Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants) (Review)

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[Intervention Review]

Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

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ABSTRACT

Background

'Immediate' implants are placed in dental sockets just after tooth extraction. 'Immediate-delayed' implants are those implants inserted after weeks up to about a couple of months to allow for soft tissue healing. 'Delayed' implants are those placed thereafter in partially or completely healed bone. The potential advantages of immediate implants are that treatment time can be shortened and that bone volumes might be partially maintained thus possibly providing good aesthetic results. The potential disadvantages are an increased risk of infection and failures. After implant placement in postextractive sites, gaps can be present between the implant and the bony walls. It is possible to fill these gaps and to augment bone simultaneously to implant placement. There are many techniques to achieve this but it is unclear when augmentation is needed and which could be the best augmentation technique.

Objectives

To evaluate success, complications, aesthetics and patient satisfaction between 'immediate', 'immediate-delayed' and 'delayed' implants.

To evaluate whether and when augmentation procedures are necessary and which is the most effective technique.

Search methods

The Cochrane Oral Health Group's Trials Register (to 2 June 2010), CENTRAL (*The Cochrane Library* 2010, Issue 2), MEDLINE via OVID (1950 - 2 June 2010) and EMBASE via OVID (1980 - 2 June 2010) were searched. Several dental journals were handsearched.

Selection criteria

Randomised controlled trials (RCTs) comparing immediate, immediate-delayed, and delayed implants, or comparing various bone augmentation procedures around the inserted implants, reporting the outcome of the interventions to at least 1 year after functional loading.

Data collection and analysis

Screening of eligible studies, assessment of the methodological quality of the trials and data extraction were conducted independently and in duplicate. Trial authors were contacted for any missing information. Results were expressed as random-effects models using mean differences for continuous outcomes and risk ratios (RR) for dichotomous outcomes with 95% confidence intervals (CIs). The statistical unit of the analysis was the patient.

Main results

Fourteen eligible RCTs were identified but only seven trials could be included. Four RCTs evaluated implant placement timing. Two RCTs compared immediate versus delayed implants in 126 patients and found no statistically significant differences. One RCT compared immediate-delayed versus delayed implants in 46 patients. After 2 years patients in the immediate-delayed group perceived the time to functional loading significantly shorter, were more satisfied and independent blinded assessor judged the level of the perimplant marginal mucosa in relation to that of the adjacent teeth as more appropriate (RR = 1.68; 95% CI 1.04 to 2.72). These differences disappeared 5 years after loading but significantly more complications occurred in the immediate-delayed group (RR = 4.20; 95% CI 1.01 to 17.43). One RCT compared immediate with immediately delayed implants in 16 patients for 2 years and found no differences. Three RCTs evaluated different techniques of bone grafting for implants immediately placed in extraction sockets. No statistically significant difference was observed when evaluating whether autogenous bone is needed in postextractive sites (1 trial with 26 patients) or which was the most effective augmentation technique (2 trials with 56 patients).

Authors' conclusions

There is insufficient evidence to determine possible advantages or disadvantages of immediate, immediate-delayed or delayed implants, therefore these preliminary conclusions are based on few underpowered trials often judged to be at high risk of bias. There is a suggestion that immediate and immediate-delayed implants may be at higher risks of implant failures and complications than delayed implants on the other hand the aesthetic outcome might be better when placing implants just after teeth extraction. There is not enough reliable evidence supporting or refuting the need for augmentation procedures at immediate implants placed in fresh extraction sockets or whether any of the augmentation techniques is superior to the others.

PLAIN LANGUAGE SUMMARY

Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Dental implants can be placed in sockets just after tooth extraction (immediate implants) or after a couple of weeks up to a couple of months (immediate-delayed implants) or thereafter (delayed implants). This review looked at which was the best time to place dental implants and whether it would be advantageous to augment sites with gaps present at implant placement. It also tried to determine the most effective bone augmentation procedure.

The seven identified studies included too few patients to answer the questions. Four studies evaluated which is the best time to place implants. One study evaluated whether bone grafting is advantageous at implant placement and two studies evaluated which are the best grafting techniques.

There is currently too little evidence to draw any reliable conclusions, however, the aesthetic outcome could be slightly better when placing implants early after tooth extraction, though early placed implants might be at a higher risk of failure. There is not enough evidence supporting or refusing the need of bone augmentation when extracted teeth are immediately replaced with dental implants, nor it is known whether any augmentation procedure is better than the others. Bone substitutes (anorganic bovine bone) can be used instead of self generated (autogenous) bone graft.

BACKGROUND

Missing teeth and supporting oral tissues have traditionally been replaced with dentures or bridges permitting restoration of chewing function, speech, and aesthetics. Dental implants offer an alternative. These implants are inserted into the jawbones to support a dental prosthesis and are retained because of the intimacy of bone growth on to their surface. This direct structural and functional connection between living bone and implant surface, termed osseointegration, was first described by Brånemark 1977 and has undoubtedly been one of the most significant scientific breakthroughs in dentistry over the past 30 years.

Teeth may have been lost through dental disease or trauma or they may be congenitally absent. However in many clinical situations compromised teeth or roots may still be present in the patient's mouth. Traditionally, before placing dental implants, compromised teeth were removed and the extraction sockets were left to heal for between several months and 1 year. However, the great majority of patients are interested in shortening the treatment time between tooth extraction and implant placement, or even better in having the implants inserted during the same session as the teeth are extracted (immediate implants). This would result in patients having fewer surgical sessions and shorter treatment periods. Another potential advantage with immediate implants is that the amount of bone loss which physiologically occurs during the remodeling phase of the extraction socket might be reduced if the implant is placed early during the healing process. Finally, it may not even be necessary to raise a flap in several situations when placing dental implants. On the other hand there are also some potential disadvantages with immediate implants such as: (1) an enhanced risk of infections and the associated failures if the socket becomes infected (Rosenquist 1996; Takeshita 1997); (2) the mismatch between the implant surface and the socket wall, therefore gaps may be present after implantation since dental roots do not have a regular circular diameter shape (it is also possible that one or more bony socket walls are partly resorbed either due to the disease processes or damaged as a result of the tooth extraction procedure); (3) the necessity of raising a flap for covering the implants, if a two-stage implantation procedure is preferred (Rosenquist 1997).

These potential problems have been tackled in different ways. Manufacturers have designed specific implant systems to be used as immediate implants having various troncoconical shapes and different diameters in order to be used in sockets of varying dimensions (Gomez-Roman 1997). Some dentists wait for some time, generally 2 to 8 weeks, before placing the implants, in order to achieve some soft tissue healing and decrease the risk of infections (immediate-delayed implants).

Depending on the degree of damage of the extraction socket and of the shape as well as the diameter of the extracted root, some portion of the implants could remain exposed and/or there might remain a residual gap between the implant and the bony wall. Since alveolar bone will remodel after tooth extraction, the degree of bone resorption is difficult to predict and could leave some portion of the implants exposed, determining a poor aesthetic outcome. In order to prevent this problem it has been suggested to augment the socket just after implant placement using various bone augmentation techniques such as autogenous bone grafts (Ross 1989; Becker 1994a), bone substitutes (Block 1991; Yukna 1991), guided bone regeneration (GBR) with resorbable (Lazzara 1989; Becker 1994b; Rosenquist 2000) or non-resorbable barriers, and various bone promoting molecules such as enamel matrix derivative (Cangini 2005), platelet rich plasma (PRP), growth factors and bone morphogenetic proteins (BMPs) in order to accelerate and increment bone formation. However, it is unclear whether bone augmentation procedures are of any benefit for immediate implants, since immediate and immediate-delayed implants can be successful and heal properly without any bone graft procedures (Covani 2004).

A few reviews (Esposito 1998; Chen 2004; Fugazzotto 2005; Schropp 2008) evaluating the efficacy of immediate implants, have been published over the years but so far evidence was inconclusive. It would be of great benefit to know whether the number of surgical sessions, treatment time and patient discomfort may be reduced using immediate implants without compromising the success of the implant therapy, and if and when bone augmentation could be beneficial, by conducting a rigorous systematic review of randomised controlled trials (RCTs).

OBJECTIVES

(A) To test the null hypothesis of no difference in the success, function, complications and patient satisfaction between 'immediate', 'immediate-delayed' and 'delayed' implants, against the alternative hypothesis of a difference. The following comparisons were evaluated.

(1) Immediate versus delayed implants.

(2) Immediate-delayed versus delayed implants.

(3) Immediate versus immediate-delayed implants.

(B) To test whether and when augmentation procedures are necessary at immediate and immediate-delayed implants.

(C) To test which is the most effective augmentation technique.

METHODS

Criteria for considering studies for this review

Types of studies

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

Types of participants

Patients with compromised teeth to be extracted who required dental implants with or without bone augmentation procedures at the extraction sites.

Types of interventions

We used the following definitions:

- Immediate implants (test procedure 1): any implant placed in a fresh extraction socket just after tooth extraction.
- Immediate-delayed implants (test procedure 2): any implant placed in a extraction socket within 8 weeks after tooth extraction.
- Delayed implants (control procedure): any implants placed at least 2 months after tooth extraction.

For RCTs to be eligible in this review, they had to evaluate osseointegrated 'root-formed' dental implants with a follow-up of at least 1 year under functional loading comparing:

- immediate versus delayed implants
- immediate-delayed versus delayed implants
- immediate versus immediate-delayed implants
- augmentation versus no augmentation at immediate or immediate-delayed implants
- various augmentation procedures at immediate or immediate-delayed implants.

Patients treated with augmentation procedures, including grafting with autogenous bone or bone substitutes, guided bone regeneration (GBR), and other active agents such as bone morphogenetic proteins (BMPs) or platelet rich plasma (PRP) at placement of immediate or immediate-delayed implants were included in this review. The following time points were considered: 1, 3 and 5 years after loading.

Types of outcome measures

- Prosthesis failure: planned prosthesis which could not be placed because of implant failure(s) and loss of the prosthesis secondary to implant failure(s).
- Implant failure: implant mobility and removal of stable implants dictated by progressive marginal bone loss or infection (biological failures). Biological failures were grouped as early (failure to establish osseointegration) and late failures (failure to maintain the established osseointegration). Implant mobility could be assessed manually or with instruments such as Periotest (Siemens AG, Benshein, Germany) or resonance frequency (Osstell, Integration Diagnostics, Göteborg, Sweden).
- Major complications at the implant or donor site (i.e. infection, nerve injury, haemorrhage, etc).
- Patient satisfaction including aesthetics.
- Patient preference including aesthetics (only in split-mouth trials).
- Aesthetics evaluated by dentist.
- Perimplant marginal bone level changes over time on periapical radiographs taken with the paralleling technique.
- Vertical and/or horizontal bone gain expressed in mm or percentage (only for the augmentation procedures).
- Duration of the treatment time starting from tooth extraction to functional loading of the implants.
- Difference in treatment costs.

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

Search methods for identification of studies

For the identification of studies 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 5.0.2 [updated September 2009] (Higgins 2009). Details of the MEDLINE search are provided in Appendix 1.

Searched databases

- The Cochrane Oral Health Group's Trials Register (to 2nd June 2010) (see Appendix 2).
- CENTRAL (*The Cochrane Library* 2010, Issue 2) (see Appendix 3).
- MEDLINE via OVID (1950 to 2nd June 2010) (see Appendix 1).
- EMBASE via OVID (1980 to 2nd June 2010) (see Appendix 4).

Language

There were no language restrictions.

Unpublished studies

We wrote to all the authors of the identified RCTs, we checked the bibliographies of all identified RCTs and relevant review articles, and we 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 this due to poor yield.

Handsearching

Details of the journals being handsearched by the Cochrane Oral Health Group's ongoing programme are given on the website: www.ohg.cochrane.org.

