghoebar 2005; Felice 2009a; Felice 2009b; Checchi 2010; Crespi 2012; Esposito 2012; Lindgren 2012; Rickert 2013), one trial had a mixed split-month and parallel group design (Torres 2009) but only data from its split-mouth portion could be used in the present review, and another trial had two components: 106 patients were treated according to a parallel group study design and five according to a split-mouth design (Torres 2013), but only data from its parallel group component could be used in the present review.
- For 11 trials it was declared that support was received from industry directly involved in the product being tested, also in the form of free material (Hallman 2002; Raghoebar 2005; Felice 2009a; Felice 2009b; Checchi 2010; Felice 2011; Esposito 2012; Felice 2012; Lindgren 2012; Felice 2013; Si 2013). The authors of seven trials declared that no support was received from commercial parties whose products were being tested in the trials (Wannfors 2000; Cannizzaro 2009; Torres 2009; Crespi 2012; Merli 2013; Rickert 2013; Torres 2013).
- Eight trials were conducted at university or specialist dental clinics (Wannfors 2000; Hallman 2002; Raghoebar 2005; Felice 2011; Crespi 2012; Lindgren 2012; Rickert 2013; Si 2013), six trials in private practices (Cannizzaro 2009; Felice 2009a; Torres 2009; Checchi 2010; Merli 2013; Torres 2013), and four multicentre trials both in private practices and hospitals (Felice 2009b; Esposito 2012; Felice 2012; Felice 2013).

Inclusion and exclusion criteria

For more details *see* the Characteristics of included studies table.

Main inclusion criteria

- Severely resorbed maxillae (classes V-VI according to Cawood 1991) with maxillary sinuses having less than 5 mm in height of residual alveolar bone with reduced stability and retention of upper dentures (Raghoebar 2005; Rickert 2013).
- Less than 5 mm in residual alveolar bone height in the floor of the edentulous sinus (Hallman 2002; Lindgren 2012).
- 1 to 3 mm in residual alveolar bone height in the floor of the edentulous sinus (Felice 2013; Merli 2013).
- 1 to 5 mm in residual alveolar bone height in the floor of the edentulous sinus (Felice 2009b).
- 1 to 7 mm in residual alveolar bone height in the floor of the edentulous sinus (Torres 2009; Torres 2013).
- 2 to 7 mm in residual alveolar bone height in the floor of the edentulous sinus (Wannfors 2000).
- 2 to 8 mm in residual alveolar bone height in the floor of the edentulous sinus (Si 2013).
- 3 to 6 mm in residual alveolar bone height in the floor of the edentulous sinus (Cannizzaro 2009).
- 4 to 6 mm in residual alveolar bone height in the floor of the edentulous sinus (Felice 2009a; Felice 2012).
- 4 to 7 mm in residual alveolar bone height in the floor of the edentulous sinus (Checchi 2010).
- 5 to 7 mm in residual alveolar bone height in the floor of the edentulous sinus (Esposito 2012).
- 5 to 9 mm in residual alveolar bone height at implant sites of severely resorbed edentulous maxillas (Felice 2011).
- Insufficient alveolar bone height in the floor of the edentulous sinus (baseline alveolar bone height: 6.71 mm $\pm$ 1.55 for hand mallet and 6.54 mm $\pm$ 1.67 for the electric mallet group) (Crespi 2012).

Main exclusion criteria

- Bone metabolic diseases (Wannfors 2000; Merli 2013; Torres 2013).
- Medications which could interfere with bone metabolism (i.e. corticosteroids, bisphosphonate, etc.) (Wannfors 2000;

Cannizzaro 2009; Felice 2009a; Felice 2009b; Checchi 2010; Felice 2011; Esposito 2012; Felice 2012; Felice 2013; Torres 2013).

- Sinusitis (Wannfors 2000; Cannizzaro 2009; Felice 2009a; Felice 2009b; Checchi 2010; Felice 2011; Crespi 2012; Esposito 2012; Felice 2012; Felice 2013; Si 2013).
- History of maxillary sinusitis or sinus surgery (Torres 2009; Crespi 2012; Torres 2013).
- History of reconstructive, pre-prosthetic surgery or previous oral implantology (Raghoebar 2005; Rickert 2013; Si 2013).
- Edentulous period less than one year (Raghoebar 2005; Rickert 2013).
- Severe systemic disease (ASA III and IV) (Torres 2009; Torres 2013).
- Smoking (Crespi 2012).
- Smoking more than 10 cigarettes per day (Lindgren 2012).
- Smoking more than 20 cigarettes per day (Merli 2013).
- None specified (Hallman 2002).

Sample size

An a priori calculation for the sample size was reported in eight trials (Cannizzaro 2009; Felice 2009a; Checchi 2010; Felice 2011; Esposito 2012; Merli 2013; Si 2013; Torres 2013); however in four trials (Cannizzaro 2009; Felice 2011; Si 2013; Torres 2013) the number of included patients did not reach the calculated sample size and in one trial it was based on inappropriate numbers (Merli 2013).

Baseline comparability between treatment groups

- No apparent major baseline differences (Wannfors 2000; Raghoebar 2005; Felice 2009b; Torres 2009; Checchi 2010; Esposito 2012; Felice 2012; Lindgren 2012; Merli 2013; Si 2013).
- Unclear whether major baseline differences existed (Hallman 2002; Crespi 2012; Rickert 2013; Torres 2013).
- The following major baseline differences existed:
  - more large diameter implants were placed in the sites treated with 8 mm long implants and crestal sinus lift (Cannizzaro 2009);
  - short 6 mm diameter implants were compared to longer implants with a 4 mm diameter (Felice 2009a);
  - more females and more implants were placed in the augmented group (Felice 2011), however the latter difference was obvious since the resorbed maxillas were grafted and therefore there was more available bone to place more and longer implants;
  - more implants placed in the one-stage group (55 versus 47); more prostheses in the two-stage group connected to implants placed in non-augmented bone (12 versus 6); more 3.8 mm small diameter implants used in the one-stage group (33 versus 20) (Felice 2013).

Characteristics of the interventions

The following comparisons were made.

1. Long implants in augmented sinuses versus short implants without augmentation (four trials with 102 participants)

- Four trials evaluating sinus lift versus short implants (Felice 2009a; Felice 2011; Esposito 2012; Felice 2012).

2. Comparing different sinus lift procedures (14 trials with 548 participants)

- One trial compared the use of rotary instruments or piezosurgery for opening a lateral window into the sinus (Rickert 2013).
- Two trials compared sinus lift with and without bone grafting (Felice 2009b; Si 2013).
- Two trials compared sinus list with autogenous bone versus bone substitutes (Hallman 2002; Merli 2013).
- One trial compared different bone substitutes (Lindgren 2012).
- Two trials evaluated the additional use of platelet-rich plasma (PRP) to bone grafts (Raghoebar 2005; Torres 2009).
- One trial evaluated the use of a resorbable barrier to seal the lateral window (Torres 2013).
- One trial compared one-stage versus two-stage augmentation procedures (Felice 2013).
- One trial compared one-stage autogenous bone block versus two-stage lateral window sinus lift (Wannfors 2000).
- One trial compared lateral versus crestal sinus lift (Cannizzaro 2009).
- Two trials compared different crestal sinus lift procedures (Checchi 2010; Crespi 2012).

Characteristics of outcome measures

- Prosthesis failure: (Wannfors 2000; Hallman 2002; Raghoebar 2005; Cannizzaro 2009; Felice 2009a; Felice 2009b; Torres 2009; Checchi 2010; Felice 2011; Crespi 2012; Esposito 2012; Felice 2012; Lindgren 2012; Felice 2013; Merli 2013; Rickert 2013; Si 2013, Torres 2013).
- Implant failure by individual implant stability assessment with removed prostheses (with the exception of single implants): (Wannfors 2000; Hallman 2002; Raghoebar 2005; Cannizzaro 2009; Felice 2009a; Felice 2009b; Torres 2009; Checchi 2010; Felice 2011; Crespi 2012; Esposito 2012; Felice 2012; Lindgren 2012; Felice 2013; Merli 2013; Rickert 2013; Si 2013, Torres 2013).
- Augmentation procedure failure: (Wannfors 2000; Hallman 2002; Raghoebar 2005; Cannizzaro 2009; Felice 2009a; Felice 2009b; Torres 2009; Checchi 2010; Felice 2011; Crespi 2012; Esposito 2012; Felice 2012; Lindgren 2012; Felice 2013; Merli 2013; Rickert 2013; Si 2013; Torres 2013). In one trial (Si 2013), in the case of maxillary sinus membrane perforation patients were excluded and we classified these patients as failures of the augmentation procedures and for the rest of the rehabilitation.
- Complications: (Hallman 2002; Raghoebar 2005; Cannizzaro 2009; Felice 2009a; Felice 2009b; Torres 2009; Checchi 2010; Felice 2011; Crespi 2012; Esposito 2012; Felice 2012; Felice 2013; Merli 2013; Rickert 2013). Two trials reported only selected complications: perforation of the sinus membrane (Wannfors 2000; Torres 2013).
- Patient satisfaction: (Felice 2011).
- Patient preference (only in split-mouth trials): (Felice 2009a; Felice 2009b; Checchi 2010; Esposito 2012; Felice 2012). Data for one trial (Felice 2009a) were reported, however they might have been biased because of the study design. All augmentation procedures were performed first and, after four months, test and control implants were placed bilaterally in the same surgical session. The potential advantage of having the prostheses on

the short implants loaded four months earlier was lost with this study design.
- Bone gain expressed in millimetres or as a percentage: (Felice 2009b; Crespi 2012; Si 2013).
- Duration of the treatment period starting from the first intervention to the functional loading of the implants: all trials.
- Treatment costs: no trials. However, this outcome measure was indirectly extrapolated by us for all trials.

Duration of follow-up (including unpublished data kindly provided by the investigators)

- Five-month post-loading (Felice 2011).
- Six-month post-loading (Merli 2013).
- One-year post-loading (Hallman 2002; Felice 2009a; Felice 2009b; Esposito 2012; Felice 2012; Felice 2013; Rickert 2013; Torres 2013).
- Nineteen-month post-loading (Crespi 2012).
- Two-year post-loading (Raghoebar 2005; Torres 2009).
- Two-year and half post-loading (Si 2013).
- Three-year post-loading (Wannfors 2000; Checchi 2010; Lindgren 2012).
- Five-year post-loading (Cannizzaro 2009).

Excluded studies

Forty-five studies had to be excluded for various reasons such as: they reported only histological outcomes without presenting any implant-related outcomes (Barone 2005; Kassolis 2005; Steigmann 2005; Froum 2006; Suba 2006; Consolo 2007; Aimetti 2008; Cordaro 2008; Froum 2008; Hallman 2008; Canullo 2009; Choi 2009; Crespi 2009; Kim 2009; Pikdöken 2011; Kühl 2012; Barone 2013; Corinaldesi 2013; Froum 2013; Kühl 2013; Payer 2013; Testori 2013; Yilmaz 2013); too short follow-up (Szabó 2005; Barone 2008; Schaaf 2008; Bettega 2009; Badr 2010; Kock 2010; Bensaha 2011; Borges 2011; Sammartino 2011; Hermund 2012; Kühl 2012; Trombelli 2012; Froum 2013; Gassling 2013; Khairy 2013; Silvestri 2013); problems with study design and data reporting (Froum 1998; Tawil 2001; Boyne 2005; Triplett 2009; Wagner 2012); data presented for only four out of 16 treated patients (Aimetti 2008); not an RCT (Mangano 2007; Ghanaati 2014).

Risk of bias in included studies

Allocation

Random sequence generation

We assessed 14 studies as at low risk of bias for this domain, with four being assessed as unclear.

Allocation concealment

When assessing the information presented in the articles, allocation concealment was scored as adequate for 13 trials (Cannizzaro 2009; Felice 2009a; Felice 2009b; Torres 2009; Checchi 2010; Felice 2011; Esposito 2012; Felice 2012; Lindgren 2012; Felice 2013; Merli 2013; Si 2013; Torres 2013) and unclear for five trials (Wannfors 2000; Hallman 2002; Raghoebar 2005; Crespi 2012; Rickert 2013). When evaluating authors' replies one trial was judged to be properly concealed (Hallman 2002) and four trials remained unclear (Wannfors 2000; Raghoebar 2005; Crespi 2012; Rickert 2013). In Lindgren 2012, although the randomisation was unclear the envelope was opened after the sinus membrane was elevated.

Therefore, the overall risk of selection bias was low in 14 studies and unclear in four studies.

Blinding

Blinding was not feasible in all of the included studies. Based on the evaluation of the trial reports and responses from authors, outcome assessment was scored as blinded for 14 trials (Raghoebar 2005; Cannizzaro 2009; Felice 2009a; Felice 2009b; Torres 2009; Checchi 2010; Felice 2011; Crespi 2012; Esposito 2012; Felice 2012; Felice 2013; Rickert 2013; Si 2013; Torres 2013); not blinded for four trials (Wannfors 2000; Hallman 2002; Lindgren 2012; Merli 2013) although an independent assessor was used (Merli 2013). When reading the original articles blinding was unclear for five trials (Wannfors 2000; Hallman 2002; Torres 2009; Crespi 2012; Lindgren 2012) and one trial was not blinded (Merli 2013). When evaluating authors' replies, the outcome assessors of two trials were judged to be blinded (Torres 2009; Crespi 2012) and not blinded for three trials (Wannfors 2000; Hallman 2002; Lindgren 2012).