The following journals have been identified as being potentially important to be handsearched for this review: *British Journal of Oral and Maxillofacial Surgery*, *Clinical Implant Dentistry and Related Research*, *Clinical Oral Implants Research*, *European Journal of Oral Implantology*, *Implant Dentistry*, *International Journal of Oral and Maxillofacial Implants*, *International Journal of Oral and Maxillofacial Surgery*, *International Journal of Periodontics and Restorative Dentistry*, *International Journal of Prosthodontics*, *Journal of Clinical Periodontology*, *Journal of Dental Research*, *Journal of Oral Implantology*, *Journal of Oral and Maxillofacial Surgery*, *Journal of Periodontology*, *Journal of Prosthetic Dentistry*. Where these have not already been searched as part of the Cochrane Journal Handsearching Programme, the journals were handsearched by one review author up to the month in which the last electronic search was undertaken.

The bibliographies of all identified RCTs and relevant review articles were checked for studies outside the handsearched journals. Personal references were also searched.

Data collection and analysis

Study selection

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 validity assessment and data extraction. Studies rejected at this or subsequent stages were recorded in the 'Characteristics of excluded studies' table, and reasons for exclusion recorded.

Data extraction

Data were extracted by two review authors independently 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 consulted where necessary. All authors were contacted for clarification or missing information.

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.

Measure of treatment effect

For dichotomous outcomes, the estimate of effect of an intervention was expressed as risk ratios (RR) together with 95% confidence intervals (CIs). For continuous outcomes, mean differences and standard deviations were used to summarise the data for each group using mean differences and 95% CIs.

Unit of analysis issues

The statistical unit was the patient and not the prosthesis or implant.

Dealing with missing data

All trial authors were contacted to retrieve missing data where necessary. Data were excluded until further clarification was available if agreement could not be reached. Methods for estimating missing standard deviations in section 7.7.3 of the Cochrane Handbook (Higgins 2009) will be used. An ITT analysis was undertaken if data available and appropriate.

Assessment of heterogeneity

The significance of any discrepancies 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 $P < 0.1$. 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 substantial 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 the recommendations on testing for funnel plot asymmetry (Egger 1997) as described in the Cochrane Handbook (Higgins 2009). If asymmetry was identified we would have examined possible causes.

Data synthesis

Only if there were studies of similar comparisons reporting the same outcome measures a meta-analysis was done. Risk ratios were combined for dichotomous data, and mean differences for continuous data, using fixed-effect models. Random-effects models were to be used if there were more than three studies in the meta-analysis. Data from split-mouth studies were to be combined with data from parallel group trials with the method outlined by Elbourne (Elbourne 2002), using the generic inverse variance method in RevMan. Numbers needed to treat (NNT) were to be calculated for patients affected by implant failures. The Cochrane Handbook (Higgins 2009) recommendations were followed for studies with zero-cell counts. The fixed value of 0.5 was added to all cells with zero-cell counts and risk ratios calculated with the RevMan software. If there were no events in both arms, no calculations were undertaken because in this situation the study does not provide any indication of the direction or magnitude of the relative treatment effect.

For the Visual Analogue Scores where the median and interquartile range were presented, and the data were not skewed, the standard deviation was estimated as the width of the interquartile range/ 1.35.

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. No hypotheses, to be investigated for subgroup analyses, were formulated, however this may be done in future updates of this review.

Sensitivity analyses

It was planned to undertake sensitivity analyses to examine the effect of the study quality assessment on the overall estimates of effect. In addition, the effect of including unpublished literature on the review's findings was also to be examined. There were too few trials to undertake these analyses.

Assessment of risk of bias in included studies

This was conducted using the recommended approach for assessing risk of bias in studies included in Cochrane reviews (Higgins 2009). It is a two-part tool, addressing the six specific domains (namely sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting and 'other issues'). Each domain includes one specific entry in a 'Risk of bias' table. Within each entry, the first part of the tool involves describing what was reported to have happened in the study. The second part of the tool involves assigning a judgement relating to the risk of bias for that entry. This is achieved by answering a prespecified question about the adequacy of the study in relation to the entry, such that a judgement of 'Yes' indicates low risk of bias, 'No' indicates high risk of bias, and 'Unclear' indicates unclear or unknown risk of bias.

The risk of bias assessment of the included trials was undertaken independently and in duplicate by two review authors as part of the data extraction process. 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 trials.

Summarising risk of bias for a study:

After taking into account the additional information provided by the authors of the trials, 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

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.
See Characteristics of included studies table.

Characteristics of the trial setting and investigators

- Of the 14 potentially eligible trials (Gher 1994; Carpio 2000; Norton 2002; Prosper 2003; Schropp 2003; Cornelini 2004; Chen 2005a; Chen 2005b; Fiorellini 2005; Lindeboom 2006; Chen 2007; Palattella 2008; Becker 2009; Block 2009), seven trials were included (Schropp 2003; Chen 2005a; Chen 2005b; Lindeboom 2006; Chen 2007; Palattella 2008; Block 2009) and seven trials were excluded for the following reasons: problems with study design and/or the data (Gher 1994; Prosper 2003); reported only histological outcomes without presenting any implant related outcomes (Fiorellini 2005); described as randomised controlled trial (RCT) but in fact patients were not randomised (Norton 2002); an unknown quota of patients had immediate-delayed implant sites augmented (Carpio 2000; Becker 2009); and follow-up limited to abutment connection/ implant loading (Cornelini 2004).

- All trials had a parallel group study design. Data of two distinct RCTs were presented together as if it was a single RCT in one publication. However the authors clarified this, and we presented the trials as two separate RCTs (Chen 2005a; Chen 2005b).

- Three trials were conducted in Australia (Chen 2005a; Chen 2005b; Chen 2007), one in Denmark (Schropp 2003), one in the Netherlands (Lindeboom 2006), one in Italy (Palattella 2008), and one in USA (Block 2009).

- Three trials were conducted in private practices (Chen 2005a; Chen 2005b; Chen 2007) and 4 in university dental clinics (Schropp 2003; Lindeboom 2006; Palattella 2008; Block 2009).

- For four trials it was declared that some sort of support was received from industry directly involved in the product being tested also in the form of free material (Schropp 2003; Chen 2005a; Chen 2005b; Lindeboom 2006). The authors of three trials declared that no support was received from commercial parties whose products were being tested in the trial (Chen 2007; Palattella 2008; Block 2009).

Characteristics of the interventions

(1) Immediate versus delayed implants (2 trials)

- One trial (Lindeboom 2006) compared immediate (same day) versus delayed (3 months on average) implants after extractions of periapically infected single teeth. Twenty-five patients were included in each group. Implants were placed 2 mm below the cervical junction of the adjacent teeth. Autogenous bone grafts from the trigonum retromolar or chin region were covered with a bioresorbable collagen membrane (Bio-Gide, Geistlich AG, Wolhusen, Switzerland) in all patients and implants were submerged and left healing for 6 months. Single crowns were cemented with temporary cement. All implants were Frialit-2 Synchro (Dentsply Friadent Ceramed, Mannheim, Germany).

- One trial (Block 2009) compared single immediate (same day) versus delayed (4 months) implants in maxillary anterior sites up to premolars. Seventy-six patients were recruited and randomised, however it was not specified how many in each group. The implant's axis of immediate implants was directed palatal to the planned incisal edge, and at least 2 mm palatal to the emergence line angle. The implant was placed with the coronal surface of the implant 3 mm apical to the gingival margin of the planned restoration. The length of the implants was 13 mm except when the maxillary sinus limited the implant length to 11.5 mm. When a gap was present between the implant and the labial bone, a graft of human mineralised bone was used to graft the site and preserve the width of the ridge. Immediate implants were immediately provisionalised with acrylic crowns not in occlusion, whereas delayed sites were grafted with human mineralised bone (350 to 500 micron, cortical, freeze-dried, U Miami Tissue Bank, Miami, FL, USA). After the graft had been compressed, a piece of collagen (Collaplug; Zimmer Dental, Carlsbad, CA) was placed over the graft and under the margins of the labial and palatal gingiva. 4-0 Chromic sutures were placed in a horizontal mattress fashion to gently conform the gingiva to the collagen. After a healing period of 4 months, implants were placed and immediately temporised. Four months after implant placement final restorations were made. All implants were straight wall design, threaded, with a roughened surface, and a parallel type abutment implant interface (Certain Implant; Biology of Metals 3i, Palm Beach Gardens, FL, USA).

2) Immediate-delayed versus delayed implants (1 trial)

- One trial (Schropp 2003) compared immediate-delayed (10 days on average) versus delayed implants (3 months on average) after extractions of compromised single teeth. Twenty-three patients were included in each group. Implants were placed with the top of the cover screw even with the bone ridge. Autogenous bone grafting was done when implants threads were exposed at

abutment connection for immediate-delayed implants and at both implant placement and at abutment connection for delayed implants. Implants were submerged and left to heal for about 3 months. Single-tooth metal-ceramic crowns were provided. All implants were Osseotite (3i Implant Innovations Inc, Palm Beach Gardens, FL, USA).

(3) Immediate versus immediate-delayed implants (1 trial)

- One trial (Palattella 2008) compared immediate implants versus immediate-delayed implants (8 weeks) after flap elevation and extractions of compromised single maxillary teeth in the aesthetic area. Eight patients (nine teeth) were included in each group. Implants were placed with an insertion torque of 35 Ncm 2 mm apical to the cemento-enamel junction of the adjacent teeth. Implants were immediately restored within 48 hours with provisional acrylic crowns not in occlusal contact. All implants were tapered effect (TE) implants Straumann Dental Implant System (Institut Straumann AG, Waldenburg, Switzerland).

(4) Are augmentation procedures necessary? (1 trial)

- One trial compared particulate autogenous bone harvested from the implant site by means of a filter attached to a dedicated suction line (Osseous Coagulum Trap, Quality Aspirators, Duncanville, TX, USA) in 14 patients versus no augmentation procedure in 12 patients for immediate single implants placed in fresh extraction sockets at maxillary anterior or premolar sites (Chen 2005b). Wound closure was achieved by use of a connective tissue graft taken from the palate. Implants were submerged and left to heal for 6 months. All implants were turned surface, screw-type, titanium Brånemark implants (Nobel Biocare, Göteborg, Sweden). All patients were rehabilitated with single implant supported crowns.

(5) Which are the most effective augmentation procedures? (2 trials)

- One trial compared non-resorbable ePTFE barrier (Gore-Tex, WL Gore and Associates, Inc, Flagstone, USA) alone in 12 patients versus resorbable barrier (Resolut, Gore-Tex, WL Gore and Associates, Inc, Flagstone, USA) alone in 11 patients versus resorbable barrier (Resolut) supported by particulate autogenous bone harvested from the implant site by means of a filter attached to a dedicated suction line (Osseus Coagulum Trap, Quality Aspirators, Duncanville, TX, USA) in 13 patients for immediate single implants placed in fresh extraction sockets at maxillary anterior or premolar sites (Chen 2005a). All barriers were tucked beneath the flaps. Wound closure was achieved by use of a connective tissue graft taken from the palate. All implants were turned surface, screw-type, titanium Brånemark implants (Nobel Biocare, Göteborg, Sweden). All patients were rehabilitated with single implant supported crowns.

- One trial compared bovine anorganic bone (Bio-Oss, Geistlich Pharmaceutical, Wolhusen, Switzerland) in 10 patients versus Bio-Oss plus resorbable porcine-derived collagen barrier (Bio-Gide) in 10 patients for immediate single implants placed in fresh extraction sockets at maxillary anterior or premolar sites 2 to 3 mm apical to the cemento-enamel junction of the adjacent teeth (Chen 2007). Barriers were trimmed as required and fixed to the implants by the healing screw. Implants were not submerged and left to heal for 6 months. All implants were ITI SLA (Institut Straumann AG, Waldenburg, Switzerland). In the original trial a control group that received no graft or barrier was included, but we could not use the data due the subversion of the randomisation procedure. All patients were rehabilitated with single implant supported crowns.