Incomplete outcome data

When assessing the information presented in the articles, information on drop-outs was clearly presented in all trials with four exceptions (Torres 2009; Crespi 2012; Rickert 2013; Torres 2013) where the authors supplied the missing information. In another trial, in the case of maxillary sinus membrane perforation patients were excluded (Si 2013).

Selective reporting

Six trials did not present or only appeared to present full data on complications (Wannfors 2000; Crespi 2012; Lindgren 2012; Rickert 2013; Si 2013; Torres 2013), but the authors of three trials provided the missing information (Crespi 2012; Lindgren 2012; Rickert 2013); the remaining three trials were judged to be at high risk of bias since they did not answer to our request for information. Data for some of the outcome measures were not presented in one trial (Crespi 2012) resulting in it also being judged at high risk of bias.

Other potential sources of bias

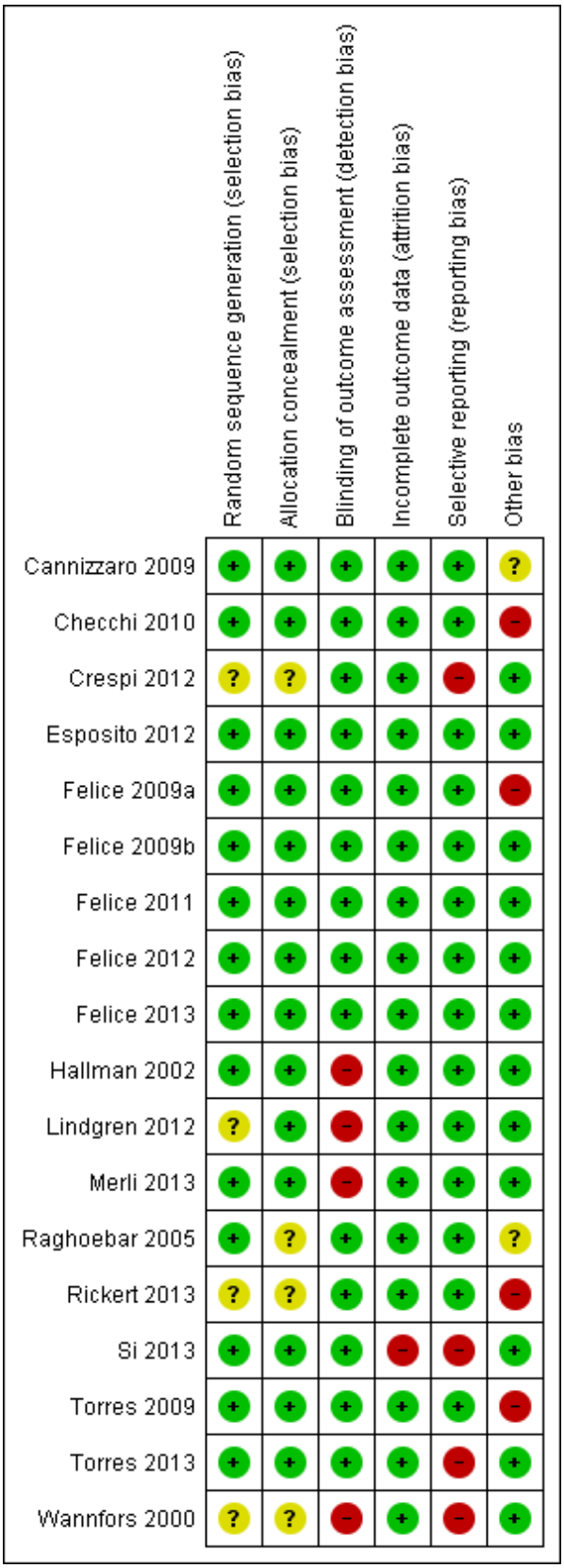
Other potential sources of bias that were detected were: differences in implant diameters between groups (Cannizzaro 2009; Felice 2009a); and additional buccal onlays performed making more difficult result interpretation since the role of the additional buccal onlays on the final outcome cannot be quantified (Raghoebar 2005; Rickert 2013). These were assessed as at unclear risk of bias unless they were included in the following list. The following four trials were considered at high risk because: they used a mixed split-mouth and parallel group design (Torres 2009); patients always had augmentation procedure performed first and then had implant placement bilaterally, since this may have affected patient preference (Felice 2009a); eight of 15 patients were treated by the inventor of one of the techniques under evaluation (Checchi 2010); it was a split-mouth study not taking pairing into account (Rickert 2013).

Overall risk of bias

Looking at the summary risk of bias for each trial in Figure 1, five trials were judged to be at low risk of bias (Felice 2009b; Felice 2011;

Esposito 2012; Felice 2012; Felice 2013), 11 trials were judged at high risk of bias (Wannfors 2000; Hallman 2002; Felice 2009a; Torres 2009; Checchi 2010; Crespi 2012; Lindgren 2012; Merli 2013; Rickert 2013; Si 2013; Torres 2013), and two trials at unclear risk of bias (Raghoebar 2005; Cannizzaro 2009).

Figure 1. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Effects of interventions

See: **Summary of findings for the main comparison** Long implants with augmentation versus short implants without augmentation for replacing missing teeth; **Summary of findings 2** Different sinus lift procedures

1. Long implants in augmented sinuses versus short implants without augmentation (four trials with 102 participants)

See Summary of findings for the main comparison.

Four trials (Felice 2009a; Felice 2011; Esposito 2012; Felice 2012) provided data for this comparison where short implants without augmentation were compared with long implants with augmentation. Three of these trials were assessed as at low risk of bias (Felice 2011; Esposito 2012; Felice 2012) and one at high risk of bias (Felice 2009a). Although two of these were split-mouth studies, the prosthesis and implant failures, and complications were in different patients and so the data have been entered as though they were in parallel group studies for ease of analysis and interpretation.

Prosthesis, implant and augmentation failures at one year

The meta-analyses for prosthesis failures and implant failures are shown in Analysis 1.1 and Analysis 1.2. There was no evidence of a difference in prosthesis or implant failures for the long implants with augmentation compared with the short implants, however the confidence intervals were wide. The odds ratio (OR) (Peto) for prosthesis failures was 0.37 (95% confidence interval (CI) 0.05 to 2.68, P value = 0.33) with no evidence of heterogeneity. The OR (Peto) for implant failures was 0.44 (95% CI 0.10 to 1.99, P value = 0.29) with no evidence of heterogeneity. One bilateral augmentation failure occurred in one trial only (Felice 2011).

Complications at one year

The meta-analysis for complications at treated sites is shown in Analysis 1.3. There was some evidence of more complications with the sinus lift, with an OR (Peto) of 4.77 (95% CI 1.79 to 12.71, P value = 0.002), however there was heterogeneity between the studies (Chi^2 P value = 0.04, I^2 = 64%).

Patient preference

Patient preference could only be ascertained in two split-mouth studies. In Felice 2009a all patients expressed no preference for any of the two procedures at four months post-loading, judging both of them as acceptable, however this measurement was considered to be biased as previously described in the 'Characteristics of outcome measures'. In Esposito 2012, five months after loading 15 patients preferred short implants whereas five patients described both procedures as equally acceptable.

Costs and treatment time

There were additional costs associated with the long implants with augmentation group: in Felice 2009a this group required one additional surgical intervention for placing the implants (two-stage procedure) plus there was the cost of the bone substitute with the barrier and four additional months to complete the treatment; in Esposito 2012 and Felice 2012 there was the additional cost of the bone substitute with the barrier; and in Felice 2011 there were the additional costs of three days of hospitalisation, the barrier, and four additional months required to rehabilitate the patients. Also more implants were placed in the long implant group with augmentation in one trial (Felice 2011).

2. Comparing different sinus lift procedures (14 trials with 548 participants)

These comparisons frequently involved only one trial, and the results for all outcomes are presented in Additional Table 1. Only results for more than one trial were shown in forest plots.

Rotary instruments versus piezosurgery to open a lateral window in the maxillary sinus (one trial with 36 participants)

One trial at high risk of bias (Rickert 2013) with 36 patients undertook this comparison, at one year after loading. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure, implant failure, augmentation procedure failure, complications at augmented site and complications at donor site. None of these were significant.

Sinus lift with and without bone graft (two trials with 55 participants)

Two trials, one at low and one at high risk of bias (Felice 2009b; Si 2013), compared granular anorganic bovine bone (Bio-Oss) with a resorbable rigid barrier (Inion) (Felice 2009b) or no bone (Si 2013) at one year. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure, implant failure, complications, augmentation procedure failure (one year), and bone gain (6, 18, 30 months after augmentation). Both studies provided data for bone gain at six months. This was significant for Si 2013 (P value < 0.001), with graft sites gaining more bone, but not for Felice 2009b. This observed gain in bone in Si 2013 was not apparent at 18 or 30 months.

The meta-analysis of these two trials (Felice 2009b; Si 2013) for implant failures at one year is given in Analysis 2.1. There was no evidence to suggest that more implant failures occurred in sinus lift with or without a bone graft (OR 0.52, 95% CI 0.10 to 2.82).

There was heterogeneity between the studies so it was probably not advisable to pool the data for bone gain at six months (Analysis 2.2).

Autogenous bone versus bone substitutes (two trials with 51 participants)

Two trials that were both at high risk of bias (Hallman 2002; Merli 2013) provided data for this comparison. One trial (Hallman 2002) compared autogenous bone versus 80% anorganic bovine bone (Bio-Oss) and 20% autogenous bone in 11 patients. The other trial (Merli 2013) compared autogenous bone harvested from the mandibular ramus versus anorganic bovine bone in 40 patients. Both trials reported implant failures and complications (none for Hallman 2002), and the data are shown in Additional Table 1 and a forest plot (Analysis 2.3). No statistically significant difference was found for implant failures (OR 4.20, 95% CI 0.81 to 21.79). For both trials the additional cost was that of the bone substitute.

Comparing different bone substitutes (one trial with 11 participants)

One trial at high risk of bias (Lindgren 2012) and with 11 patients undertook this comparison at one year after loading. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure, implant failure, augmentation procedure

failure, and complications at augmented site. None of these were significant.

Grafts with or without platelet-rich plasma (PRP) (two trials with 62 participants)

Two split-mouth trials provided data for this comparison. One trial (Raghoebar 2005) with five patients was at unclear risk of bias and compared a two-stage sinus lift with autogenous bone together with buccal onlay grafts that were harvested from the iliac crest, one side with PRP and the other without. The other trial (Torres 2009) with 57 patients was at high risk of bias and compared one- or two-stage sinus lift procedures using a lateral window technique and 100% granular Bio-Oss with or without PRP. Both trials provided useable data on implant failures and complications and forest plots are shown (Analysis 2.4). There were no statistically significant differences between groups who received PRP and those who did not for implant failures and complications. For both trials the difference in cost and treatment time was due to the use of PRP.

Use or not of a resorbable barrier to seal the lateral window (one trial with 106 participants)

One trial at high risk of bias (Torres 2013) and with 106 patients undertook this comparison at one year after loading. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure and implant failure. None of these were significant.

One-stage versus two-stage augmentation procedures (one trial with 60 participants)

One trial at low risk of bias (Felice 2013) and with 60 patients undertook this comparison at one year after loading. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure, implant failure, and complications. None of these were significant.

One-stage blocks versus two-stage sinus lift with autogenous granular bone (one trial with 40 participants)

One trial at high risk of bias (Wannfors 2000) and with 40 patients undertook this comparison at three years after loading. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure, implant failure, and complications. None of these were significant.

Comparing lateral versus crestal sinus lift (one trial with 40 participants)

One trial at unclear risk of bias (Cannizzaro 2009) and with 40 patients undertook this comparison at five years after loading. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure, implant failure, graft failure, complications, and partial graft loss. There were no statistically significant differences. There was an additional cost of the bone substitute in the group with the lateral approach but treatment duration was the same.

Comparing different crestal sinus lift procedures (two trials with 55 participants)

(a) Osteotomes with mallet versus sites prepared with rotary instruments

One trial at high risk of bias compared sinus lifting procedures performed bilaterally and in the same surgical session: the Summers' technique (using osteotomes and a mallet) and the Cosci's technique (sites prepared only with rotary instruments), in 15 patients (Checchi 2010). The following outcomes were reported and the data are given in Additional Table 1: prosthetic failure, implant failure, and complications at three years after loading. There were no failures in either group, and no statistically significant differences for these outcomes. Five months after loading (one year after surgery) 13 out of 15 patients preferred the side treated with the Cosci technique (P value < 0.007). Treatment duration and costs were the same.

(b) One-stage crestal sinus lifting procedures: osteotomes with a hand mallet versus an electric mallet without placing any bone grafts

One trial at high risk of bias (Crespi 2012) and with 40 patients per group undertook this comparison at three years. The following outcomes were reported and the data are given in Additional Table 1: prosthesis failure, implant failure, augmentation failure, complications at augmented site, and bone gain. None of these were statistically significant.

DISCUSSION

Summary of main results

See Summary of findings for the main comparison; Summary of findings 2.

Four trials evaluated whether sinus lift procedures are indicated in patients having a residual crestal height between 4 to 9 mm. There was moderate quality evidence, which was insufficient to determine whether procedures with or without using a sinus lift led to more prosthesis or implant failures. However, there were more complications at the treated sites when using the sinus lift procedures.