Characteristics of outcome measures

- Prosthesis failures: all trials.
- Implant failures: all trials.
- Major complications at implant/donor site: all trials with one exception (Block 2009).
- Patient satisfaction including aesthetics: Schropp 2003; Chen 2007. We used the patients' answers on a 100 mm visual analogue scale (VAS) to the following questions: (1) "How did you experience the period between tooth extraction and insertion of the implant crown?"; (2) "Are you in general satisfied with the appearance of the crown?"; (3) "How was your experience of the overall treatment?" On the VAS, the most negative expression corresponded to 0 and the most positive to 100 (Schropp 2003). Patients expressed whether they were dissatisfied or not with the aesthetic outcome in the other trial (Chen 2007).
- Patient preference including aesthetics (only in split-mouth trials): no trials.
- Aesthetics assessed by dentist: evaluated in five trials (Schropp 2003; Lindeboom 2006; Chen 2007; Palattella 2008; Block 2009). In one trial (Schropp 2003), an experienced prosthodontist, who had not been involved in the treatment and blind to the interventions, evaluated the clinical photographs of the single crowns which included one adjacent tooth from each side. Photographs were done 1 week after seating of the prosthetic restoration and 16 to 18 months later. The following parameters were evaluated: (a) the interproximal papilla dimensions, assessed as 0 = no papilla or negative papilla; 1 = less than half of the height of the proximal area occupied by soft tissue; 2 = at least half of the height of the proximal area occupied by soft tissue; (b) clinical crown height, assessed as: 1 = too long; 2 = too short; 3 = appropriate in relation to the level of the marginal mucosa when compared to that of the adjacent teeth, rather than the incisal/occlusal extension of the crown. The papilla score was dichotomised as 2 (good outcome) or not. The crown length was also dichotomised as appropriate (score 3) or not. In three trials (Lindeboom 2006; Palattella 2008; Block 2009), the interproximal gingival papillae was evaluated

according to the papilla score (Jemt 1998): 0 = no papillae; 1 = less than one half of the gingival embrasure; 2 = at least one half of the height; 3 = complete closure of the proximal space; 4 = overgrowth. We dichotomised this outcome into 0, 1 and 4 as negative outcome, and 2 to 3 as positive outcome, and evaluated the proportion for the negative outcome. The mid-buccal gingival level (Lindeboom 2006) was assessed by measuring the difference with the buccal gingival outline of the adjacent teeth: 0 = no difference in gingival level; 1 = less than 1 mm difference; 2 = less than 2 mm difference; 3 = less than 3 mm difference; 4 = differences in buccal gingival outline greater than 3 mm. We dichotomised this outcome into 0 to 1 (= positive outcome) and 2 to 4 (= negative outcome) and evaluated the proportion for the negative outcome. The papilla score could not be evaluated in two trials (Palattella 2008; Block 2009) since data were presented in a way we could not use. In one trial (Chen 2007) the operator assessed whether marginal mucosal recession occurred or not. In one trial (Palattella 2008) the position of mucosal margin was measured by the operator as the distance in mm from the most apical point of the gingival margin to the implant shoulder measured in mm with the aid of a periodontal probe. The records were taken to the nearest 0.5 mm at the moment of the delivery of the provisional restoration (baseline) and at the 2-year follow-up visit. In another trial (Block 2009) the position of mucosal margin was measured by using a fixed reference mark on a a customised stent, however data were presented in a way we could not use.

- Perimplant marginal bone level changes were measured in five trials (Schropp 2003; Lindeboom 2006; Chen 2007; Palattella 2008; Block 2009) but data were presented in a way we could not use in two trials (Chen 2007; Block 2009) whereas for another trial (Lindeboom 2006) we randomly picked up the measurements of mesial sides since measurements at mesial and distal sides were presented separately (baseline implant placement). Our preferred baseline was set at implant placement, however, in one trial (Schropp 2003), baseline was set at abutment connection.
- Bone gain vertically or horizontally or both expressed in mm or percentage including bone level changes over time (only for the augmentation procedures): vertical bone gain was measured in mm by direct measurements in three studies (Chen 2005a; Chen 2005b; Chen 2007).
- Treatment duration: all trials.
- Difference in treatment costs: possible to extrapolate.

Characteristics at baseline

Main inclusion criteria

- Single postextractive fresh sockets at anterior and premolar sites (Schropp 2003).
- Single postextractive fresh sockets at maxillary anterior and premolar sites (Chen 2005a; Chen 2005b; Chen 2007; Palattella 2008; Block 2009).
- Single postextractive fresh sockets at maxillary anterior and premolar sites of periapically infected teeth (Lindeboom 2006).

Main exclusion criteria

- Medically compromised patients (metabolic diseases, immune deficient or under immune-suppressive therapy, irradiated, etc) (Schropp 2003; Lindeboom 2006; Palattella 2008; Block 2009).
- Smokers (Chen 2005a; Chen 2005b; Lindeboom 2006), heavy smokers (Palattella 2008).
- Postmenopausal women with known osteoporosis as determined by their medical internist (Block 2009).
- Acute infection and suppuration at the fresh extraction socket (Chen 2005a; Chen 2005b; Chen 2007; Palattella 2008; Block 2009).
- 5 mm or more of buccal bone loss (Chen 2007).
- Insufficient bone to achieve primary stability of the implant (Schropp 2003).
- Insufficient primary implant stability (< 25 Ncm) (Lindeboom 2006).
- Loss of alveolar bone at extraction (Palattella 2008).
- Less than 2 mm of attached or keratinised gingiva (Palattella 2008).
- No bone present on all surfaces of the experimental tooth site within 3 mm of the gingival margin of the planned restoration (Block 2009).
- Less than 1:2 crown-implant ratio (Block 2009).

Comparability of control and treatment groups at entry

No apparent major baseline differences for all trials, however, implants with a larger diameter were used in the immediate group in one trial (Lindeboom 2006), and another trial did not present sufficient information to be able to decide (Block 2009).

Antibiotic prophylaxis at implant placement

- Amoxicillin tablets 750 mg were given 1 hour before surgery and 750 mg x 3 daily the following 5 days (Schropp 2003).
- Clindamycin 600 mg was given 1 hour before surgery (Lindeboom 2006).
- Amoxicillin 0.5 g 3 times a day postoperatively for 7 days (Chen 2005a; Chen 2005b).
- Amoxicillin 0.5 g 3 times a day postoperatively for 5 days (Chen 2007).
- Amoxicillin with clavulanate 1 g every 12 hours for 5 days (Palattella 2008).
- Postoperative second generation cephalosporin for 7 days (Block 2009).

Type and frequency of maintenance

- Patients were referred to their own dentists for maintenance recalls every 6 months (Schropp 2003; Palattella 2008; Block 2009). In one trial (Schropp 2003) the referring dentists were contacted by letter where they were instructed in the maintenance procedure: oral hygiene instructions, scaling/cleaning with proper instruments and intrapocket irrigation with chlorhexidine in case of suppuration. They were also invited to refer the patients back to the implant centre in case of complications that they could not handle by themselves.
- Yearly recall (Chen 2005a; Chen 2005b; Chen 2007).
- Not described (Lindeboom 2006).

Duration of the studies (after implant loading)

- One year (Lindeboom 2006).
- Two years (Chen 2005a; Chen 2005b; Palattella 2008; Block 2009).
- Three years (Chen 2007).
- Five years (Schropp 2003).

Risk of bias in included studies

Sample size

Only two trials performed a sample size calculation (Schropp 2003; Lindeboom 2006).

- The trialists informed us that the sample size calculations were based on a power calculation, which indicated that 26 patients in each group should be included in order to be able to find a statistically significant difference in bone defect reduction of 1 mm or more between the two groups, with alpha = 0.05, power = 95% (Schropp 2003). However, only 23 patients in each group were included.
- The sample size was calculated to find a difference in Implant Stability Quotient (ISQ) measured with Osstell of 10 or more assuming a common standard deviation of 15 with a power of 80% and a type 1 error rate of 0.05. Twenty-five patients in each group would be needed to reject the null hypothesis (Lindeboom 2006).

Quality assessment

The final risk of bias assessment after having incorporated the additional information kindly provided by the authors of the included trials is summarised in Figure 1 and Figure 2. For each trial we assessed whether it was at low, unclear or high risk of bias. One trial was judged to be at low (Lindeboom 2006) and the remaining six trials at high risk of bias.

Figure 1. Methodological quality graph: review authors' judgements about each methodological quality item presented as percentages across all included studies.

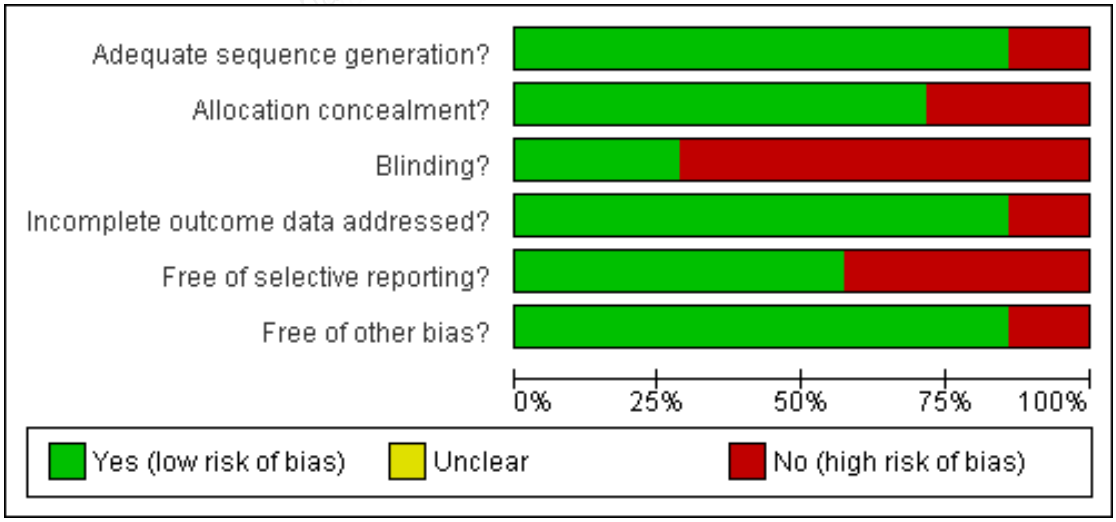
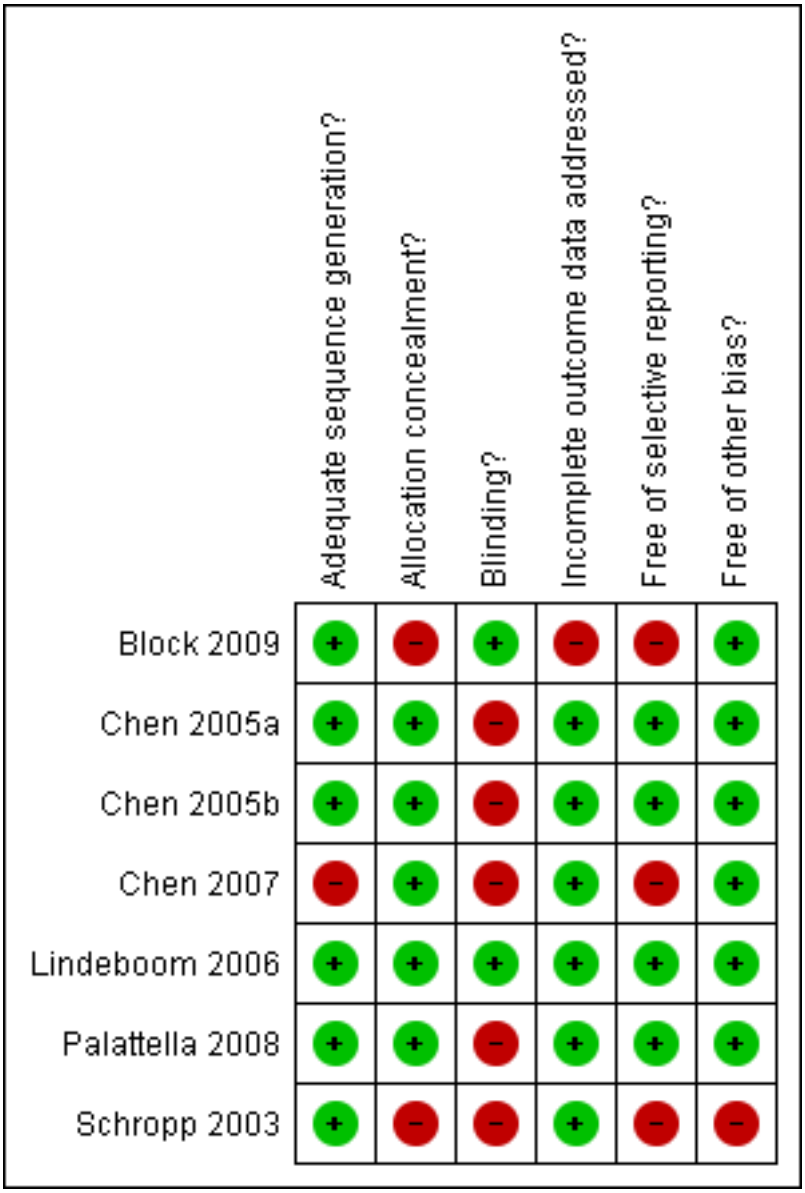


Figure 2. Methodological quality summary: review authors' judgements about each methodological quality item for each included study.



Effects of interventions

In total 270 patients were enrolled in 7 trials.

Immediate versus delayed implant placement (2 trials with 126 patients; comparison 1)

- One study (Lindeboom 2006) of parallel group design compared immediate versus delayed implants in periapical infected sites. Twenty-five patients were enrolled in each group and none dropped out. All patients were bone grafted at implant placement and subjected to a regenerative therapy with resorbable membranes. Two early implant failures occurred in the immediate group, however the authors informed us that no complication occurred. One year after placement, there were no statistically significant differences for prosthesis (Analysis 1.1) and implant failures (Analysis 1.2), aesthetics assessed by a dentist: papilla height and the level of the perimplant marginal mucosa in relation to that of the adjacent teeth (Analysis 1.3), and perimplant marginal bone level changes (Analysis 1.4). All interdental papillae covered from 50% to 100% of the interdental space (papilla score 2 or 3 according to Jemt 1998) The trial was judged to be at low risk of bias.

- One study (Block 2009) of parallel group design compared immediate versus delayed implants. Seventy-six patients were enrolled and 16 dropped out or were excluded but it was not described from which group. When a gap was present at immediate implants, the site was grafted with human mineralised bone. Immediate implants were immediately provisionalised with non-occluding temporary acrylic crowns, whereas delayed sites were grafted with human mineralised bone and left to heal for 4 months before placing the implants. Two years after loading, four implants failed in the immediate group versus one in the delayed group and this was not statistically significant (Analysis 1.1; Analysis 1.2). The trial was judged to be at high risk of bias.

The meta-analysis of the two trials (Lindeboom 2006; Block 2009) for prosthesis (Analysis 1.1) and implant (Analysis 1.2) failures did not show any statistical significant difference, though trends favoured delayed implants.

Immediate-delayed versus delayed implant placement (1 trial with 46 patients; comparison 2)

- One study (Schropp 2003) of parallel group design compared immediate-delayed versus delayed implant placement up to 5 years after loading. Twenty-three patients were enrolled in each group. Two patients withdrew, one from each group, because they did not pay for the implant crown at the 1-year follow-up. At the 5-year follow-up more drop-out/withdrawals occurred: two from the immediate-delayed group (one excluded because the implant was used to support a removable denture and one because the crown was remade) and five from the delayed group (one excluded since treated with a bridge and not a single crown, one because the crown was remade, three did not want to attend the 5-years examination, though their implant supported crowns were still in place without causing any inconvenience). At implant placement six patients out of 10, having bone dehiscence, of the delayed group were bone grafted versus none of the immediate-delayed group. At abutment connection six out of 15 patients with bone dehiscence of the immediate-delayed group and four out of 11 of the delayed group were bone grafted. The consequence of these bone grafting procedures on the final results are difficult to evaluate since only some patients with dehiscence were actually grafted. Three early implant failures occurred, two in the immediate-delayed group and one in the delayed group (Analysis 2.2). Four postoperative minor complications occurred all in the immediate-delayed group: one fistula in relation to remnants of cement at the implant-abutment joint (after meticulous scaling the fistula disappeared but the patient suffered from a bad taste originating from the perimplant mucosa), two cases of temporarily sensibility disturbances which recovered within 1 month, and one minor postoperative bleeding (Analysis 2.3). The following additional complications occurred up to the fifth year: five in the immediate-delayed group (one crown was remade, two crown recementations, one case with several recementations, one case with metal margin of the implant restoration exposed) and two in the delayed group (one crown was remade and one crown was recemented). After 2 years there were no statistically significant differences for prosthesis (Analysis 2.1) and implant failures (Analysis 2.2), complications (Analysis 2.3), aesthetics assessed by the patient (Analysis 2.5), the papilla height assessed by the dentist (Analysis 2.7), and marginal bone level changes (Analysis 2.9). There was a statistically significant difference with patients in the delayed group perceiving the period between tooth extraction and insertion of the crown significantly longer than patients in the immediate-delayed group, mean difference of visual analogue scale (VAS) -20.30 (95% confidence interval (CI) -33.36 to -7.24) (Analysis 2.4). There was also statistically significantly higher patient satisfaction in the immediate-delayed group (Analysis 2.6), mean difference of VAS 6.51 (95% CI 0.39 to 12.63). An independent blinded assessor also judged the level of the perimplant marginal mucosa in relation to that of the adjacent teeth as more appropriate in the immediate-delayed group, with risk ratio (RR) 1.68 (95% CI 1.04 to 2.72) (Analysis 2.8). After 5 years, no significant differences were observed apart from that immediate-delayed implants had significantly more complications (RR = 4.20; 95% CI 1.01 to 17.43) (Analysis

2.3). The trial was judged to be at high risk of bias.

Immediate versus immediate-delayed implant placement (1 trial with 16 patients; comparison 3)

- One trial of parallel group design compared eight patients receiving nine single immediate postextractive implants with eight patients receiving nine immediate-delayed implants 8 weeks after extraction at maxillary anterior and premolar teeth (Palattella 2008). Implants were restored within 48 hours with provisional acrylic crowns not in occlusal contact. Two years after implant placement there were no implant failures, complications, drop-outs, nor statistically significant differences for the level of the perimplant marginal mucosa in relation to the implant collar (Analysis 3.1), and perimplant marginal bone level changes (Analysis 3.2). The trial was judged to be at high risk of bias.

Are augmentation procedures necessary? (1 trial with 26 patients; comparison 4)

- One trial of parallel group design compared 14 patients receiving particulate autogenous bone harvested from the implant osteotomy site versus 12 patients who were not subjected to any augmentation procedure at immediate single implants placed in fresh extraction sockets at maxillary anterior and premolar sites (Chen 2005b) up to 2 years post-loading. The following bone measurements at implant placement and 6 months after at implant exposure were included in the present review: the vertical height of the defect (VDH) measured from the most apical extent of the defect to the coronal aspect of the implant collar, and the horizontal depth of the defect (HDD) measured bucco-lingually from the most buccal extent of the implant collar to the labial bone crest (at dehisced sites, the HDD was estimated by measuring the horizontal distance from the implant collar to a periodontal probe placed against the intact portions of the labial plate at the level of the implant collar). No patients dropped out. Two complications occurred in the group treated with autogenous bone: one abscess that determined the early failure of the implant and one wound dehiscence. In total two implants were lost in the autogenous bone group, whereas no complications or failures occurred in the non-augmented control group (Analysis 4.1). Both treatments resulted in statistically significant bone gain, however no statistically significant differences were found among the two procedures (Analysis 4.2). With respect to cost and treatment time, the difference between groups may not be clinically significant. The trial was judged to be at high risk of bias.

Which is the most effective augmentation technique? (2 trials with 56 patients: comparison 5)

- One trial of parallel group design compared 12 patients receiving non-resorbable barriers versus 11 patients receiving resorbable barriers versus 13 patients receiving resorbable barriers and particulate autogenous bone harvested from the implant osteotomy site at immediate single implants placed in fresh extraction sockets at maxillary anterior or premolar sites (Chen 2005a) up to 2 years post-loading. The following bone measurements at implant placement and 6 months after implant exposure were included in the present review: the vertical height of the defect (VDH) measured from the most apical extent of the defect to the coronal aspect of the implant collar, and the horizontal depth of the defect (HDD) measured bucco-lingually from the most buccal extent of the implant collar to the labial bone crest (at dehisced sites, the HDD was estimated by measuring the horizontal distance from the implant collar to a periodontal probe placed against the intact portions of the labial plate at the level of the implant collar). No patients dropped out. Four complications occurred, two dehiscences occurred in the resorbable group whereas one abscess (successfully treated with systemic antibiotics) and one dehiscence occurred in the group treated with resorbable barriers and autogenous bone (Analysis 5.1; Analysis 5.3; Analysis 5.5). All treatments resulted in statistically significant bone gain, however no statistically significant differences were found between the three procedures (Analysis 5.2; Analysis 5.4; Analysis 5.6). With respect to cost and treatment time, the differences between groups may not be clinically significant. The trial was judged to be at high risk of bias.

- One trial compared 10 patients receiving Bio-Oss versus 10 patients receiving Bio-Oss plus a resorbable barrier at immediate single implants placed in fresh extraction sockets at maxillary anterior or premolar sites (Chen 2007) up to 3 years post-loading. A third control group of 10 patients who received no barrier and no graft could not be evaluated since some patients were systematically excluded from that group and included in the remaining two groups. The following bone measurements at implant placement and 6 months after implant exposure were included in the present review: the vertical height of the defect (VDH) measured from the most apical extent of the defect to the coronal aspect of the implant collar, and the horizontal depth of the defect (HDD) measured bucco-lingually from the most buccal extent of the implant collar to the labial bone crest (at dehisced sites, the HDD was estimated by measuring the horizontal distance from the implant collar to a periodontal probe placed against the intact portions of the labial plate at the level of the implant collar). After 3 years, three patients dropped out from the Bio-Oss group and five patients from the Bio-Oss plus barrier group. There were no prosthesis or implant failures. Two complications occurred in the Bio-Oss plus barrier group: one abscess developed during the healing period around one implant (the site was re-treated with the same procedure); another implant displayed a chronic inflammation of the perimplant tissues (perimplant mucositis) for the entire study period (Analysis 5.7). All treatments resulted in statistically

significant bone gain, however, no statistically significant differences in bone gain were found between the two procedures (Analysis 5.8). After delivery of the prostheses one patient in each group, when asked by the operator, was dissatisfied with aesthetics due to recession of the mucosa on the buccal aspect. Both patients refused a corrective intervention with a soft tissue graft. Aesthetics (position of the soft tissue margin in relation to the adjacent teeth) were also evaluated by the operator after the 6-month healing period, at placement of the final restorations and after 3 years of loading. After healing, 3/10 sites treated with Bio-Oss and 4/10 sites treated with Bio-Oss plus barrier were considered aesthetically unsatisfactory by the operator. The two sites which were judged as unsatisfactory by the patients, were also judged unsatisfactory by the operator. The operator then treated two sites with recession in the Bio-Oss group and one patient with recession and one without recession (marginal mucosa judged to be too thin) in the Bio-Oss plus barrier group with connective tissue grafts. After placement of the final restorations (about 2 months after), the operator judged aesthetics to be poor in 2/10 patients of the Bio-Oss group and in 4/10 of the Bio-Oss plus barrier group. After 3 years of loading, the operator judged aesthetics to be poor in 2/7 patients of the Bio-Oss group and in 2/5 patients of the Bio-Oss plus barrier group. No statistically significant differences were found for any of the aesthetic outcomes (Analysis 5.7). With respect to treatment time, the differences among groups may not be clinically significant. The only difference in cost between the two procedures was the additional cost of the barrier. The trial was judged to be at high risk of bias.