Several trials compared different sinus lift procedures. Data for prosthetic failure were available for five comparisons but with only one small trial in each. There was insufficient evidence to conclude that one sinus lift procedure had more or fewer prosthetic failures than the other. Eight comparisons, including one or two small studies, presented data on implant failures. There was insufficient evidence to conclude that one sinus lift procedure led to more implant failures than the other.

Given the lack of evidence to support one sinus lift procedure over another, clinicians should use their clinical judgement and take patient preference into account when choosing between procedures.

Overall completeness and applicability of evidence

Most of the augmentation procedures evaluated in these trials were performed by experienced clinicians, therefore caution is recommended when extrapolating the results of the present review to other clinical settings, such as general practice. There were insufficient studies comparing the same interventions to enable robust conclusions to be made via meta-analysis.

Quality of the evidence

Four trials (102 participants) provided data for the first objective of the review, to compare interventions with and without a sinus lift procedure. These trials provided moderate quality evidence

for prosthesis and implant failures, which was downgraded for imprecision.

Sample sizes were relatively small with only eight trials (Cannizzaro 2009; Felice 2009a; Checchi 2010; Felice 2011; Esposito 2012; Merli 2013; Si 2013; Torres 2013) reporting a sample size calculation and several of them were definitively underpowered to detect a clinically significant difference.

Potential biases in the review process

There were no events in some of the trial arms for some outcomes and we therefore used Peto odds ratios to undertake the meta-analysis. This may lead to conservative estimates of the effect size.

Although two of these were split-mouth studies, the prosthesis and implant failures, and complications were in different patients and so the data have been entered as though they are from parallel group studies for ease of analysis and interpretation. This is unlikely to have produced biased estimates.

Eleven of the 18 trials received funding from manufacturers of the interventions, however there was no evidence that this caused any bias in the assessment of the trials. This is not included in the risk of bias assessment in accord with Cochrane policy.

Agreements and disagreements with other studies or reviews

Several 'systematic' reviews have been published on the outcomes of sinus lifting procedures (Tong 1998; Wallace 2003; Del Fabbro 2004; Emmerich 2005; Aghaloo 2007; Pjetursson 2008; Tan 2008; Nkenke 2009; Del Fabbro 2013) however, since these findings were not based on the most reliable clinical studies, direct comparisons with our findings could be misleading and difficult to interpret.

AUTHORS' CONCLUSIONS

Implications for practice

There is moderate quality evidence which is insufficient to determine whether sinus lift procedures in bone with residual height between 4 and 9 mm are more or less successful than placing short implants (5 to 8.5 mm) for reducing prosthesis or implant failure. However, there are more complications at sites treated with the sinus lift procedure up to one year after loading. Many trials compared different sinus lift procedures and none of these indicated that one procedure reduced prosthetic or implant failures when compared to the other. Based on low quality evidence, patients may prefer rotary instruments over hand malleting for crestal sinus lift.

Implications for research

In order to understand when sinus lift procedures are needed, and which are the most effective sinus lift techniques, larger, well designed trials are needed. Such trials should include long-term follow-up and be reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Moher 2001). It is difficult to provide clear indications with respect to which sinus lift procedures should be evaluated first however, once the clinical situations are established in which these procedures are actually needed, priority should be given to those interventions that are simpler, less invasive, involve less risk of complications, and reach their goals within the shortest timeframe. Research efforts should be concentrated on a few important clinical questions, using larger sample sizes. This might be obtained through collaborative efforts among various research groups. Among the identified research priorities is the evaluation of whether and when sinus lift procedures are required, whether and when one-stage lifting via a crestal approach can replace the more invasive lateral window procedures, and whether bone grafts are needed and, if needed, whether bone substitutes can be used for replacing autogenous bone in augmenting severely atrophic maxillary sinuses. Trials should focus on clinically important outcomes, such as implant failure and complication rates, rather than histological or surrogate outcomes such as histomorphometry or bone height.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Cannizzaro 2009

Methods	Randomised trial of parallel group design, 5-year post-loading follow-up. 1 drop-out from the lateral window sinus lift group who died of cancer just before the 3-year post-loading follow-up
Participants	Patients having 3 to 6 mm of alveolar bone at the floor of the sinus. Adults treated at a private dental practice, Pavia, Italy. Exclusion criteria were: general contraindications to implant surgery, subjected to irradiation in the head and neck area less than 1 year ago, treated or under treatment with intravenous amino-bisphosphonates, poor oral hygiene and motivation, uncontrolled diabetes, pregnant or lactating, substance abusers, psychiatric problems or unrealistic expectations, lack of opposite occluding dentition/prosthesis in the area intended for implant placement, acute infection in the area intended for implant placement. 20 patients were treated in each group
Interventions	1-stage sinus lift using 1 to 3 8 mm long implants placed in simultaneously crestally augmented sinus with autogenous particulate bone, harvested from the implant site, versus 1 to 3 10 mm or longer implants placed in simultaneously augmented sinuses using the lateral approach with a mixture of 50% particulate autogenous bone from the tuberosity area and 50% Bio-Oss. A modified 'Cosci technique' was used to crestally augment the sinus. In brief implant sites were prepared with a 2.5 mm trephine drill up to about 1 mm of the sinus cortical wall, to collect autogenous bone, and with a 3.1 mm diameter atraumatic lifting drill. Resorbable barriers (Biomend Extend, Sulzer Dental Inc., Carlsbad, CA, USA) were used to seal the lateral windows. All the augmentation procedures were performed under local anaesthesia. All implants were left to heal submerged for 45 days and were functionally loaded within 1 week after abutment connection. All implants were tapered Screw-Vent MP-1 HA Dual Transition Selective Surface implants (Zimmer Dental, Carlsbad, CA, USA) inserted in under prepared osteotomy sites with a torque of at least 35 N/cm
Outcomes	Prosthesis and implant failures, complications at the augmented and donor sites, and peri-implant marginal bone levels
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "A computer generated restricted randomisation list was created"
Allocation concealment (selection bias)	Low risk	Article: "Only one of the investigators (Marco Esposito), not involved in the selection and treatment of the patients, was aware of the randomization sequence and could have access to the randomization list stored in his password protected portable computer. The randomized codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially after eligible patients were anaesthetised, therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "One dentist (Giuseppe Fontana) not involved in the treatment of the patients made all the clinical assessments without knowing group allocation, therefore outcome assessor was blinded, however Bio-Oss augmented sites could be identified on radiographs because they appeared more radio-opaque and implants were longer"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, no drop-outs

Cannizzaro 2009 *(Continued)*

Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	Unclear risk	The 8 mm implants were in general of larger diameter than the longer implants, therefore it cannot be ruled out that also the implant diameter played a role in the clinical outcome

Checchi 2010

Methods	Randomised trial of split-mouth design, 1 year post-loading follow-up. 3 withdrawals between years 1 and 3
Participants	Patients having 5 to 7 mm of alveolar bone height with a thickness of 5 mm or more below the sinus. Adults treated in 2 private practices in Bologna, Italy. Exclusion criteria were: general contraindications to implant surgery, subjected to irradiation in the head and neck area, treated or under treatment with intravenous amino-bisphosphonates, poor oral hygiene and motivation, untreated periodontal disease, uncontrolled diabetes, pregnant or lactating, substance abusers, psychiatric problems or unrealistic expectations, lack of opposite occluding dentition/prosthesis in the area intended for implant placement, acute or chronic infection/inflammation in the area intended for implant placement, patients participating in other trials, if the present protocol could not be properly followed, referred only for implant placement. 15 patients were treated and 12 patients were followed up to 3 years after loading
Interventions	1-stage crestal sinus lift according to the Summers' technique using dedicated osteotomes of increasing diameters and a mallet versus the Cosci's technique using dedicated rotatory instruments with increasing working lengths and finally a special drill with a non-cutting head (atraumatic lifting drill). Particulate cancellous human allograft (Puros, Zimmer Dental, Carlsbad, Ca, USA) was used. Augmentation procedures were performed under local anaesthesia and 1 or 2 8 to 10 mm long TSV Screw-Vent tapered implants with internal connection and MTX microtextured titanium surface (Zimmer Dental) were placed and submerged for 6 months. Provisional screw-retained reinforced resin prostheses were replaced after 4 months by definitive provisionally cemented metal-ceramic prostheses
Outcomes	Prosthesis, implant and augmentation failures, complications, patient preference 1 and 5 months after augmentation, peri-implant marginal bone level changes, operator preference, duration of the sinus lift procedures
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Article: "A computer generated restricted randomisation list was created.Only one of the investigators (Marco Esposito), not involved in the selection and treatment of the patients, was aware of the randomisation sequence and could have access to the randomisation list stored in his pass-word protected portable computer"
Allocation concealment (selection bias)	Low risk	Article: "The randomised codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially after flap elevation, therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "Follow-ups were conducted by an independent blind outcome assessor (Gerardo Pellegrino)"

Checchi 2010 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, no drop-outs
Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	High risk	8 out of 15 patients were treated by Dr Cosci who was the inventor of the Cosci's technique

Crespi 2012

Methods	Randomised trial of parallel group design, 19-month post-loading follow-up. No withdrawals
Participants	Patients having an unspecified "inadequate" alveolar bone height below the sinus and bone quality of type 3 or 4. Adults treated at the Department of Dentristy, San Raffaele Hospital, Milan, Italy. Exclusion criteria were: smoking, any chronic systemic disease and acute or chronic sinus problems, coagulation disorders, sing of acute infection around the alveolar bone at the site, alcohol and drug abuse. 40 patients were treated in each group
Interventions	1-stage crestal sinus lift with osteotomes and hand mallet versus electric mallet (Magnetic Mallet MetaErgonomica, Turbigo (MI), Italy). Augmentation procedures were performed under local anaesthesia, no grafting material was used and Outlink tapered implants (Sweden & Martina, Due Carrare (PD), Italy), with external hexagon connection, titanium plasma-spayed surface and 0.8 mm of polished neck, were left to heal submerged for 3 months. Provisional prostheses were replaced after 2 months by definitive screw-retained metal-ceramic prostheses
Outcomes	Prosthesis, implant and augmentation failures, complications, patient preference, vertical bone gain and maintenance over time, peri-implant marginal bone level changes, probing pocket depths, pain, modified plaque index and modified marginal bleeding index
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Article: "...group assignment was performed by lots in closed envelopes" Author's reply: "Each patient was assigned to control or test group by lots in closed envelopes"
Allocation concealment (selection bias)	Unclear risk	Article: "...group assignment was performed by lots in closed envelopes" Author's reply: "Each patient was assigned to control or test group by lots in closed envelopes"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "A blinded radiologist measured the changes in marginal bone height over time" Authors' reply: "In measuring all clinical and radiographic parameters, the assessors were blinded anyhow"
Incomplete outcome data (attrition bias) All outcomes	Low risk	No mention regarding drop-outs in the text Authors' reply: "No drop-out occurred"

Crespi 2012 *(Continued)*

Selective reporting (reporting bias)	High risk	Complication data apparently not fully reported; for some other outcomes (PD) data not provided by study group, for other outcomes (modified plaque index and modified bleeding index) data not provided at all Authors' reply: "No, we didn't find other complications"
Other bias	Low risk	None apparent

Esposito 2012

Methods	Randomised trial of split-mouth design, 1 year post-loading follow-up. No withdrawals
Participants	Patients having 5 to 7 mm of alveolar bone height with a thickness of 6 mm or more below the sinus. Adults treated in dental hospitals/university clinics and private practices in Bologna, Roma and Chieti, Italy. Exclusion criteria were: general contraindications to implant surgery, patients irradiated in the head and neck area, immunosuppressed or immunocompromised patients, patients who took or are taking bisphosphonates intravenously, patients with untreated periodontitis, poor oral hygiene and motivation, uncontrolled diabetes, pregnancy or lactation, addiction to alcohol or drugs, psychiatric problems, lack of opposite occluding dentition in the area intended for implant placement, patients with an acute or chronic infection inflammation in the area intended for implant placement. 20 patients were treated and followed up to 1 year after loading
Interventions	**Comparison 1: short implants without augmentation versus long implants with augmentation** 1 to 3 6 mm long implants of 4 mm in diameter versus 1 to 3 10 mm or longer implants of 4 mm in diameter placed in 1-stage laterally augmented sinuses with 100% cortical porcine-derived collagenated bone (Gen-Os, OsteoBiol, Tecnoss Dental, Pianezza, TO, Italy) with their lateral windows sealed with a resorbable collagen membrane from equine pericardium (Evolution, Fine 30 x 30 mm, OsteoBiol) simultaneously to implant placement. Augmentation procedures were performed under local anaesthesia and implants were left to heal submerged for 4 months. Southern implants (Irene, South Africa), with external hexagon connection, were used. Provisional screw-retained reinforced resin prostheses were replaced after 4 months by definitive screw-retained or provisionally cemented metal-ceramic prostheses
Outcomes	Prosthesis and implant failures, complications, peri-implant marginal bone levels and patient preference at 5 months post-loading
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Article: "A computer generated restricted random list was created"
Allocation concealment (selection bias)	Low risk	Article: "Only one of the investigators (ME), not involved in the selection and treatment of the patients, was aware of the random sequence and could have access to the random list stored in his pass-word protected portable computer. The information on how to treat site number 1 was enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially before giving anaesthesia and surgeons should have treated both sites in the same surgical session, starting from the intervention allocated to site number 1. Therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"