DISCUSSION

Only four trials comparing different timing for implant placement could be included in this review (Schropp 2003; Lindeboom 2006; Palattella 2008; Block 2009). Different timings for implant placement after tooth extraction were evaluated, however all trials were underpowered, therefore only limited indications can be gained from them.

The meta-analyses of two trials (Lindeboom 2006; Block 2009) comparing immediate versus delayed implants found no statistically significant differences for prosthesis and implant failures, though trends clearly suggested that more implant failures occurred at immediate implants (6 versus 1). No other meta-analysis could be done, nor other outcome was significant. According to the authors of one trial (Block 2009), there was 1 mm more recession of buccal soft tissues at delayed implants. This is plausible but since data were not clearly presented in the study, we were unable to evaluate this outcome as well as other outcomes that they presented. It was disappointing that limitations in data reporting in one trial (Block 2009) did not allow us to conduct additional meta-analyses. This could have been easily obviated if the trial authors had answered our request for information.

One study (Schropp 2003) compared immediate-delayed implants placed on average 10 days after extraction with delayed implants placed on average 3 months after extractions. After 2 years patients in the delayed group perceived the period between tooth extraction and insertion of the crown significantly longer and were less satisfied. Moreover an independent blinded assessor judged the level of the perimplant marginal mucosa in relation to that of the adjacent teeth as more appropriate in the immediate-delayed group. The possible biological explanation is that the early implant placement decreased resorption of the alveolar bone. In other words, the implants may have contributed to maintaining the alveolar bone height with a perceived aesthetic benefit. However after 5 years all these differences disappeared, but complications become statistically more common for immediate-delayed implants. These findings are difficult to interpret also because there were many drop-outs that reduced the sample size. Data interpretation is further complicated by the fact that the authors withdrew several patients from the study. No patient should have been withdrawn from the study, according to the principle of the intention-to-treat analysis, allowing the readers to draw their conclusions, and avoiding unnecessary bias.

The study comparing immediate and immediate-delayed implants (Palattella 2008), though well conducted, included only eight patients per group. Such a small sample size does not allow for any reliable conclusion, since the probability to find a difference, if any, is remote.

Regarding the need for bone augmentation procedures at implant placement, only one trial (Chen 2005b) evaluated whether they could be advantageous or not. The trial tested in 26 patients augmentation with autogenous bone collected from the implant site. It was underpowered to detect any difference, however all failures (two) and complications (two) occurred in the augmented group. A second trial (Chen 2007) including a control group not subject to augmentation could not be used because the authors subverted the randomisation, allocating preferentially patients with buccal defect to the augmentation arms of the study.

Five different augmentation procedures were tested in two trials (Chen 2005a; Chen 2007) including 56 patients. By dividing the few patients into five different groups, the authors eliminated the already scarce possibility to find any possible statistically significant difference, therefore the findings were inconclusive.

The only trial (Cornelini 2004) showing some statistically significant difference was excluded from this review update because it was decided to include only trials having a follow-up of at least 1 year after loading. This trial, having a follow-up to abutment connection/implant loading, compared 10 patients with an immediate postextractive implant covered by a resorbable barrier versus 10 patients treated with a resorbable barrier plus anorganic bovine

bone (Bio-Oss) at implants placed in fresh extraction sockets. No failures, complications or drop-outs occurred. A statistically significant higher position of the soft tissue margins in relation to the implant shoulder was found at the buccal aspects of implants treated with barrier plus Bio-Oss (2.1 mm versus 0.9 mm; mean difference = -1.2 mm; 95% confidence interval -2.29 to -0.11) (Cornelini 2004).

With respect to generalisation of the results of the present review to general practice, failures and complications at immediate postextractive implants were slightly higher. Caution is therefore recommended when deciding to place implants immediately after tooth extraction. The first question that clinicians should ask themselves is what are the added benefits for the patient by having immediate implants. Then the expected benefits need to be carefully weighed against the risk of complications of the chosen procedures.

AUTHORS' CONCLUSIONS

Implications for practice

There is insufficient evidence to determine possible advantages or disadvantages of immediate, immediate-delayed or delayed implants, therefore these preliminary conclusions are based on few underpowered trials often judged to be at high risk of bias. There is a suggestion that immediate and immediate-delayed implants may be at higher risk of implant failures and complications than delayed implants; on the other hand the aesthetic outcome might be better when placing implants just after teeth extraction. There is not enough reliable evidence supporting or refuting the need for augmentation procedures at immediate implants placed in fresh extraction sockets or whether any of the augmentation techniques are superior to the others.

Implications for research

There is a definite need for randomised controlled trials evaluating the best timing for placing dental implants after teeth extractions. These trials must be powered to detect a difference for primary outcomes such as prosthesis/implant success and complications, should evaluate objective aesthetic outcomes assessed by blind outcome assessors and the patient's own perception of aesthetics, and should be reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (www.consort-statement.org). We also need to understand when bone augmentation procedures are needed and which are the most effective. Trials evaluating the efficacy of non/slow resorbable bone substitutes in alternative to autogenous bone should be prioritised.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Block 2009

Methods	2-year post-loading randomised, parallel group study. There were 14 withdrawals for specified reason but it was not described from which group
Participants	Patients requiring immediate implant placement in 1 maxillary anterior or premolar tooth site. Adults treated at the School of Dentistry in New Orleans, USA. Patients were excluded if there was an acute infection or suppuration at the planned implant site, had any form of diabetes, poor oral hygiene, active caries or periodontal disease, receiving any therapy that suppresses their immune system, such as radiation, chemotherapy, or chronic steroid usage, advanced cardiovascular, pulmonary, renal, liver disease (ASA III or IV), postmenopausal women with known osteoporosis as determined by their medical internist, alcoholics, lack of intact first molar occlusion, presence of bony defects at the experimental socket, a crown-implant ratio less than 1:2; less than 2 mm of attached or keratinised gingiva at the experimental site. Seventy-six patients randomised but it is unclear how many in each group
Interventions	Single immediate (same day) versus delayed (4 months) implants in maxillary anterior sites up to premolars. The implant's axis of immediate implants was directed palatal to the planned incisal edge, and at least 2 mm palatal to the emergence line angle. The implant was placed with the coronal surface of the implant 3 mm apical to the gingival margin of the planned restoration. The length of the implants was 13 mm except when the maxillary sinus limited the implant length to 11.5 mm. When a gap was present between the implant and the labial bone, a graft of human mineralised bone was used to graft the site and preserve the width of the ridge. Immediate implants were immediately provisionalised with acrylic crowns not in occlusion, whereas delayed sites were grafted with human mineralised bone (350 to 500 micron, cortical, freeze-dried, U Miami Tissue Bank, Miami, FL, USA). After the graft had been compressed, a piece of collagen (Collaplug; Zimmer Dental, Carlsbad, CA) was placed over the graft and under the margins of the labial and palatal gingiva. 4-0 Chromic sutures were placed in a horizontal mattress fashion to gently conform the gingiva to the collagen. After a healing period of 4 months, implants were placed and immediately temporised. Four months after implant placement final restorations were made. All implants were straight wall design, threaded, with a roughened surface, and a parallel type abutment implant interface (Certain Implant; Biology of Metals 3i, Palm Beach Gardens, FL, USA)
Outcomes	Prosthesis failure, implant failure, marginal bone level changes, aesthetics by dentist (recession of the mucosal margin, papilla index)
Notes	

Risk of bias

Item	Authors' judgement	Description

Block 2009 (*Continued*)

Adequate sequence generation?	Yes	From the article: "The study statistician provided a computer-generated randomization schedule. Patients were assigned to 1 prosthodontist and then randomly assigned to either treatment group using a generalized randomized block design. The randomization scheme used ensured that balance was achieved with respect to the number of patients receiving a given treatment both within and across blocks. This balance was accomplished by randomising treatments to patients in groups of 6."
Allocation concealment?	No	From the article: "The preoperative workup was the same for both groups. After the subject signed the consent form, he/she was assigned to a treatment method group. " No reply to request.
Blinding? All outcomes	Yes	"To remove examiner bias, the examiner was not told which group the patient was in, and evaluated the patient with the crowns in place without being able to distinguish the two groups. Patients were asked not to reveal their treatment to the examiner." "The bone levels were measured over a period of 0, 6, 12, 18, and 24 months. Two independent, double-blinded oral surgeons (M.R. and W.M.) with experience with this method performed the measurements of the radiographs. The radiographs were provided by our research associate without group labels, to blind them during their measurement session."
Incomplete outcome data addressed? All outcomes	No	Unknown number of patients allocated to each group; some patients withdrew from the study; unknown from which group drop-out occurred. No reply to request
Free of selective reporting?	No	Missing several baseline values. No reply to request.
Free of other bias?	Yes	None identified.

Chen 2005a

Methods	2-year post-loading randomised, parallel group study. There were no withdrawals
Participants	Patients requiring immediate implant placement in 1 maxillary anterior or premolar tooth site. Adults treated at a private practice in Melbourne, Australia. Patients were excluded if there was an acute infection or suppuration at the planned implant site, if they smoked, and if there were psychological or systemic contraindications. 11 patients enrolled in the resorbable group, 12 in the non-resorbable group and 13 in the resorbable plus autogenous bone group
Interventions	Non-resorbable ePTFE barrier (Gore-Tex, WL Gore and Associates, Inc, Flagstone, USA) alone versus resorbable barrier (Resolut, Gore-Tex, WL Gore and Associates, Inc, Flagstone, USA) alone versus resorbable barrier (Resolut) supported by particulate autogenous bone harvested from the implant site by means of a filter attached to a dedicated suction line (Osseus Coagulum Trap, Quality Aspirators, Duncanville, TX, USA). All barriers were tucked beneath the flaps. Wound closure was achieved by use of a connective tissue graft taken from the palate. Implants were submerged and left to heal for 6 months. All implants were turned surface, screw-type, titanium Brånemark implants (Nobel Biocare, Göteborg, Sweden). All patients were rehabilitated with single implant supported crowns
Outcomes	Prosthesis failure, implant failure, postoperative complications at augmented sites. Various bone measurements at the augmentation intervention and at abutment connection
Notes	Though published as a single RCT, the authors actually conducted 2 different randomised trials in the way we presented the data

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	No information was presented in the study. The authors replied that patients were allocated to their groups by draw of lots (15 lots provided for each experimental group) . The box with the lots was completely obscured
Allocation concealment?	Yes	From the article it is clearly stated that randomisation was done after the extractions, implant placement and the characterisation of the peri-implant defects The authors replied that randomisation took place at the time of surgery, after the extractions were performed and once the implants were placed
Blinding? All outcomes	No	The authors replied that one operator performed all treatments and measurements, therefore he was not blinded

Chen 2005a (*Continued*)

Incomplete outcome data addressed? All outcomes	Yes	No missing data.
Free of selective reporting?	Yes	No selective reporting could be identified.
Free of other bias?	Yes	None identified.