Esposito 2012 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "Two dentists (Dr Gerardo Pellegrino and Valeria Corvino) not involved in the treatment of the patients performed all clinical measurements without knowing group allocation..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, no drop outs
Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	Low risk	None apparent

Felice 2009a

Methods	Randomised trial of split-mouth design, 1 year post-loading follow-up. No withdrawals
Participants	Patients having 4 to 6 mm of alveolar height with a thickness of 8 mm or more below the sinus. Adults treated in dental hospitals/university clinics in Bologna, Roma and Chieti, Italy. Exclusion criteria were: general contraindications to implant surgery, patients irradiated in the head and neck area, immunosuppressed or immunocompromised patients, patients who took or are taking bisphosphonates intravenously, patients with untreated periodontitis, poor oral hygiene and motivation, uncontrolled diabetes, pregnancy or lactation, addiction to alcohol or drugs, psychiatric problems, lack of opposite occluding dentition in the area intended for implant placement, patients with an acute or chronic infection inflammation in the area intended for implant placement. 15 patients were treated and all patients were followed up to 1 year after loading, therefore there were no drop-outs
Interventions	**Comparison 1: short implants without augmentation versus long implants with augmentation** 1 to 3 5 mm long implants of 6 mm in diameter versus 1 to 3 10 mm or longer implants of 4 mm in diameter placed in 2-stage laterally augmented sinus with 100% bovine anorganic bone (Bio-Oss, Geistlich Pharmaceutical, Wolhusen, Switzerland) with their lateral windows sealed with a resorbable collagen membrane (OsseoGuard, Biomet 3i, Palm Beach, FL, USA) 4 months before. All augmentation procedures were performed under local anaesthesia. All implants were left to left to heal submerged for 4 months. Rescue implants (MegaGen Implant Co. Lld., Gyeongbuk, South Korea) as short implants and EZ Plus (MegaGen) as long implants, all with internal connection were used. Implant site preparation was also different since a 5 mm diameter trephine was used initially to prepare the osteotomy sites for Rescue implants. Provisional screw-retained reinforced resin prostheses were replaced after 4 months by definitive screw-retained metal-ceramic prostheses
Outcomes	Prosthesis and implant failures, complications, peri-implant marginal bone levels, and patient preference
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "A computer generated restricted randomisation list was created"
Allocation concealment (selection bias)	Low risk	Article: "Only one of the investigators (ME), not involved in the selection and treatment of the patients, was aware of the randomisation sequence and could have access to the randomisation list stored in his pass-word protected portable computer. The randomised codes were enclosed in sequentially num-

Felice 2009a *(Continued)*

		bered, identical, opaque, sealed envelopes. Envelopes indicating which site to augment were opened sequentially just prior to the augmentation procedure. Therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "One dentist (GP) not involved in the treatment of the patients performed all clinical and radiographic assessments without knowing group allocation, therefore the outcome assessor was blinded, however the Bio-Oss augmented sites could be identified both clinically when testing implant stability because of the different diameters and on radiographs because they appeared more radio-opaque and implants were different"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, no drop-outs
Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	High risk	Implants of small diameter (4 mm) and of different design were inserted with a different surgical technique in the augmented group instead of the originally planned identical but longer implants Patients had always the augmentation procedure performed first and then had implant placement bilaterally. This may have affected patient preference since patient could not experience the benefit of having the prosthesis 4 months earlier

Felice 2009b

Methods	Randomised trial of split-mouth design, 1 year post-loading follow-up. 1 patient, who had a complication, dropped out before prosthetic loading
Participants	Patients having 1 to 4 mm of alveolar bone at the floor of the sinus. Adults treated in dental hospitals/university clinics in Bologna, Roma and Chieti, Italy. Exclusion criteria were: general contraindications to implant surgery, patients irradiated in the head and neck area, immunosuppressed or immunocompromised patients, patients who took or are taking bisphosphonates intravenously, patients with untreated periodontitis, poor oral hygiene and motivation, uncontrolled diabetes, pregnancy or lactation, addiction to alcohol or drugs, psychiatric problems, lack of opposite occluding dentition in the area intended for implant placement, patients with an acute or chronic infection inflammation in the area intended for implant placement. 10 patients were treated
Interventions	2-stage sinus lift with lateral window approach using either a synthetic resorbable barrier (Inion, GTR Biodegradable Membrane System, Tampere, Finland) to keep the sinus membrane or 100% granular Bio-Oss. Inion barriers were used to seal the lateral windows. Inion barriers are made of a synthetic copolymer (trimethylene carbonate l-lactide polyglycolide) that needs to be softened in a plasticising solution, allowing the membrane to be cut and mould to fit exactly the space. The barrier then harden in the new position maintaining the new shape and the space. This material should biodegrade in situ after 8-12 weeks. All augmentation procedures were performed under local anaesthesia. After 6 months, 1 to 3 implants were placed per side and submerged for 4 months. Implants were Way (Geass, Pozzuolo del Friuli (UD), Italy) with a laser treated surface and internal connection. Provisional screw-retained reinforced resin prostheses were replaced after 4 months by definitive screw-retained metal-ceramic prostheses. 1 patient was excluded after perforation
Outcomes	Prosthesis and implant failures, complications, amount of vertically augmented bone (mm), peri-implant marginal bone levels, patient and clinician preference. Time necessary to complete the augmentation procedure

Felice 2009b *(Continued)*

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "A computer generated restricted randomisation list was created"
Allocation concealment (selection bias)	Low risk	Article: "Only one of the investigators (Marco Esposito), not involved in the selection and treatment of the patients, was aware of the randomization sequence and could have access to the randomization list stored in his password protected portable computer. The randomized codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially after the sinus lining epithelium of site number 1 was lifted, therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "One dentist (Gerardo Pellegrino), not involved in the treatment of the patients, made all the clinical assessments without knowing group allocation, therefore outcome assessor was blinded, however Bio-Oss augmented sites could be identified on radiographs because they appeared more radio-opaque while Inion treated sites appeared rather radiolucent"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, 1 drop-out after perforation
Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	Low risk	None apparent

Felice 2011

Methods	Randomised trial of parallel group design, 5-month post-loading follow-up. No withdrawals
Participants	Patients with fully edentulous maxillas having residual bone heights of 5 to 9 mm with a thickness of 5 mm at the implant sites. Adults treated in dental hospitals/university clinics in Bologna, Roma, Italy. Exclusion criteria were: general contraindications to implant surgery, patients irradiated in the head and neck area, immunosuppressed or immunocompromised patients, patients who took or are taking bisphosphonates intravenously, patients with untreated periodontitis, poor oral hygiene and motivation, uncontrolled diabetes, pregnancy or lactation, addiction to alcohol or drugs, psychiatric problems, severe intermaxillary discrepancies, patients with an acute or chronic infection inflammation in the area intended for implant placement, lack of opposite occluding dentition/prosthesis. 28 patients were treated, 15 with short implants and 13 with long implants after augmentation. Patients were followed up to 5 months after loading and no patients dropped out
Interventions	**Comparison 1: short implants without augmentation versus long implants with augmentation** 4 to 8 5 to 8.5 mm long implants versus 4 to 8 11.5 mm or longer implants placed in sinuses and maxillae of totally edentulous patients augmented with particulated autogenous bone from the iliac crest via lateral windows and, if necessary with onlay blocks 4 months prior to implant placement. The maxillary windows and the bone blocks were covered with 30 x 40 mm synthetic resorbable barriers (Inion GTR Biodegradable Membrane System, Tampere, Finland). Augmentation procedures were performed under general anaesthesia. Implants were left to heal submerged for 4 months. ExFeel and Rescue implants (MegaGen Implant Co. Lld., Gyeongbuk, South Korea) with external hexagon connections were

Felice 2011 *(Continued)*

	used. Either overdentures or fixed provisional screw-retained reinforced resin prostheses were placed. The latter were replaced after 4 months by fixed definitive screw-retained metal-resin prostheses
Outcomes	Prosthesis and implant failures, complications, peri-implant marginal bone levels, patient satisfaction
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "A computer generated restricted randomisation list was created"
Allocation concealment (selection bias)	Low risk	Article: "Only one of the investigators (ME), not involved in the selection and treatment of the patients, was aware of the randomisation sequence and could have access to the randomisation list stored in his pass-word protected portable computer.The randomised codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially after eligible patients signed the informed consent form to be enrolled in the trial. Therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "One dentist (ES) not involved in the treatment of the patients performed all clinical assessments without knowing group allocation, therefore the outcome assessor was blinded"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, 1 drop-out
Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	Low risk	None apparent

Felice 2012

Methods	Randomised trial of parallel group design, 1 year post-loading follow-up. 1 patient, from the maxillary augmented group, dropped out before the 1 year follow-up because she did not want to continue the follow-up at the dental practice
Participants	Patients having 4 to 6 mm of alveolar bone height with a thickness of 6 mm or more below the sinus. Adults treated in dental hospitals/university clinics and private practices in Bologna, Roma and Chieti, Italy. Exclusion criteria were: general contraindications to implant surgery, patients irradiated in the head and neck area, immunosuppressed or immunocompromised patients, patients who took or are taking bisphosphonates intravenously, patients with untreated periodontitis, poor oral hygiene and motivation, uncontrolled diabetes, pregnancy or lactation, addiction to alcohol or drugs, psychiatric problems, lack of opposite occluding dentition in the area intended for implant placement, patients with an acute or chronic infection inflammation in the area intended for implant placement. 20 patients were treated in each group
Interventions	**Comparison 1: short implants without augmentation versus long implants with augmentation** 1 to 3 5 mm long implants of 5 mm in diameter versus 1 to 3 10 mm or longer implants of 5 mm in diameter placed in 1-stage laterally augmented sinuses using a 1 cc sterile syringe of a sticky paste of made of 600-1000 micron pre-hydrated collagenated cortico-cancellous bone granules of porcine ori-

Felice 2012 *(Continued)*

	gin, mixed with OsteoBiol Gel 0 (mp3, OsteoBiol, Tecnoss Dental, Pianezza, TO, Italy) with their lateral windows sealed with a resorbable collagen membrane from equine pericardium (Evolution, Fine 30 x 30 mm, OsteoBiol) simultaneously to implant placement. Augmentation procedures were performed under local anaesthesia and implants were left to heal submerged for 4 months. ExFeel implants (Mega-Gen Implant Co. Lld., Gyeongbuk, South Korea), with external hexagon connection and a nanostructured calcium-incorporated titanium surface (Xpeed), were used. Provisional screw-retained reinforced resin prostheses were replaced after 4 months by definitive screw-retained or provisionally cemented metal-ceramic prostheses
Outcomes	Prosthesis and implant failures, complications, and peri-implant marginal bone levels
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "A computer generated restricted random list was created"
Allocation concealment (selection bias)	Low risk	Article: "Only one of the investigators (Marco Esposito), not involved in the selection and treatment of the patients, was aware of the random sequence and could have access to the random list stored in his pass-word protected portable computer. The information on how to treat each patient was enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially after the patients signed the informed consent accepting to participate into the trial. Therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "Two dentists (Dr Laura Piana and Dr Daniele Panetta) not involved in the treatment of the patients performed all clinical measurements without knowing group allocation...."
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, 1 drop-out
Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	Low risk	None apparent

Felice 2013

Methods	Randomised trial of parallel group design, 1 year post-loading follow-up. 2 patients dropped out from the 1-stage group just after augmentation: 1 never come back for unknown reasons and the other because of financial reasons
Participants	Patients having 1 to 3 mm of alveolar bone height with a thickness of 5 mm or more below the sinus. Adults treated in dental hospitals/university clinics and private practices in Bologna, Roma and Chieti, Italy. Exclusion criteria were: general contraindications to implant surgery, subjected to irradiation in the head and neck area, immunosuppressed or immunocompromised, treated or under treatment with intravenous amino-bisphosphonates, untreated periodontitis, poor oral hygiene and motivation, uncontrolled diabetes, pregnant or nursing, substance abusers, psychiatric problems or unrealistic expectations, lack of opposite occluding dentition/prosthesis in the area intended for implant placement, acute chronic infection/inflammation (sinusitis) in the area intended for implant placement, patients

Felice 2013 *(Continued)*

	participating in other trials, if the present protocol could not be properly followed, referred only for implant placement or unable to attend a 5-year follow-up 30 patients were treated in each group, followed up to 1 year after loading
Interventions	1-stage with simultaneous implant placement versus a 2-stage lateral window sinus lift procedure with implant placement delayed by 4 months using a bone substitute (Bio-Oss, Geistlich Pharmaceutical, Wolhusen, Switzerland). All patients were treated under local anaesthesia and the lateral sinus windows were sealed with resorbable collagen barriers (Bio-Gide, Geistlich). 1 to 3, 11 to 15 mm long, tapered Way Milano implants (Geass, Pozzuolo del Friuli, UD, Italy) with microtextured surface treated with laser (Synthegra) and conical internal hexagonal connection were submerged for 4 months, loaded with reinforced provisional prostheses which were replaced, after 4 months, by definitive metal-ceramic or zirconia restorations, rigidly joining the implants by being either provisionally cemented or screw-retained
Outcomes	Augmentation, prosthesis and implant failures, complications, and peri-implant marginal bone level changes on periapical radiographs
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "3 computer generated restricted randomisation lists were created. Only 1 of the investigators (Marco Esposito), not involved in the selection and treatment of the patients, was aware of the random sequence and could have access to the randomisation lists stored in his pass-word protected portable computer"
Allocation concealment (selection bias)	Low risk	Article: "The random codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially after the sinus lining epithelium of was lifted, therefore, treatment allocation was concealed to the investigators in charge of enrolling and treating the patients"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "One dentist (Gerardo Pellegrino), not involved in the treatment of the patients, made all clinical assessments without knowing group allocation, therefore outcome assessor was blind"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, 2 drop-outs
Selective reporting (reporting bias)	Low risk	All planned outcomes were reported
Other bias	Low risk	None apparent