Chen 2005b

Methods	2-year post-loading randomised, parallel group study. There were no withdrawals
Participants	Patients requiring immediate implant placement in 1 maxillary anterior or premolar tooth site. Adults treated at a private practice in Melbourne, Australia. Patients were excluded if there was an acute infection or suppuration at the planned implant site, if they smoked, and if there were psychological or systemic contraindications. 12 patients enrolled in the control group and 14 in the bone grafted group
Interventions	Particulate autogenous bone harvested from the implant site by means of a filter attached to a dedicated suction line (Osseus Coagulum Trap, Quality Aspirators, Duncanville, TX, USA) versus no augmentation procedure. Wound closure was achieved by use of a connective tissue graft taken from the palate. Implants were submerged and left to heal for 6 months. All implants were turned surface, screw-type, titanium Brånemark implants (Nobel Biocare, Göteborg, Sweden). All patients were rehabilitated with single implant supported crowns
Outcomes	Prosthesis failure, implant failure, postoperative complications at augmented sites. Various bone measurements at the augmentation intervention and at abutment connection
Notes	Though published as a single RCT, the authors actually conducted 2 different randomised trials in the way we presented the data

Risk of bias

Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Yes	No information was presented in the study. The authors replied that patients were allocated to their groups by draw of lots (15 lots provided for each experimental group) . The box with the lots was completely obscured
Allocation concealment?	Yes	From the article it is clearly stated that randomisation was done after the extractions, the implant placement and the characterisation of the peri-implant defects The authors replied that randomisation took place at the time of surgery, after the

		extractions were performed and once the implants were placed
Blinding? All outcomes	No	The authors replied that one operator performed all treatments and measurements, therefore he was not blinded
Incomplete outcome data addressed? All outcomes	Yes	No missing data.
Free of selective reporting?	Yes	No selective reporting could be identified.
Free of other bias?	Yes	None identified.

Chen 2007

Methods	3-year post-loading randomised, parallel group study. There were 8 drop-outs at 3 years. 5 patients dropped out from the Bio-Oss + resorbable group and 3 patients from the Bio-Oss group
Participants	Patients requiring immediate implant placement in 1 maxillary anterior or premolar tooth site. Adults treated at a private practice in Melbourne, Australia. Patients were excluded if there was an acute infection or suppuration at the planned implant site, clinical attachment loss of 5 mm or more on the buccal aspect, and if there were psychological or systemic contraindications. 10 patients enrolled in each group
Interventions	Bovine anorganic bone (Bio-Oss, Geistlich Pharmaceutical, Wolhusen, Switzerland) versus Bio-Oss plus resorbable porcine-derived collagen barrier (Bio-Gide). Barriers were trimmed as required and fixed to the implants by the healing screw. Implants were not submerged and left to heal for 6 months. All implants were ITI SLA (Institut Straumann AG, Waldenburg, Switzerland). All patients were rehabilitated with single implant supported crowns
Outcomes	Prosthesis failure, implant failure, postoperative complications at augmented sites. Various bone measurements at the augmentation intervention and at abutment connection. Aesthetics were assessed by patients and by the operator (recession of the mucosal margin)
Notes	The original trial included also a control group that received no graft or barrier, which could not be used in the evaluation due to subversion of the randomisation procedure

Risk of bias

Item	**Authors' judgement**	**Description**
Adequate sequence generation?	No	No information was presented in the study. The authors replied that randomisation was done as follows: 10 lots for each group

		were placed in an opaque container. Patients were screened and after providing consent, teeth have been extracted and implants have been placed allocated to their groups by draw of lots by one of the surgical assistants However, "In four cases dehiscence defects of the buccal plate were discovered following extraction of the teeth. For ethical reasons, these cases were randomly allocated to the BG or BG + M groups only." which means that the authors subverted the randomisation procedure
Allocation concealment?	Yes	From the article it is clearly stated that randomisation was done after the extractions, the implant placement and the characterisation of the peri-implant defects
Blinding? All outcomes	No	The authors replied that one operator performed all treatments and measurements, therefore he was not blinded
Incomplete outcome data addressed? All outcomes	Yes	Reasons for drop-out given.
Free of selective reporting?	No	The author provided some missing data, thought not on the marginal bone level data which were presented in the article as combined data for the 3 groups
Free of other bias?	Yes	None identified.

Lindeboom 2006

Methods	1.5-year post-loading, randomised parallel group study. No drop-outs
Participants	Patients with a single tooth to be replaced by a single-tooth implant in the maxillary anterior and premolar region. Adults treated at the ACTA, University of Amsterdam, The Netherlands. Patients were excluded if were medically compromised, if smokers, or if a primary implant stability of 25 Ncm could not be achieved. 25 patients enrolled in each group
Interventions	Immediate (same day) versus delayed (3 months on average) implants after extractions of periapically infected single teeth. Implants were placed 2 mm below the cervical junction of the adjacent teeth. Autogenous bone grafts from the trigonum retromolar or chin region were covered with a bioresorbable collagen membrane (Bio-Gide, Geistlich AG, Wolhusen, Switzerland) in all patients and the implants were submerged and left healing for 6 months. Single crowns were cemented with temporary cement. All implants were

Lindeboom 2006 (*Continued*)

	Frialit-2 Synchro (Dentsply Friadent Ceramed, Mannheim, Germany)	
Outcomes	Prosthesis failure, implant failure, complications, perimplant marginal bone level changes on intraoral radiographs, pocket probing depth, patient satisfaction, aesthetics assessed by a blinded outcome assessor (interproximal papilla dimensions and mid-buccal perimplant gingival levels)	
Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Yes	From the article: "patients were randomly allocated (computer randomization program) to an immediate placement or a delayed placement protocol" The author replied that patients were randomised via a computer program located at the department of Clinical Epidemiology and Biostatistics of Academic Medical Center Amsterdam during the surgery
Allocation concealment?	Yes	The authors replied that during the surgery (after tooth removal and microbiological sampling) a nurse made contact with the Epidemilogy Department for the determination of the treatment and the clinician placed the implant immediately or not
Blinding? All outcomes	Yes	The authors replied that assessors were blinded for treatment allocation
Incomplete outcome data addressed? All outcomes	Yes	Missing data provided from the authors.
Free of selective reporting?	Yes	No selective reporting identified.
Free of other bias?	Yes	None identified.

Palattella 2008

Methods	2-year post-loading, randomised parallel group study. No drop-outs
Participants	Patients with a single tooth to be replaced by a single-tooth implant in the maxillary anterior area including the first premolars. Adults treated at the Eastmann Dental Hospital in Rome, Italy. Patients were excluded if were presenting uncontrolled diabetes, coagulation impairments, acute infections and/or suppuration at the surgical site, bruxists,

	heavy smokers and patients addicted to drug or alcohol. 8 patients enrolled in each group
Interventions	Immediate implants versus immediate-delayed implants (8 weeks) after flap elevation and extractions of compromised single maxillary teeth in the aesthetic area. Implants were placed with an insertion torque of 35 Ncm 2 mm apical to the cemento-enamel junction of the adjacent teeth. Implants were immediately restored within 48 hours with provisional acrylic crowns not in occulsal contact. All implants were tapered effect (TE) implants Straumann Dental Implant System (Institut Straumann AG, Waldenburg, Switzerland)
Outcomes	Prosthesis failure, implant failure, complications, perimplant marginal bone level changes on intraoral radiographs, aesthetics assessed by dentist (papilla index and mid-buccal perimplant gingival levels), implant stability by means of ISQ (implant stability quotient) with Osstell Mentor (Integration Diagnostics AB, Goteborg, Sweden)
Notes	

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	From the article: "The randomization list was generated through the block method by an independent statistician and kept by an administrative employee"
Allocation concealment?	Yes	Not described in the article. The authors informed us the dentist was informed of the treatment group after implant placement
Blinding? All outcomes	No	From the article: "papilla index was measured directly from the patient's mouth at the 2 year follow-up visit by the same operator", "The distance from the most apical point of the gingival margin to the implant shoulder measured directly from the patient's mouth by the same operator"
Incomplete outcome data addressed? All outcomes	Yes	No data missing.
Free of selective reporting?	Yes	No selective reporting identified.
Free of other bias?	Yes	None identified.

Schropp 2003

Methods	5-year post-loading, randomised parallel group study. Nine drop-outs/exclusions: 3 from the immediate-delayed group (1 did not pay for the treatment; 1 excluded because the implant was used to support a removable denture; and 1 because the crown was remade) and 6 from the delayed group (1 did not pay for the treatment; 1 excluded since treated with a bridge and not a single crown; 1 because the crown was remade; 3 did not want to attend the 5-years examination, though their implant supported crowns were still in place without causing any inconvenience)	
Participants	Patients with a single tooth to be replaced by a single-tooth implant in the anterior and premolar region of both mandibles and maxillas. Adults treated at the Royal Dental College, University of Århus, Denmark. Patients were excluded if were medically compromised (metabolic diseases, immune deficient or under immune-suppressive therapy, irradiated, etc) or if they had insufficient bone to achieve primary stability of the implant. 23 patients enrolled in each group	
Interventions	Delayed immediate (10 days on average) versus delayed implants (3 months on average) after extractions of compromised single teeth. Autogenous bone grafting was done when implants threads were exposed at abutment connection for immediate-delayed implants and at both implant placement and at abutment connection for delayed implants. Implants were submerged and left to heal for about 3 months. Single-tooth metal-ceramic crowns were provided. All implants were Osseotite (3i Implamt Innovations Inc, Palm Beach Gardens, FL, USA)	
Outcomes	Prosthesis failure, implant failure, complications, various bone measures at implantation and abutment connection, perimplant marginal bone level changes on intraoral radiographs, pocket probing depth, patient satisfaction, aesthetics assessed by patients and by an independent experienced prosthodontist (interproximal papilla dimensions and the mid-buccal gingival level), resonance frequency stability assessed with Ostell, and microbiologic evaluation. At 5 years the medians and interquartile range values for the VAS were presented for the patient perception of aesthetics and patient satisfaction. These data were used to estimate the mean and standard deviation	
Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Yes	From the article: "The patients were randomly allocated to an early or a delayed group at the initial examination", "performing a closed randomisation ensured an even distribution in the two groups" The author replied to us that each patient drew one card from an envelope of 23 cards marked as immediate and 23 cards marked delayed at the initial examination

Schropp 2003 (*Continued*)

Allocation concealment?	No	From the article: "the patients were randomly allocated to an early or a delayed group at the initial examination" The author replied that the surgeon was informed on the day of surgery just before the intervention to which group the patient was belonging
Blinding? All outcomes	No	From the article: "The radiographic examinations were blinded", "blinded evaluation of the interproximal papillae mesial and distal to the implant restoration, as well as the clinical implant height and the clinical implant crown height, was carried out by an experienced prosthodontist who had not been involved in the treatment" All the other outcomes were measured by a non-blinded examiner
Incomplete outcome data addressed? All outcomes	Yes	Missing data provided from the authors.
Free of selective reporting?	No	Data of two patients from each group were not provided from the authors
Free of other bias?	No	From the article: "However, grafting of dehiscences or fenestrations was performed in cases of exposed implant surfaces at implant surgery or abutment surgery in the delayed group. No grafting was used at implant placement in the early group, but in cases of dehiscence or fenestrations at abutment surgery exposed implants threads were covered with autogenous bone grafts"

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

Study	Reason for exclusion
Becker 2009	Study including un unknown quota of patients who were subjected to bone augmentation procedures at sites where immediate-delayed implants were placed
Carpio 2000	Study including un unknown quota of patients who were subjected to bone augmentation procedures at sites where immediate-delayed implants were placed. Follow-up limited to abutment connection/implant loading

(*Continued*)

Cornelini 2004	Follow-up limited to abutment connection/implant loading. Three years data after loading were recorded but were lost due to the premature death of the main author
Fiorellini 2005	No clinical outcome measures related to implant treatment.
Gher 1994	Problems with design and analysis. The unit of randomisation was both the patient and the implant and it was not possible to use the data without further information from authors. The authors did not reply to our letter
Norton 2002	The author kindly informed us that the trial was not an RCT but a cohort study with unequal number of patients treated in the intervention groups and with a mixed parallel group/split-mouth design
Prosper 2003	Unclear how many patients were included in each group. No reply to the letter requesting additional clarification

DATA AND ANALYSES

Comparison 1. Immediate versus delayed implants

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Prosthesis failure 1 year	2	110	Risk Ratio (M-H, Fixed, 95% CI)	4.33 [0.76, 24.56]
2 Implant failure 1 year	2	110	Risk Ratio (M-H, Fixed, 95% CI)	4.33 [0.76, 24.56]
3 Aesthetics (dentist): position of the perimplant tissues 1 year	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4 Bone level changes 1 year	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 2. Immediate-delayed versus delayed implants

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Prosthesis failure	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
1.1 1 year	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
1.2 5 years	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
2 Implant failure	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
2.1 1 year	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
2.2 5 years	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
3 Complications	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
3.1 1 year	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
3.2 5 years	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
4 Patients' perception of how long treatment took	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4.1 2 years	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable
5 Patients' aesthetic perception	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5.1 2 years	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable
5.2 5 years	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable
6 Patients' general satisfaction of treatment	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6.1 2 years	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable
6.2 5 years	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable
7 Aesthetics (dentist): interproximal papilla dimension	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
7.1 2 years	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
7.2 5 years	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
8 Aesthetics (dentist): position of perimplant tissues	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
8.1 2 years	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
8.2 5 years	1		Risk Ratio (M-H, Fixed, 95% CI)	Not estimable
9 Bone level changes	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

9.1 2 years	1	Mean Difference (IV, Fixed, 95% CI)	Not estimable
9.2 5 years	1	Mean Difference (IV, Fixed, 95% CI)	Not estimable

Comparison 3. Immediate versus Immediate-delayed implants

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Aesthetics (dentist): position of perimplant tissues	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 2 years	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable
2 Bone level changes	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 2 years	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable

Comparison 4. Augmentation versus no augmentation: immediate implants in extraction sockets

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Autogenous bone graft versus no augmentation (binary)	1		Risk Ratio (M-H, Random, 95% CI)	Totals not selected
1.1 Prosthetic failure (2 years)	1		Risk Ratio (M-H, Random, 95% CI)	Not estimable
1.2 Implant failure (2 years)	1		Risk Ratio (M-H, Random, 95% CI)	Not estimable
1.3 Complication	1		Risk Ratio (M-H, Random, 95% CI)	Not estimable
2 Autogenous bone graft versus no augmentation (continuous)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Bone gain (vertical - VDH)	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable
2.2 Bone gain (horizontal - HDD)	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable

Comparison 5. Augmentation versus augmentation: immediate implants in extraction sockets

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Resorbable versus non-resorbable barrier (binary)	1		Risk Ratio (M-H, Random, 95% CI)	Totals not selected
1.1 Complication	1		Risk Ratio (M-H, Random, 95% CI)	Not estimable
2 Resorbable versus non-resorbable (continuous)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Bone gain (vertical - VDH)	1		Mean Difference (IV, Fixed, 95% CI)	Not estimable

2.2 Bone gain (horizontal - HDD)	1	Mean Difference (IV, Fixed, 95% CI)	Not estimable
3 Resorbable versus resorbable + autogenous bone (binary)	1	Risk Ratio (M-H, Random, 95% CI)	Totals not selected
3.1 Complication	1	Risk Ratio (M-H, Random, 95% CI)	Not estimable
4 Resorbable versus resorbable + autogenous bone (continuous)	1	Mean Difference (IV, Random, 95% CI)	Totals not selected
4.1 Bone gain (vertical - VDH)	1	Mean Difference (IV, Random, 95% CI)	Not estimable
4.2 Bone gain (horizontal - HDD)	1	Mean Difference (IV, Random, 95% CI)	Not estimable
5 Non-resorbable versus resorbable + autogenous bone (binary)	1	Risk Ratio (M-H, Random, 95% CI)	Totals not selected
5.1 Complication	1	Risk Ratio (M-H, Random, 95% CI)	Not estimable
6 Non-resorbable versus resorbable + autogenous bone (continuous)	1	Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6.1 Bone gain (vertical - VDH)	1	Mean Difference (IV, Fixed, 95% CI)	Not estimable
6.2 Bone gain (horizontal - HDD)	1	Mean Difference (IV, Fixed, 95% CI)	Not estimable
7 Bio-Oss versus Bio-Oss + resorbable (binary)	1	Risk Ratio (M-H, Random, 95% CI)	Totals not selected
7.1 Augmentation failure	1	Risk Ratio (M-H, Random, 95% CI)	Not estimable
7.2 Complication at augmented site	1	Risk Ratio (M-H, Random, 95% CI)	Not estimable
7.3 Poor aesthetics measured by patient (after restoration)	1	Risk Ratio (M-H, Random, 95% CI)	Not estimable
7.4 Poor aesthetics measured by dentist (after restoration)	1	Risk Ratio (M-H, Random, 95% CI)	Not estimable
7.5 Poor aesthetics measured by dentist (3 years)	1	Risk Ratio (M-H, Random, 95% CI)	Not estimable
8 Bio-Oss versus Bio-Oss + resorbable (continuous)	1	Mean Difference (IV, Random, 95% CI)	Totals not selected
8.1 Bone gain (vertical - VDH)	1	Mean Difference (IV, Random, 95% CI)	Not estimable
8.2 Bone gain (horizontal - HDD)	1	Mean Difference (IV, Random, 95% CI)	Not estimable

Analysis 1.1. Comparison 1 Immediate versus delayed implants, Outcome 1 Prosthesis failure 1 year.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 1 Immediate versus delayed implants

Outcome: 1 Prosthesis failure 1 year

Study or subgroup	Immediate n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
Block 2009	4/30	1/30		66.7 %	4.00 [0.47, 33.73]
Lindeboom 2006	2/25	0/25		33.3 %	5.00 [0.25, 99.16]
Total (95% CI)	**55**	**55**		**100.0 %**	**4.33 [0.76, 24.56]**

Total events: 6 (Immediate), 1 (Delayed)

Heterogeneity: $Chi^2 = 0.01$, df = 1 (P = 0.91); $I^2 = 0.0\%$

Test for overall effect: Z = 1.66 (P = 0.098)

Analysis 1.2. Comparison 1 Immediate versus delayed implants, Outcome 2 Implant failure 1 year.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 1 Immediate versus delayed implants

Outcome: 2 Implant failure 1 year

Study or subgroup	Immediate n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Weight	Risk Ratio M-H,Fixed,95% CI
Block 2009	4/30	1/30		66.7 %	4.00 [0.47, 33.73]
Lindeboom 2006	2/25	0/25		33.3 %	5.00 [0.25, 99.16]
Total (95% CI)	**55**	**55**		**100.0 %**	**4.33 [0.76, 24.56]**

Total events: 6 (Immediate), 1 (Delayed)

Heterogeneity: $Chi^2 = 0.01$, df = 1 (P = 0.91); $I^2 = 0.0\%$

Test for overall effect: Z = 1.66 (P = 0.098)

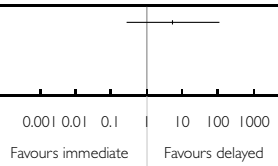
Analysis 1.3. Comparison 1 Immediate versus delayed implants, Outcome 3 Aesthetics (dentist): position of the perimplant tissues 1 year.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 1 Immediate versus delayed implants

Outcome: 3 Aesthetics (dentist): position of the perimplant tissues 1 year

Study or subgroup	Immediate n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
Lindeboom 2006	2/23	0/25		5.42 [0.27, 107.20]



Analysis 1.4. Comparison 1 Immediate versus delayed implants, Outcome 4 Bone level changes 1 year.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 1 Immediate versus delayed implants

Outcome: 4 Bone level changes 1 year

Study or subgroup	Immediate N	Mean(SD)	Delayed N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Lindeboom 2006	23	0.49 (0.11)	25	0.52 (0.16)		-0.03 [-0.11, 0.05]

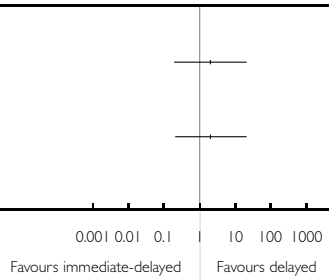
Analysis 2.1. Comparison 2 Immediate-delayed versus delayed implants, Outcome 1 Prosthesis failure.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 1 Prosthesis failure

Study or subgroup	Immediate-delayed n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
1 1 year				
Schropp 2003	2/23	1/23		2.00 [0.19, 20.55]
2 5 years				
Schropp 2003	2/22	1/22		2.00 [0.20, 20.49]



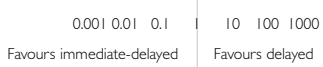
Analysis 2.2. Comparison 2 Immediate-delayed versus delayed implants, Outcome 2 Implant failure.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 2 Implant failure

Study or subgroup	Immediate-delayed n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
1 1 year				
Schropp 2003	2/23	1/23		2.00 [0.19, 20.55]
2 5 years				
Schropp 2003	2/22	1/22		2.00 [0.20, 20.49]



Analysis 2.3. Comparison 2 Immediate-delayed versus delayed implants, Outcome 3 Complications.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 3 Complications

Study or subgroup	Immediate-delayed n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
1 1 year				
Schropp 2003	4/23	0/23		9.00 [0.51, 158.17]
2 5 years				
Schropp 2003	8/20	2/21		4.20 [1.01, 17.43]

Analysis 2.4. Comparison 2 Immediate-delayed versus delayed implants, Outcome 4 Patients' perception of how long treatment took.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 4 Patients' perception of how long treatment took

Study or subgroup	Immediate-delayed N	Mean(SD)	Delayed N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 2 years						
Schropp 2003	20	-71.7 (18.8)	21	-51.4 (23.7)		-20.30 [-33.36, -7.24]

Analysis 2.5. Comparison 2 Immediate-delayed versus delayed implants, Outcome 5 Patients' aesthetic perception.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 5 Patients' aesthetic perception

Study or subgroup	Immediate-delayed N	Mean(SD)	Delayed N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 2 years						
Schropp 2003	20	94.8 (6.4)	21	87.5 (20.7)		7.30 [-1.99, 16.59]
2 5 years						
Schropp 2003	18	96 (11.9)	16	93 (14.8)		3.00 [-6.10, 12.10]

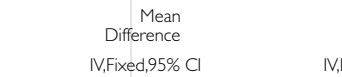
Analysis 2.6. Comparison 2 Immediate-delayed versus delayed implants, Outcome 6 Patients' general satisfaction of treatment.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 6 Patients' general satisfaction of treatment

Study or subgroup	Immediate-delayed N	Mean(SD)	Delayed N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 2 years						
Schropp 2003	20	93.89 (7.2)	21	87.38 (12.26)		6.51 [0.39, 12.63]
2 5 years						
Schropp 2003	18	95.5 (5.2)	16	95 (4.4)		0.50 [-2.73, 3.73]



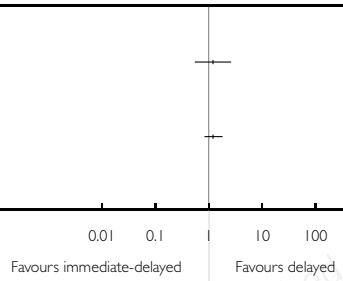
Analysis 2.7. Comparison 2 Immediate-delayed versus delayed implants, Outcome 7 Aesthetics (dentist): interproximal papilla dimension.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 7 Aesthetics (dentist): interproximal papilla dimension

Study or subgroup	Immediate-delayed n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
1 2 years				
Schropp 2003	8/19	7/20		1.20 [0.54, 2.67]
2 5 years				
Schropp 2003	15/18	11/16		1.21 [0.82, 1.79]



Analysis 2.8. Comparison 2 Immediate-delayed versus delayed implants, Outcome 8 Aesthetics (dentist): position of perimplant tissues.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 8 Aesthetics (dentist): position of perimplant tissues

Study or subgroup	Immediate-delayed n/N	Delayed n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
1 2 years				
Schropp 2003	16/19	10/20		1.68 [1.04, 2.72]
2 5 years				
Schropp 2003	15/18	12/16		1.11 [0.78, 1.58]

Analysis 2.9. Comparison 2 Immediate-delayed versus delayed implants, Outcome 9 Bone level changes.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 2 Immediate-delayed versus delayed implants

Outcome: 9 Bone level changes

Study or subgroup	Immediate-delayed N	Mean(SD)	Delayed N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 2 years						
Schropp 2003	19	0.7 (0.78)	20	0.8 (0.94)		-0.10 [-0.64, 0.44]
2 5 years						
Schropp 2003	18	0.6 (0.71)	16	0.8 (1.1)		-0.20 [-0.83, 0.43]

Analysis 3.1. Comparison 3 Immediate versus Immediate-delayed implants, Outcome 1 Aesthetics (dentist): position of perimplant tissues.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 3 Immediate versus Immediate-delayed implants

Outcome: 1 Aesthetics (dentist): position of perimplant tissues

Study or subgroup	Immediate N	Mean(SD)	Immediate-delayed N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 2 years						
Palattella 2008	8	0.8 (0.7)	8	0.6 (0.6)		0.20 [-0.44, 0.84]

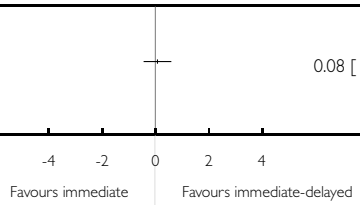
Analysis 3.2. Comparison 3 Immediate versus Immediate-delayed implants, Outcome 2 Bone level changes.