Hallman 2002

Methods	Randomised, split-mouth study, 1 year post-loading follow-up. No withdrawals
Participants	Patients having less than 5 mm of alveolar bone in the floor of the sinus. Adults treated at the Gävla Hospital, Gävla, Sweden. No specific exclusion criteria were given (unhealthy, systemic or local contraindications such as undergoing radiation therapy). 11 patients were treated in the split-mouth study and 10 in the preference group

Hallman 2002 *(Continued)*

Interventions	2-stage sinus lift with autogenous particulate bone from the mandibular ramus versus 2-stage sinus lift with a mixture of 80% of bovine anorganic bone (Bio-Oss) and 20% of particulate bone from the mandibular ramus left to heal for 6 months. A fibrin glue (Tisseel Duo Quick, Immuno, Wien, Austria) was added to the grafts after thrombin (Thrombin, Immuno). Procedures were performed under local anaesthesia and oral sedation. All implants were turned titanium self tapping (Nobel Biocare, Göteborg, Sweden): Mark II type implants were used in the former 2 groups and Mark III in the latter. All patients were rehabilitated with screw-retained metal-ceramic fixed prostheses A third group (not part of this review) was composed by patients who refused to provide autogenous bone but accepted the treatment with a 2-stage sinus lift with 100% Bio-Oss
Outcomes	Prosthesis and implant failures, complications at augmented and donor sites; histomorphometry
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: No information presented Author's reply: "The randomization was done by a third party as a lottery. In an envelope there were 12 papers with either 6 possibilities for the mixture to be on the left side or the right side. Each patient was allotted by picking up one paper which said mixture on the left or right side"
Allocation concealment (selection bias)	Low risk	Article: No information presented Author's reply: "The surgeon knew the outcome of the surgery at the time of surgery just before making the incision"
Blinding of outcome assessment (detection bias) All outcomes	High risk	Article: No information presented Author's reply: "The study was not blinded"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, no drop-outs
Selective reporting (reporting bias)	Low risk	All planned outcomes apparently reported
Other bias	Low risk	None apparent

Lindgren 2012

Methods	Randomised, split-mouth study, 3-year post-loading follow-up. No withdrawals
Participants	Completelly or partially edentulous patients in the maxilla with less than 5 mm of residual bone in the floor of the maxillary sinus and a crest width of at least 4 mm. Adults treated at the department of Oral and Maxillofacial Surgery, Public Health Service, Gävle, Sweden. Patients were excluded if they any severe disease or smoked more than 10 cigarettes/day. 11 patients were treated
Interventions	2-stage lateral window sinus lift with granular bone substitutes: anorganic bovine bone (Bio-Oss®, Geistlich, Biomaterials, Wolhusen, Switzerland, particle diameters 0.25 to 1 mm) versus synthetic biphasic calcium phosphate consisting of 60% hydroxyapatite (HA) and 40% tricalcium phosphate (TCP) (Bone-Ceramic, Straumann® Basel, Switzerland, particle diameters 0.5 to 1 mm) left to heal for 8

Lindgren 2012 *(Continued)*

	months in a split-mouth trial. Lateral windows were sealed with resorbable collagen barriers (BioGide®, Geistlich). Implants were inserted into the healed graft of each side and were left to heal for an additional 4 months. All the augmentation procedures were performed under local anaesthesia. All implants were non-submerge SLActive surface (Straumann®) which were rehabilitated with cross-arch or partial fixed implant-supported prostheses
Outcomes	Prosthesis, implant and augmentation failures, complications (selectively reported), radiographic stability of bone height gain on panoramic radiographs, histomorphometry, peri-implant marginal bone level changes on peri-apical radiographs, plaque index (PLI), bleeding on probing (BPI), sulcus bleeding index (SBI), and probing pocket depth (PPD)
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Article: No information presented Unclear reply to letter
Allocation concealment (selection bias)	Low risk	Article: "The randomization envelope was opened after the sinus membrane was elevated"
Blinding of outcome assessment (detection bias) All outcomes	High risk	Article: No information presented Authors' answer: "Outcome assessors not blinded"
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-out
Selective reporting (reporting bias)	Low risk	Full data of complications not provided Authors's provided the missing information
Other bias	Low risk	Appropriate analysis for split-mouth study. None apparent

Merli 2013

Methods	Randomised trial of parallel group design, 6-month post-loading follow-up. 1 drop-out from the autogenous bone group because patient moved to another country
Participants	Partially edentulous patients in the maxilla with 1 to 3 mm of residual bone in the floor of the maxillary sinus. Adults treated in a private practice in Rimini, Italy. Patients were excluded if there were general contraindications to implant surgery, irradiated in the head and neck area, poor oral hygiene (full mouth plaque score and full mouth bleeding score ≥ 20%) and lack of motivation, uncontrolled diabetes, metabolic disease and drugs affecting bone remodeling, pregnancy and lactating period, substance abusers, smoking more than 20 cigarettes per day. 20 patients were treated in each group
Interventions	1-stage lateral window sinus lift with particulated autogenous bone harvested from the mandibular ramus versus granules of anorganic bovine bone (Bio-Oss). The windows were sealed with resorbable collagen barriers (Bio-Gide). Implants were left to heal submerged for 8 months. All the augmentation procedures were performed under conscious sedation and local anaesthesia. All implants were titanium Nobel Speedy Groovy or MK IV implants (Nobel Biocare AG, Kloten, Switzerland) with oxidised sur-

Merli 2013 *(Continued)*

	faces (TiUnite) and were rehabilitated with provisional implant-supported prostheses replaced, after 6 months, by metal-ceramic screwed partial fixed prostheses
Outcomes	Prosthesis, implant and augmentation failures, complications, radiographic stability of bone height gain and peri-implant marginal bone level changes on periapical radiographs, chair-time from local anaesthesia administration to last suture placement, post-operative pain with a visual analogue scale and analgesic intake for 6 post-operative days
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "An investigator (LF), not involved in the selection and treatment of the patients, randomly assigned participants following simple randomization procedures (computerised random numbers) to 1 of 2 treatment groups"
Allocation concealment (selection bias)	Low risk	Article: "The randomised codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially only after the sinus membrane was elevated. Therefore, treatment allocation was concealed to the investigator in charge of enrolling and treating the patients included in the trial"
Blinding of outcome assessment (detection bias) All outcomes	High risk	Article: "While both the patients and the surgeon were aware of the allocated arm, the radiographic outcome examiner (GM) was unaware of the aim of the study and blinded to group allocation although Bio-Oss is usually more radiopaque than bone and can be recognized on radiographs. Implant failure and complications were assessed by an independent examiner (Moscatelli M.), who was not blinded to the intervention. Some complications, such as perforation of the sinus membrane, could occur during the surgical phase. The clinical examiner was present during surgery to register any complications, hence he was aware of the treatment administered"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, 1 drop-out
Selective reporting (reporting bias)	Low risk	All planned outcomes apparently reported
Other bias	Low risk	None apparent

Raghoebar 2005

Methods	Randomised, split-mouth study, 2-year post-loading follow-up. No withdrawals
Participants	Patients with severely resorbed fully edentulous maxillae and reduced stability and retention of the upper dentures. Adults treated at the University Hospital Groningen, the Netherlands. Patients were excluded if were edentulous for a period less than 1 year, history of irradiation in the head and neck area, history of reconstructive pre-prosthetic surgery or previous implant surgery. 5 patients were treated
Interventions	2-stage lateral window sinus lift with autogenous blocks and particulate bone together with buccal onlays monocortico-cancellous bone grafts, to reconstruct the width of the maxilla, fixed with titanium screws harvested from the iliac crest with or without PRP left to heal for 3 months in a split-mouth trial. Barriers were not used. PRP was made using the Platelet Concentration Collection System kit (PCCS kit, 3i Implant Innovations Inc. Palm Beach Gardens, FL, USA). 54 ml of blood were mixed with 6

Raghoebar 2005 *(Continued)*

	ml of anticoagulant (citrate dextrose) and processed with the platelet concentration system. To promote the release of growth factors from the platelets, 10% calcium chloride solution and the patient's serum, as a source of autologous thrombin, were added before actual reconstruction of the defect with the bone graft. The resulting gel was mixed with the bone graft and some gel was applied at the closure of the wound at the side treated with PRP. 3 implants were inserted into the healed graft of each side and were left to heal for an additional 6 months. All the augmentation procedures were performed under general anaesthesia. Surgical templates were used to optimise implant insertion. All implants were turned titanium self tapping (Nobel Biocare, Göteborg, Sweden) and were rehabilitated with 2 implant-supported prostheses
Outcomes	Prosthesis, implant and graft failures, complications and histomorphometric evaluation
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: No information presented Author's reply: "Randomisation by lot"
Allocation concealment (selection bias)	Unclear risk	Article: No information presented Author's reply failed to clarify the issue
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "The investigators were blinded for both the clinical and laboratory investigations with regard to the PRP-treated side"
Incomplete outcome data (attrition bias) All outcomes	Low risk	All data presented, no drop-outs
Selective reporting (reporting bias)	Low risk	All planned outcomes apparently reported
Other bias	Unclear risk	In all patients additional buccal onlays were performed meaning that these patients might have not been the ideal candidates for the hypothesis tested. It is therefore more difficult to interpret the results since the role of the additional buccal onlays on the final outcome cannot be quantified

Rickert 2013

Methods	Randomised, split-mouth study, 1 year post-loading follow-up. No withdrawals
Participants	Patients with severely resorbed fully edentulous maxillae and reduced stability and retention of the upper dentures. Adults treated at the University Hospital Groningen, the Netherlands. Patients were excluded if were edentulous for a period less than 1 year, history of irradiation in the head and neck area, history of reconstructive pre-prosthetic surgery or previous implant surgery, pathology in the maxillary sinuses. 36 patients were treated
Interventions	2-stage lateral window sinus lift with autogenous particulate bone together with buccal onlays monocortico-cancellous bone blocks, to increase the width of the maxilla, fixed with titanium screws, harvested from the iliac crest left to heal for 3 to 4 months. The bilateral windows were opened following randomisation using rotative instruments of piezosurgery (Piezosurgery, Mectron Medical Technology Spa, Carasco, Genoa, Italy). In addition patients' sides were randomly allocated to received or not re-

Rickert 2013 *(Continued)*

	sorbable collagen membranes (Bio-Gide®, Geistlich Pharma AG, Wolhusen, Switzerland) over the grafts. All augmentation procedures were performed under general anaesthesia. 4 to 6 non-submerged 1-piece titanium implants (ITI®, Dental Implant System,Institut Straumann, Waldenburg, Switzerland) were inserted and left to heal for an additional 3 months. Patients were rehabilitated with implant-supported overdentures
Outcomes	Prosthesis, implant and graft failures, complications, time required to open the lateral window, changes over times of the maxillary bone width
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	No information in the text and no reply to answer
Allocation concealment (selection bias)	Unclear risk	Article: "Randomly, by envelopes, one side was treated with conventional rotative instruments .... and the other side with piezosurgery" Authors' reply: "We used envelopes with the operative procedures to randomize. The surgeon had to draw a envelope and had to treat the patient according to the procedure within that envelope"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "Clinically, all patients were evaluated according to a standardized protocol 1, 3, 6, and 12 weeks after surgery by a clinical research not knowing which procedure had been performed at a particular site"
Incomplete outcome data (attrition bias) All outcomes	Low risk	In the article bone dehiscence at implant placement were not described by study group and it was unclear whether all complications were reported. The authors clarified the data after request of information
Selective reporting (reporting bias)	Low risk	Drop-outs, if any, were not specified in the article but the authors replied that no drop-outs occurred
Other bias	High risk	Split-mouth study and pairing of data not taken into account

Si 2013

Methods	Randomised trial of parallel group design, 2-year and half post-loading follow-up. 1 drop-out from the augmentation group because of death and 3 patients excluded because of sinus epithelium perforation, 1 from the augmented group and 2 from the non-augmented group. These latter 3 patients were accounted for as failures
Participants	Patients having 2 to 8 mm of bone height below the maxillary sinus. Adult treated at the Department of Oral and Maxillofacial Implantology, Shanghai 9th People's Hospital, Shanghai Jiaotong University, China. Exclusion criteria were uncontrolled diabetes mellitus or other systemic disorders, untreated periodontal disease, endodontic lesions or other oral disorders, heavy smokers (> 10 cigarettes per day), rhinitis or sinusitis, insufficient residual bone quality to achieve implant stability, and previous implant installation or bone grafting at the surgical site. 45 patients were treated, 23 in the augmented group and 22 in the non-augmented group
Interventions	1-stage crestal sinus lift procedure with osteotomes with or without granular Bio-Oss. Implants left to heal for 6 months. Straumann SLA (Waldenburg, Switzerland) implants were used

Si 2013 *(Continued)*

Outcomes	Prosthesis, implant and augmentation failures, radiographic bone gain and peri-implant marginal bone levels
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "Patients eligible for this study were assigned to two groups using the random numbers table (Complete randomization) by an assistant"
Allocation concealment (selection bias)	Low risk	Article: "The assignment was concealed from the clinical operators until the sealed, numbered envelopes were opened before OSFE application during implant surgery"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "The outcome examiners and the patients were kept blinded to the assignment"
Incomplete outcome data (attrition bias) All outcomes	High risk	Article: "Any patient with membrane perforation was excluded from this study" 3 patients were actually excluded and the outcome of the therapy remains unknown, but we counted them as failures
Selective reporting (reporting bias)	High risk	Data on complications not presented and no reply to letter
Other bias	Low risk	None apparent

Torres 2009

Methods	Randomised hybrid study design combining patients with a split-mouth study design with patients treated according to a quasi-random parallel group design with follow-up to 2 years after loading. No withdrawals
Participants	Patients having less than 7 mm of alveolar bone at the floor of the sinus. Adults treated at private clinic in Madrid, Spain. Exclusion criteria were severe systemic diseases (ASA score 3 or more), a previous history of chronic sinusitis. 57 patients were treated
Interventions	1- or 2-stage sinus lift procedures using a lateral window technique and 100% granular Bio-Oss with or without PRP, left to heal for 6 months. Patients having up to 4 mm of residual bone height were augmented first and implant were placed after 6 months whereas patients with residual bone more than 4 mm up to 7 mm received implants during the sinus lift procedures. Implants were left to heal unloaded for 6 months. 10 to 20 cc of venous blood were collected 30 minutes prior to the surgery and mixed with a 3.8% sodium citrate solution at a 5/1 ratio, achieving anticoagulation through calcium binding. The blood was then centrifuged into 3 and separated into 3 layers: red blood cells (RBCs), PRP and poor plasma. Flow cytometry was used for platelet counting. Platelets counts were 2.97 $\pm$ 0.7-fold over peripheral blood. PRP was activated with 30% $CaCl_2$ solution and a PRP gel was obtained and mixed with Bio-Oss. The entire bone of the buccal window was removed, and after the sinus was filled with the bone substitute no barrier was used to seal the windows. Patients were instructed not to wear their upper dentures for 2-3 weeks after surgery. Osseotite (Biomet 3I, Palm Beach, FL, USA) implants were used
Outcomes	Prosthetic and implant failures, complications, and histomorphometric evaluation

Torres 2009 *(Continued)*

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "..randomized sequence was performed by a computerized random number generated using GraphPadQuickCalc software (GraphPad Software Inc., La Joya, Ca, USA), including the concealment of the allocation schedule until the assignment was done"
Allocation concealment (selection bias)	Low risk	Article: "Patients included in the inter-patient clinical trial were allocated by a blinded assistant into two groups: the first was to be treated with ABB alone, and the second with ABB + PRP"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "The surgeon was blinded to the graft material applied to each patient before graft implantation. An assistant handled PRP-ABB or the ABB group after the surgeon had already accessed the sinus and elevated membrane. The histologist was blinded to the samples' groups throughout the histomorphometric analysis" Author's reply: "Implant stability was assessed manually with removed prostheses and mobile implants were considered as failures and this evaluation was done by a prosthodontist who was not aware of study groups"
Incomplete outcome data (attrition bias) All outcomes	Low risk	We could only evaluate those data kindly provided by the authors
Selective reporting (reporting bias)	Low risk	All planned outcomes apparently reported
Other bias	High risk	A mixed split-mouth and parallel group design was used: patients requiring augmentation at bilateral sinuses were randomised in a split-mouth study design whereas those requiring unilateral sinus lift sinus were alternated in a quasi-random study design. We have not included data from the quasi-random study

Torres 2013

Methods	Randomised study design having 106 patients treated according to a parallel group study design and 5 patients according to a split-mouth study design (not considered in the present review) with 1 year follow-up after loading. 2 withdrawals from the membrane group because moved to another city
Participants	Patients having less than 7 mm of alveolar bone at the floor of the sinus. Adults treated at private clinic in Madrid, Spain. Exclusion criteria were patients with severe systemic disease (American Society of Anaesthesiology III or IV), previous history of chronic sinusitis, pregnant, diseases affecting bone, such as osteomalacia, Paget's disease, vitamin D deficiency, hyperthyroidism, cancer (excluding non-melanoma skin cancer), alcoholism, those on corticosteroids, antiepileptic drugs, bisphosphonates, who had a perforation of the Schneiderian membrane. 106 patients treated, 55 without membranes and 51 with membranes
Interventions	The sinus floor augmentation was made using as graft material (Bio-Oss; Geistlich Pharmaceutical AG, Wolhusen, Switzerland) via a lateral window. No membranes were used to cover the antrostomy defect in the experimental sites while in the control sites a resorbable porcine derived-collagen membrane was placed (Bio- Gide; GeitlishPharma, Wolhusen, Switzerland). The membrane was extended 2–3 mm beyond the antrostomy borders and stabilized with tacks. When residual bone height was ≥ 4 mm, im-

Torres 2013 *(Continued)*

	plants were placed simultaneously to sinus augmentation, otherwise, delayed placements were conducted 6 months after graft surgery. Implants were surgically exposed 6 months after placement, and restored with a fixed implant-supported prosthesis or bar for retention of a removable prosthesis
Outcomes	Prosthetic and implant failures, selected complications, and selected histomorphometric evaluation
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Article: "Patients or sites were allocated to intervention groups in a randomized sequence using a computer generated random number (GraphPad Software Inc., La Joya, CA, USA)"
Allocation concealment (selection bias)	Low risk	Article: "All surgeries were performed by the same surgeon, who was blinded to group allocation until the last step of the surgery (closure of antrostomy defect)"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Article: "Evaluations were performed by the same prosthodontist who was blinded to group allocation throughout the restorative treatment. Patients were also blinded to group allocation"
Incomplete outcome data (attrition bias) All outcomes	Low risk	The authors informed as that 2 patients from the membrane group moved to another town
Selective reporting (reporting bias)	High risk	Full data of complications not provided. Patients with perforations of the sinus epithelium the apparently were excluded from the study
Other bias	Low risk	None apparent

Wannfors 2000

Methods	Randomised trial of parallel group design, 3-year post-loading follow-up. No withdrawals at 3 years though 3 patients in the 1-stage group refused consent to remove the prostheses for testing implant stability
Participants	Edentulous patients with more than 2 mm but less than 7 mm of residual bone under the maxillary sinuses. Adults treated under general anaesthesia at the Karolinska Hospital, Stockholm, Sweden. Patients were included if they were edentulous in the upper jaw. Patients were excluded if they were older than 80 years, had pathologies in the maxillary sinus, had bone diseases or took medications known to effect bone metabolism (i.e. corticosteroids and bisphosphonates). 40 patients enrolled, 20 in each group
Interventions	1-stage sinus lift with monocortical iliac bone blocks fixed usually with 2 implants left to heal for 6 months versus 2-stage sinus lift with particulate bone from the iliac crest left to heal for 6 months and then usually 2 implants were inserted into the healed graft and were left to heal for an additional 6 months. All implants were titanium self tapping (Brånemark System, Nobel Biocare)
Outcomes	Prosthesis failures, implant failures and marginal bone level changes on intraoral radiographs taken with a paralleling technique at abutment connection, 1 and 3 years. Intraoperative sinus membrane perforations
Notes	

Wannfors 2000 *(Continued)*

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Article: "He (patient) was allotted to one of the two treatments according to a previously designed scheme by a third person" Author's reply: "The randomization was performed by a third person without any beforehand contact with the patients"
Allocation concealment (selection bias)	Unclear risk	Article: No information presented Author's reply failed to clarify the issue
Blinding of outcome assessment (detection bias) All outcomes	High risk	Article: No information presented Author's reply: "The outcome assessor had knowledge of the randomized group, however not when assessing the x-ray data"
Incomplete outcome data (attrition bias) All outcomes	Low risk	No withdrawals at 3 years
Selective reporting (reporting bias)	High risk	Full data of complications not provided
Other bias	Low risk	None apparent

PRP - platelet-rich plasma

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Aimetti 2008	The article presented data from 4 patients treated following a split-mouth design. Authors informed us that they actually treated 16 patients. We are unable to present the data for the remaining 12 patients
Badr 2010	Insufficient follow-up time (up to abutment connection), implants were not put even in function
Barone 2005	No clinical outcome measures related to implant treatment
Barone 2008	Insufficient follow-up time with no clinical outcome measures related to implant treatment
Barone 2013	No clinical outcome measures related to implant treatment
Bensaha 2011	Insufficient follow-up time (up to implant placement), implants were not even put in function
Bettega 2009	Insufficient follow-up time (up to abutment connection), implants were not even put in function
Borges 2011	Insufficient follow-up time (up to abutment connection), implants were not even put in function
Boyne 2005	Described as RCT, unclear number of patients, unequal number of patients in the treatment groups. No reply to letter
Canullo 2009	No clinical outcome measures related to implant treatment

Study	Reason for exclusion
Choi 2009	No clinical outcome measures related to implant treatment
Consolo 2007	No clinical outcome measures related to implant treatment
Cordaro 2008	No clinical outcome measures related to implant treatment
Corinaldesi 2013	No clinical outcome measures related to implant treatment
Crespi 2009	No clinical outcome measures related to implant treatment
Froum 1998	Described as RCT, unclear number of patients and tested interventions which seem to be much more than 8, unequal number of patients in the treatment groups. No reply to letter
Froum 2006	No clinical outcome measures related to implant treatment
Froum 2008	No clinical outcome measures related to implant treatment
Froum 2013	No clinical outcomes useful for the review and too short follow-up (study terminated before implant placement)
Gassling 2013	Insufficient follow-up time (up to abutment connection), implants were not put even in function
Ghanaati 2014	Trial is a CCT, not an RCT
Hallman 2008	No clinical outcome measures related to implant treatment
Hermund 2012	Insufficient follow-up time (up to abutment connection), implants were not even put in function
Kassolis 2005	No clinical outcome measures related to implant treatment
Khairy 2013	Insufficient follow-up time (up to abutment connection), implants were not put even in function
Kim 2009	No clinical outcome measures related to implant treatment
Kock 2010	Insufficient follow-up time (possibly up to initial prosthetic loading)
Kühl 2012	No clinical outcomes useful for the review and too short follow-up (study terminated before implant placement)
Kühl 2013	No clinical outcome measures related to implant treatment
Mangano 2007	The authors informed us that the trial was not an RCT but a CCT
Payer 2013	No clinical outcome measures related to implant treatment
Pikdöken 2011	No clinical outcome measures related to implant treatment
Sammartino 2011	Insufficient follow-up time (up to a couple of days after implant placements), implants were not even put in function
Schaaf 2008	Insufficient follow-up time (up to abutment connection), implants were not even put in function
Silvestri 2013	Insufficient follow-up time (up to abutment connection), implants were not even put in function
Steigmann 2005	No clinical outcome measures related to implant treatment

Study	Reason for exclusion
Suba 2006	No clinical outcome measures related to implant treatment
Szabó 2005	Insufficient follow-up time (up to abutment connection), implants were not even put in function
Tawil 2001	Inappropriate study design, neither parallel group nor split-mouth
Testori 2013	No clinical outcome measures related to implant treatment
Triplett 2009	Unclear how many patients were randomised to each group, data very confused and we were unable to retrieve sufficient data from the original publication. No reply to letter
Trombelli 2012	Insufficient follow-up time (up to 6 months after implant placement), implants were possibly loaded for a very short period
Wagner 2012	Data presented in a way we could not use. No reply to letter
Yilmaz 2013	No clinical outcome measures related to implant treatment

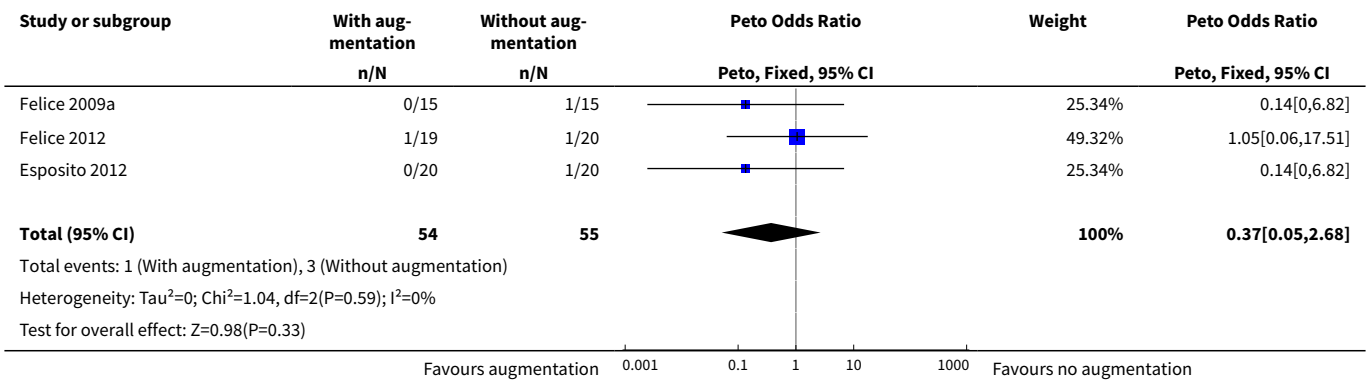
CCT - controlled clinical trial; RCT - randomised controlled trial