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 3 Immediate versus Immediate-delayed implants

Outcome: 2 Bone level changes

Study or subgroup	Immediate N	Mean(SD)	Immediate-delayed N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 2 years						
Palattella 2008	8	0.54 (0.51)	8	0.46 (0.54)		0.08 [-0.43, 0.59]



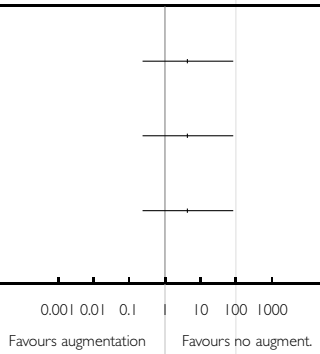
Analysis 4.1. Comparison 4 Augmentation versus no augmentation: immediate implants in extraction sockets, Outcome 1 Autogenous bone graft versus no augmentation (binary).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 4 Augmentation versus no augmentation: immediate implants in extraction sockets

Outcome: 1 Autogenous bone graft versus no augmentation (binary)

Study or subgroup	Augmentation n/N	No augmentation n/N	Risk Ratio M-H,Random,95% CI	Risk Ratio M-H,Random,95% CI
1 Prosthetic failure (2 years)				
Chen 2005b	2/14	0/12		4.33 [0.23, 82.31]
2 Implant failure (2 years)				
Chen 2005b	2/14	0/12		4.33 [0.23, 82.31]
3 Complication				
Chen 2005b	2/14	0/12		4.33 [0.23, 82.31]



Analysis 4.2. Comparison 4 Augmentation versus no augmentation: immediate implants in extraction sockets, Outcome 2 Autogenous bone graft versus no augmentation (continuous).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 4 Augmentation versus no augmentation: immediate implants in extraction sockets

Outcome: 2 Autogenous bone graft versus no augmentation (continuous)

Study or subgroup	Augmentation N	Mean(SD)	No augmentation N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 Bone gain (vertical - VDH)						
Chen 2005b	13	75.3 (20.9)	12	73.6 (24.2)		1.70 [-16.09, 19.49]
2 Bone gain (horizontal - HDD)						
Chen 2005b	13	75.6 (26)	12	69.2 (12.8)		6.40 [-9.48, 22.28]

Analysis 5.1. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 1 Resorbable versus non-resorbable barrier (binary).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 1 Resorbable versus non-resorbable barrier (binary)

Study or subgroup	Resorbable n/N	Non-resorbable n/N	Risk Ratio M-H,Random,95% CI	Risk Ratio M-H,Random,95% CI
1 Complication				
Chen 2005a	2/11	0/12		5.42 [0.29, 101.77]

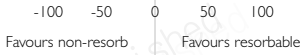
Analysis 5.2. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 2 Resorbable versus non-resorbable (continuous).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 2 Resorbable versus non-resorbable (continuous)

Study or subgroup	Resorbable N	Mean(SD)	Non-resorbable N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 Bone gain (vertical - VDH)						
Chen 2005a	11	69.1 (27.5)	12	74.9 (27.7)		-5.80 [-28.38, 16.78]
2 Bone gain (horizontal - HDD)						
Chen 2005a	11	75.8 (34.2)	12	73.6 (30.5)		2.20 [-24.38, 28.78]



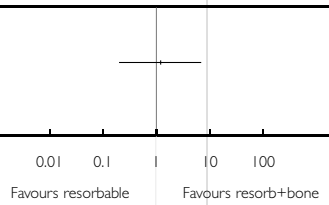
Analysis 5.3. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 3 Resorbable versus resorbable + autogenous bone (binary).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 3 Resorbable versus resorbable + autogenous bone (binary)

Study or subgroup	Resorbable n/N	Resorb + bone n/N	Risk Ratio M-H,Random,95% CI	Risk Ratio M-H,Random,95% CI
1 Complication				
Chen 2005a	2/11	2/13		1.18 [0.20, 7.06]



Analysis 5.4. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 4 Resorbable versus resorbable + autogenous bone (continuous).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 4 Resorbable versus resorbable + autogenous bone (continuous)

Study or subgroup	Resorbable N	Mean(SD)	Resorb + bone N	Mean(SD)	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Bone gain (vertical - VDH)						
Chen 2005a	11	69.1 (27.5)	13	83.1 (23.8)		-14.00 [-34.77, 6.77]
2 Bone gain (horizontal - HDD)						
Chen 2005a	11	75.8 (34.2)	13	89.7 (19.8)		-13.90 [-36.80, 9.00]

Analysis 5.5. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 5 Non-resorbable versus resorbable + autogenous bone (binary).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 5 Non-resorbable versus resorbable + autogenous bone (binary)

Study or subgroup	Non-resorbable n/N	Resorb + bone n/N	Risk Ratio M-H,Random,95% CI	Risk Ratio M-H,Random,95% CI
1 Complication				
Chen 2005a	0/12	2/13		0.22 [0.01, 4.08]

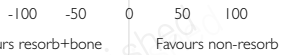
Analysis 5.6. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 6 Non-resorbable versus resorbable + autogenous bone (continuous).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 6 Non-resorbable versus resorbable + autogenous bone (continuous)

Study or subgroup	Non-resorb N	Mean(SD)	Resorb + bone N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
1 Bone gain (vertical - VDH)						
Chen 2005a	12	74.9 (27.7)	13	83.1 (23.8)		-8.20 [-28.52, 12.12]
2 Bone gain (horizontal - HDD)						
Chen 2005a	12	73.6 (30.5)	13	89.7 (19.8)		-16.10 [-36.44, 4.24]



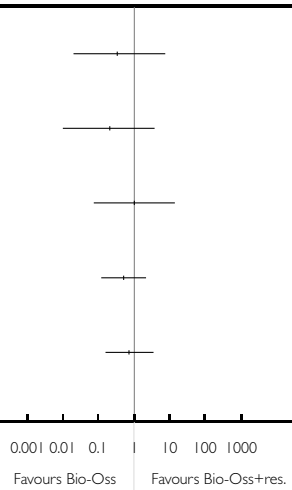
Analysis 5.7. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 7 Bio-Oss versus Bio-Oss + resorbable (binary).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 7 Bio-Oss versus Bio-Oss + resorbable (binary)

Study or subgroup	Bio-Oss n/N	Bio-Oss + resorbable n/N	Risk Ratio M-H,Random,95% CI	Risk Ratio M-H,Random,95% CI
1 Augmentation failure				
Chen 2007	0/10	1/10		0.33 [0.02, 7.32]
2 Complication at augmented site				
Chen 2007	0/10	2/10		0.20 [0.01, 3.70]
3 Poor aesthetics measured by patient (after restoration)				
Chen 2007	1/10	1/10		1.00 [0.07, 13.87]
4 Poor aesthetics measured by dentist (after restoration)				
Chen 2007	2/10	4/10		0.50 [0.12, 2.14]
5 Poor aesthetics measured by dentist (3 years)				
Chen 2007	2/7	2/5		0.71 [0.15, 3.50]



Analysis 5.8. Comparison 5 Augmentation versus augmentation: immediate implants in extraction sockets, Outcome 8 Bio-Oss versus Bio-Oss + resorbable (continuous).

Review: Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)

Comparison: 5 Augmentation versus augmentation: immediate implants in extraction sockets

Outcome: 8 Bio-Oss versus Bio-Oss + resorbable (continuous)

Study or subgroup	Bio-Oss N	Mean(SD)	Bio-Oss + resorbable N	Mean(SD)	Mean Difference IV,Random,95% CI	Mean Difference IV,Random,95% CI
1 Bone gain (vertical - VDH)						
Chen 2007	10	8.2 (1.46)	10	7.2 (2.93)		1.00 [-1.03, 3.03]
2 Bone gain (horizontal - HDD)						
Chen 2007	10	1.5 (1.01)	10	1.5 (0.9)		0.0 [-0.84, 0.84]

APPENDICES

Appendix 1. MEDLINE via 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 subject search was run with the *Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomized 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 5.0.2 [updated September 2009].*

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. The Cochrane Oral Health Group Trials Register Search Strategy

(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 "sub-periosteal 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. The Cochrane Central Register of Controlled Clinical Trials (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 via OVID Search Strategy

1. tooth implantation/
2. ((implant-supported or implant$) adj support$).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
3. ((osseointegrated adj implant$) and (dental or oral)).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
4. ((dental implant$ or dental-implant or implant$) adj (dent$ or oral or tooth)).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
5. (((overdenture$ or crown$ or bridge$ or prosthesis or prostheses or restoration$) adj5 (dental or oral)) and implant$).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
6. "implant supported dental prosthesis".mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
7. ("blade implant$" and (dental or oral or tooth or teeth)).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
8. ((endosseous adj5 implant$) and (dental or oral or tooth or teeth)).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
9. ((dental or oral or tooth or teeth) and implant$).mp. [mp=title, abstract, subject headings, drug trade name, original title, device manufacturer, drug manufacturer name]
10. or/1-9

The EMBASE subject search was run with the Cochrane Oral Health Group Search Strategy for identifying randomized controlled trials in EMBASE:

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

Last assessed as up-to-date: 1 June 2010.

Date	Event	Description
10 August 2010	Amended	Minor edit. Data in analysis 5.7 has been changed from odds ratios to risk ratios

HISTORY

Protocol first published: Issue 2, 2006

Review first published: Issue 4, 2006

Date	Event	Description
2 August 2010	New citation required but conclusions have not changed	New authorship.
2 August 2010	New search has been performed	Substantive amendment. New search. New methods. 5 new included studies. 7 new excluded studies. Conclusions not changed
13 June 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

Conceiving, designing and co-ordinating the review (Marco Esposito (ME)).

Developing search strategy and undertaking searches (ME).

Screening search results and retrieved papers against inclusion criteria (ME, Maria Gabriella Grusovin (GG), Ilias Polyzos (IP), Pietro Felice (PF)).

Writing to authors for additional information (ME, Helen Worthington (HW)).

Appraising quality (ME, GG, IP, PF).

Data extraction (ME, GG, IP, PF).

Analysis and interpretation of the data (ME, HW).

Writing the review (ME).

Providing general advice on the review (GG, IP, PF).

Performing previous work that was the foundation of the current study (ME).

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- The University of Manchester, UK.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

This review is composed by one review (Esposito 2006c) and part of another review (Esposito 1998) dealing with similar topics. The reviews were fused to make the topic more coherent from a clinical point of view. Original protocols were not changed.

INDEX TERMS

Medical Subject Headings (MeSH)

*Dental Implants [psychology]; *Tooth Extraction; Antibiotic Prophylaxis; Dental Implantation, Endosseous [*methods]; Dental Restoration Failure; Patient Satisfaction; Randomized Controlled Trials as Topic; Time Factors

MeSH check words

Humans