DATA AND ANALYSES

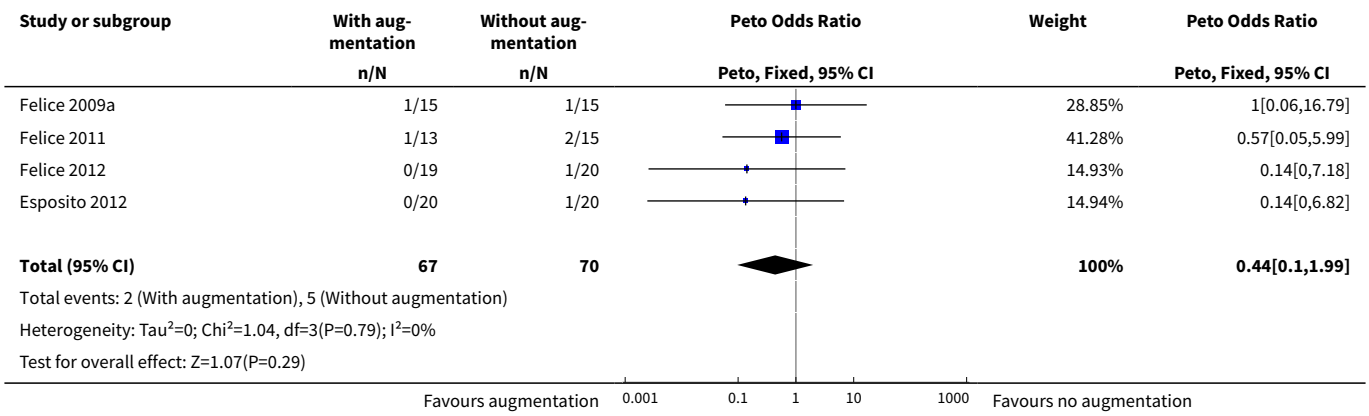
Comparison 1. Long implants with sinus lift versus short implants without augmentation

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Prosthesis failures 1 year	3	109	Peto Odds Ratio (Peto, Fixed, 95% CI)	0.37 [0.05, 2.68]
2 Implant failures 1 year	4	137	Peto Odds Ratio (Peto, Fixed, 95% CI)	0.44 [0.10, 1.99]
3 Complications 1 year	4	137	Peto Odds Ratio (Peto, Fixed, 95% CI)	4.77 [1.79, 12.71]

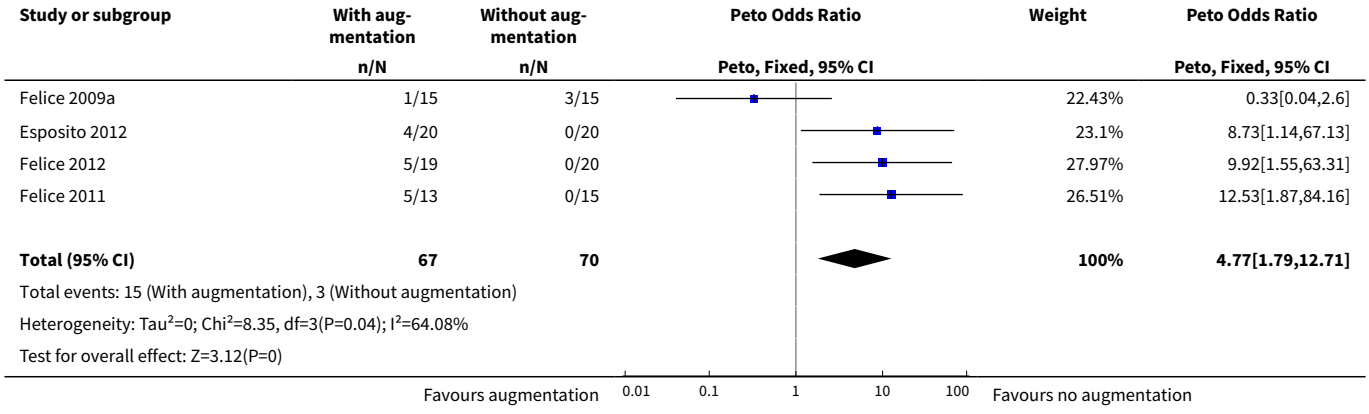
Analysis 1.1. Comparison 1 Long implants with sinus lift versus short implants without augmentation, Outcome 1 Prosthesis failures 1 year.



Analysis 1.2. Comparison 1 Long implants with sinus lift versus short implants without augmentation, Outcome 2 Implant failures 1 year.



Analysis 1.3. Comparison 1 Long implants with sinus lift versus short implants without augmentation, Outcome 3 Complications 1 year.



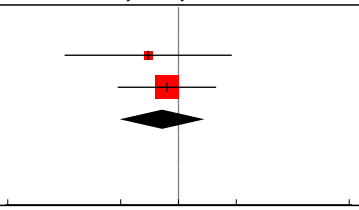
Comparison 2. Different sinus lift procedures

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Bone versus no bone graft	2		Odds Ratio (Fixed, 95% CI)	Subtotals only
1.1 Implant failures (1 year)	2		Odds Ratio (Fixed, 95% CI)	0.52 [0.10, 2.82]
2 Bone versus no bone graft	2		Mean Difference (Fixed, 95% CI)	2.89 [2.35, 3.43]
2.1 Bone gain	2		Mean Difference (Fixed, 95% CI)	2.89 [2.35, 3.43]
3 Autogenous bone versus bone substitute	2		Odds Ratio (Fixed, 95% CI)	Subtotals only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
3.1 Implant failures	2		Odds Ratio (Fixed, 95% CI)	4.20 [0.81, 21.79]
4 Autogenous bone or Bio-Oss +/- PRP	2		Odds Ratio (Fixed, 95% CI)	Subtotals only
4.1 Implant failures	2		Odds Ratio (Fixed, 95% CI)	1.40 [0.12, 16.52]
4.2 Complications	2		Odds Ratio (Fixed, 95% CI)	0.88 [0.13, 6.09]

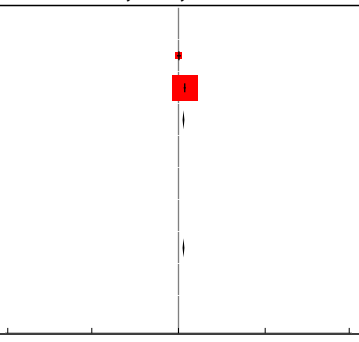
Analysis 2.1. Comparison 2 Different sinus lift procedures, Outcome 1 Bone versus no bone graft.

Study or subgroup	Bone N	No bone N	log[Odds Ratio] (SE)	Odds Ratio IV, Fixed, 95% CI	Weight	Odds Ratio IV, Fixed, 95% CI
2.1.1 Implant failures (1 year)						
Felice 2009b	0	0	-1.2 (1.7)		25.71%	0.3[0.01,8.35]
Si 2013	0	0	-0.5 (1)		74.29%	0.63[0.09,4.48]
Subtotal (95% CI)					**100%**	**0.52[0.1,2.82]**
Heterogeneity: Tau²=0; Chi²=0.14, df=1(P=0.7); I²=0%						
Test for overall effect: Z=0.76(P=0.45)						



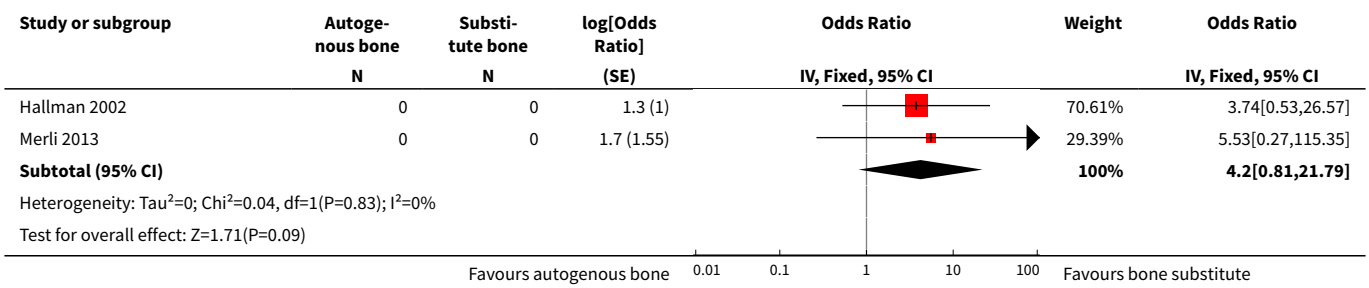
Analysis 2.2. Comparison 2 Different sinus lift procedures, Outcome 2 Bone versus no bone graft.

Study or subgroup	Bone graft N	No bone graft N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
2.2.1 Bone gain						
Felice 2009b	0	0	0.3 (0.595)		21.35%	0.26[-0.91,1.43]
Si 2013	0	0	3.6 (0.31)		78.65%	3.6[2.99,4.21]
Subtotal (95% CI)					**100%**	**2.89[2.35,3.43]**
Heterogeneity: Tau²=0; Chi²=24.78, df=1(P<0.0001); I²=95.97%						
Test for overall effect: Z=10.5(P<0.0001)						
Total (95% CI)					**100%**	**2.89[2.35,3.43]**
Heterogeneity: Tau²=0; Chi²=24.78, df=1(P<0.0001); I²=95.97%						
Test for overall effect: Z=10.5(P<0.0001)						

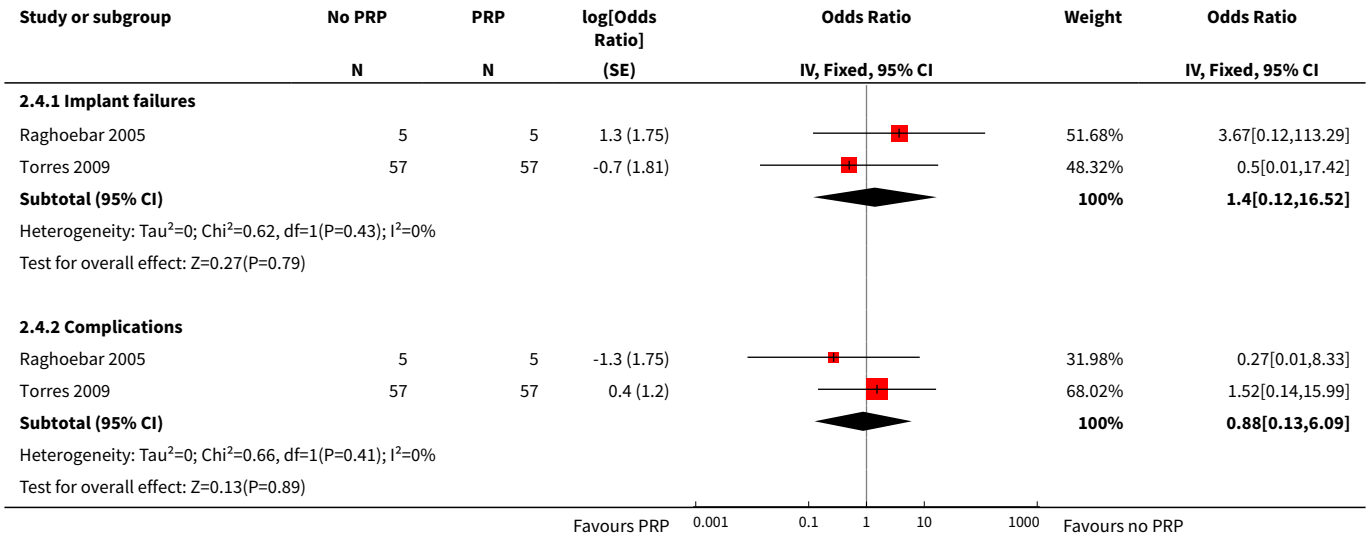


Analysis 2.3. Comparison 2 Different sinus lift procedures, Outcome 3 Autogenous bone versus bone substitute.

Study or subgroup	Autogenous bone N	Substitute bone N	log[Odds Ratio] (SE)	Odds Ratio IV, Fixed, 95% CI	Weight	Odds Ratio IV, Fixed, 95% CI
2.3.1 Implant failures						



Analysis 2.4. Comparison 2 Different sinus lift procedures, Outcome 4 Autogenous bone or Bio-Oss +/- PRP.



ADDITIONAL TABLES

Table 1. Comparison of different sinus lift procedures

Comparison	Outcome	Data	Effect estimate (95% CI) P value
Rotary instruments versus piezosurgery	Prosthesis failures	N = 36; none	N/A
	Implant failures	N = 36; none	N/A
(Rickert 2013)	Augmentation procedure failure	N = 36; none	N/A
Split-mouth	Complications at augmented site	N = 36; both = 2, rotary only = 6, piezosurgery only = 6, neither = 22	OR 1.00 (0.27 to 3.74) P = 1.00
	Complications at donor site	N = 36; none	N/A
With versus without bone graft	Prosthesis failures	N = 9; none	N/A
	Implant failures	N = 9; 1 failure for without	OR 3.35 (0.12 to 93.8) P = 0.48

Table 1. Comparison of different sinus lift procedures *(Continued)*

(Felice 2009b) Split-mouth	Complications (1 year)	N =9; both = 1, without = 2, with = 1, none = 5	OR 0.50 (0.01 to 9.60) P = 1.00
	Bone gain at 6 months	N = 9	MD 0.26 (-0.91 to 1.43) P = 0.65
With versus without bone graft (Si 2013) Parallel group	Prosthesis failures (1 year)	With bone versus without bone 2/22 versus 3/22	OR 0.63 (0.10 to 4.22) P = 0.64
	Implant failures (1 year)	2/22 versus 3/22	OR 0.63 (0.10 to 4.22) P = 0.64
	Augmentation procedure failure (1 year)	1/22 versus 2/22	OR 0.48 (0.04 to 5.67) P = 0.56
	Complications (1 year)	Not reported	N/A
	Bone gain at 6 months	Graft N = 21 5.66 (SD 0.99) versus no graft N = 20 2.06 (1.01)	MD 3.60 (2.99 to 4.21) P < 0.001
	Bone gain at 18 months	Graft N = 20 3.02 (SD 0.48) versus no graft N = 19 3.12 (0.70)	MD -0.10 (-0.47 to 0.27) P = 0.60
	Bone gain at 30 months	Graft N = 20 3.17 (SD 1.95) versus no graft N = 19 3.07 (1.68)	MD 0.10 (-1.04 to 1.24) P = 0.86
Autogenous bone versus bone substitute (Hallman 2002) Split-mouth	Implant failures (abutment connection)	N = 11; 5/11 autogenous bone versus 2/11 80% Bio-Oss. Assume not bilateral	OR 3.75 (0.54 to 26.04) P = 0.18
	Complications	N = 11; none	N/A
Autogenous bone versus bone substitute (Merli 2013) Parallel group	Implant failures	2/20 versus 0/20	OR 5.54 (0.25 to 123.08) P = 0.28
	Complications	2/20 versus 1/20	OR 2.11 (0.18 to 25.35) P = 0.56
Autogenous bone versus bone substitute (Lindgren 2012) Split-mouth	Prosthesis failures	0/11 versus 0/11	N/A
	Implant failures	1/11 versus 1/11	OR 1.00 (0.05 to 18.30) P = 1.00
	Augmentation procedure failure	0/11 versus 0/11	N/A
	Complications at augmented site	N = 11; both = 0, Bio-Oss only = 1, different bone substitute only = 0, neither = 10	OR 3.29 (0.12 to 89.8) P= 0.48
Autogenous bone ± PRP	Prosthetic failures	N = 5; none	N/A

Table 1. Comparison of different sinus lift procedures *(Continued)*

(Raghoebar 2005) Split-mouth	Implant failures	N = 5; 1 failure in PRP	OR 3.67 (0.12 to 113.73) P = 0.46
	Complications	N =5; 1 occurred in non-PRP	OR 0.27 (0.01 to 8.46) P = 0.46
Autogenous bone or Bio-Oss ± PRP (Torres 2009) Split-mouth	Implant failures	N = 57; both = 0, PRP only = 1, no PRP only = 2, neither = 54	OR 0.50 (0.01 to 17.42) P = 0.71
	Complications	N = 57; both = 0, PRP only = 3, no PRP only = 2, neither = 52	OR 1.49 (0.15 to 15.07) P = 1.00
	Partial graft loss	N = 57; both = 0, PRP only = 2, no PRP only = 3, neither = 52	OR 1.5 (0.17 to 17.96) P = 1.00 (Stata exact OR)
Membrane versus no membrane to seal the lateral window (Torres 2013) Parallel group	Prosthetic failures	9/51 versus 4/53	OR 2.63 (0.75 to 9.14) P = 0.13
	Implant failures	9/51 versus 4/53	OR 2.63 (0.75 to 9.14) P = 0.13
1-stage versus 2-stage (Felice 2013) Parallel group	Prosthesis failures	1-stage versus 2-stage 0/28 versus 1/30	0.35 (0.01 to 6.83) P = 0.52
	Implant failures (before loading)	3/28 versus 1/30	OR 3.48 (0.34 to 35.61) P = 0.29
	Complications	2/28 versus 1/30	OR 2.23 (0.19 to 26.06) P = 0.52
1-stage block versus 2-stage particulate bone (Wannfors 2000) Parallel group	Prosthetic failures	1/20 versus 1/20	OR 1.00 (0.06 to 17.18) P = 1.00
	Implant failures	8/20 versus 6/20	OR 1.56 (0.42 to 5.76) P = 0.51
	Complications	9/20 versus 10/20	OR 0.82 (0.24 to 2.84) P = 0.75
Crestal versus lateral sinus lift (Cannizzaro 2009) Parallel group	Prosthetic failures	1/20 versus 2/20	OR 0.47 (0.04 to 5.69) P = 0.56
	Implant failures	1/20 versus 3/20	OR 0.30 (0.03 to 3.15) P = 0.31
	Graft failures	0/20 versus 2/20	OR 0.18 (0.01 to 4.01) P = 0.28
	Complications at treated and donor sites (1 year)	1/20 versus 4/20	OR 0.21 (0.02 to 2.08) P = 0.18
	Partial graft loss	2/20 versus 3/20	OR 0.63 (0.09 to 4.24) P = 0.63
Mallet versus rotary	Prosthetic failures	N = 12; none	N/A

Table 1. Comparison of different sinus lift procedures *(Continued)*

(Checchi 2010)	Implant failures	N = 12; none	N/A
	Complications	N = 12; 5/12 versus 1/12	OR 7.86 (0.75 to 82.13) P = 0.09
Split-mouth	Preference 5 months after loading	N = 15; 13 preferred rotary technique	Binomial test P = 0.007
Hand mallet versus electric mallet (Crespi 2012) Parallel group Followed for 19 months after loading	Prosthesis failures	Hand mallet versus electric mallet 0/40 versus 0/40	N/A
	Implant failures (before loading)	1/40 versus 1/40	OR 1.00 (0.06 to 16.56) P = 1.00
	Augmentation failures	0/40 versus 0/40	N/A
	Complications at augmented site	3/40 versus 0/40	OR 3.16 (0.31 to 31.78) P = 0.33
	Bone gain	N = 40 4.17 (SD 1.70) versus N = 40 4.07 (SD 1.03)	MD 0.10 (-0.52 to 0.72) P = 0.75

Data on patients who dropped out removed from the table.
CI - confidence interval; MD - mean difference; OR - odds ratio; SD - standard deviation.

APPENDICES

Appendix 1. MEDLINE (OVID) search strategy

1. exp Dental Implants/
2. exp Dental Implantation/ or dental implantation
3. exp Dental Prosthesis, Implant-Supported/
4. ((osseointegrated adj implant$) and (dental or oral))
5. dental implant$
6. (implant$ adj5 dent$)
7. (((overdenture$ or crown$ or bridge$ or prosthesis or restoration$) adj5 (Dental or oral)) and implant$)
8. "implant supported dental prosthesis"
9. ("blade implant$" and (dental or oral))
10. ((endosseous adj5 implant$) and (dental or oral))
11. ((dental or oral) adj5 implant$)
12. OR/1-11

The above search was run with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials in MEDLINE: sensitivity maximising version (2009 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of the *Cochrane Handbook for Systematic Reviews of Interventions* version 5.1.0 (updated March 2011):

1. randomized controlled trial.pt.
2. controlled clinical trial.pt.
3. randomized.ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab.
9. or/1-8
10. exp animals/ not humans.sh.
11. 9 not 10

Appendix 2. Cochrane Oral Health Group's Trials Register search strategy

Updated searches were undertaken using the Cochrane Register of Studies and the search strategy below from January 2013:

#1 ("dental implant*" or "oral implant*" or "implant support*" or "endosseous implant*" or "blade implant*") AND (INREGISTER)
#2 ((implant* and (oral or dental))) AND (INREGISTER)
#3 ("subperiosteal implant*") AND (INREGISTER)
#4 ((implant* AND overdenture*)) AND (INREGISTER)
#5 (((overdenture* OR crown* OR bridge* OR prosthesis OR prostheses OR restoration*) AND ("dental implant*" OR "Oral implant" OR (zygoma* AND implant*)))) AND (INREGISTER)
#6 (#1 or #2 or #3 or #4 or #5) AND (INREGISTER)

Previous searches of the Register were undertaken using the Procite software and the search strategy below:

(dental-implants OR "dental implant*" OR "oral implant*" OR dental-implantation OR dental-prosthesis-implant-supported OR "implant supported" OR "implant supported prosthesis" OR dental-implantation-endosseous-endodontic OR "endosseous implant*" OR blade-implantation OR "blade implant*" OR (implant* AND (oral OR dental)) or dental-implantation-subperiosteal OR "subperiosteal implant" OR (implant* AND overdenture*) OR ((overdenture* OR crown* OR bridge* OR prosthesis OR prostheses OR restoration*) AND ("dental implant*" OR "Oral implant" OR (zygoma* AND implant*))))

Appendix 3. CENTRAL search strategy

#1 DENTAL IMPLANTS explode all trees (MeSH)
#2 DENTAL IMPLANTATION explode all trees (MeSH)
#3 DENTAL PROSTHESIS IMPLANT-SUPPORTED single term (MeSH)
#4 ((osseointegrat* near implant*) and (dental* or oral*))
#5 (dental next implant*)
#6 (implant* near dent*)
#7 dental-implant*
#8 ((overdenture* near dental*) and implant*)
#9 ((overdenture* near oral*) and implant*)
#10 ((crown* near dental*) and implant*)
#11 ((crown* near oral*) and implant*)
#12 ((bridge* near dental*) and implant*)
#13 ((bridge* near oral*) and implant*)
#14 ((prosthesis near dental*) and implant*)
#15 ((prosthesis near oral*) and implant*)
#16 ((prostheses near dental*) and implant*)
#17 ((prostheses near oral*) and implant*)
#18 ((restoration* near dental*) and implant*)
#19 ((restoration* near oral*) and implant*)
#20 (implant next supported next dental next prosthesis)
#21 (blade next implant*)
#22 ((endosseous near implant*) and dental)
#23 ((endosseous near implant*) and oral*)
#24 ((dental* near implant*) or (oral* near implant*))
#25 (#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24)

Appendix 4. EMBASE search strategy

1. tooth implantation/
2. ((implant-supported or implant$) adj support$).mp.
3. ((osseointegrated adj implant$) and (dental or oral)).mp.
4. ((dental implant$ or dental-implant or implant$) adj (dent$ or oral or tooth)).mp.
5. (((overdenture$ or crown$ or bridge$ or prosthesis or prostheses or restoration$) adj5 (dental or oral)) and implant$).mp.
6. "implant supported dental prosthesis".mp.
7. ("blade implant$" and (dental or oral or tooth or teeth)).mp.
8. ((endosseous adj5 implant$) and (dental or oral or tooth or teeth)).mp.
9. ((dental or oral or tooth or teeth) and implant$).mp.
10. or/1-9

The EMBASE subject search was run with the following sensitive search for controlled trials in EMBASE via OVID:

1. random$.ti,ab.
2. factorial$.ti,ab.
3. (crossover$ or cross over$ or cross-over$).ti,ab.
4. placebo$.ti,ab.
5. (doubl$ adj blind$).ti,ab.
6. (singl$ adj blind$).ti,ab.
7. assign$.ti,ab.
8. allocat$.ti,ab.
9. volunteer$.ti,ab.
10. CROSSOVER PROCEDURE.sh.
11. DOUBLE-BLIND PROCEDURE.sh.
12. RANDOMIZED CONTROLLED TRIAL.sh.
13. SINGLE BLIND PROCEDURE.sh.
14. or/1-13
15. ANIMAL/ or NONHUMAN/ or ANIMAL EXPERIMENT/
16. HUMAN/
17. 16 and 15
18. 15 not 17
19. 14 not 18

WHAT'S NEW

Date	Event	Description
12 August 2014	Amended	Minor edits.

HISTORY

Protocol first published: Issue 2, 2002
Review first published: Issue 3, 2010

Date	Event	Description
7 May 2014	New citation required and conclusions have changed	Review update including 8 new studies bringing the total to 18 included studies. The methods have been updated and the risk of bias done for all included studies.
4 March 2014	New search has been performed	Search updated to January 2014.
17 March 2010	Amended	Minor edits.

CONTRIBUTIONS OF AUTHORS

Conceiving, designing and co-ordinating the review (Marco Esposito (ME)).
Screening search results and retrieved papers against inclusion criteria (ME, Helen Worthington (HW)).
Writing to authors for additional information (ME).
Appraising quality (ME, Pietro Felice (PF), HW).
Data extraction (ME, HW, PF).
Analysis and interpretation of the data (ME, HW).
Writing the review (ME, HW).
Performing previous work that was the foundation of the current study (ME, HW).

DECLARATIONS OF INTEREST

Marco Esposito and Pietro Felice are among the authors of eight of the included trials, however, they were not involved in the quality assessment of these trials.
Helen V Worthington: no interests to declare.

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

This review originates from a previous larger review evaluating all types of augmentation procedures for dental implant placement (Esposito 2008). The minimal follow-up for trials to be included has been moved from abutment connection to four months post-loading.

INDEX TERMS

Medical Subject Headings (MeSH)

Alveolar Ridge Augmentation [methods]; Dental Implantation, Endosseous [*methods]; Dental Restoration Failure; Jaw, Edentulous, Partially [*rehabilitation]; Maxillary Sinus [surgery]; Randomized Controlled Trials as Topic; Sinus Floor Augmentation [*methods]

MeSH check words

Humans