Interventions for replacing missing teeth: surgical techniques for placing dental implants (Review)

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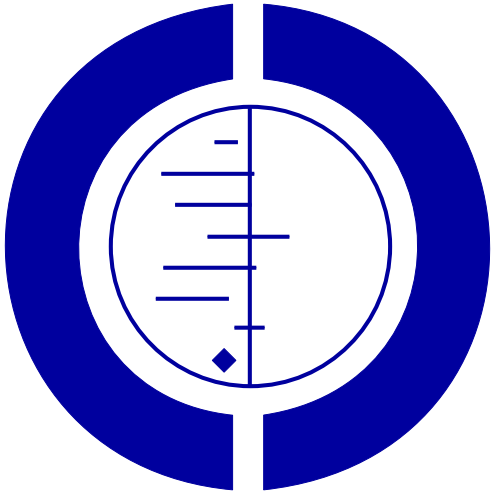

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ABSTRACT

Background
Many variations in the surgical technique for the placement of dental implants have been developed since the introduction of implant surgery into clinical practice. These include variations in the timing of implant placement in relation to the tooth removal, and variations in the way the recipient bone site is prepared, amongst others.

Objectives
To test the null hypothesis of no difference in the success, function, morbidity, patient satisfaction and cost-effectiveness of different surgical techniques for placing dental implants, against the alternative hypothesis of a difference.

Search strategy
The Cochrane Oral Health Group Trials Register, the Cochrane Central Register of Controlled Trials, MEDLINE and EMBASE were searched. In addition, the bibliographies of review articles were checked for studies outside the handsearched journals and personal references were searched. 55 implant companies were also contacted.

Selection criteria
Randomised controlled clinical trials (RCTs) of implant surgical techniques.

Data collection and analysis
Authors were contacted for details of randomisation and data and quality assessment was carried out (ME, PC). Data were independently extracted, in duplicate, by two reviewers (HW, PC). The Cochrane Oral Health Group's statistical guidelines were followed.

Main results
Four RCTs (six publications) were suitable for inclusion in this review of the nine RCTs (11 publications) identified. Two different aspects of implant surgical technique were reported in these RCTs. These were, two versus four implants to support a mandibular overdenture and crestal versus vestibular incision for implant placement. At the patient level there were no statistically significant differences for any of these alternative techniques with respect to implant failures, marginal bone levels, morbidity or patient satisfaction.

Authors' conclusions
This review included studies evaluating the surgical techniques of two versus four implants to support a mandibular overdenture and crestal versus vestibular incision for implant placement. Based on the available results of RCTs, there is no strong evidence supporting superior success with one or other of the alternative techniques for either of these two aspects of surgical technique. These conclusions are based on a few RCTs for each aspect of surgical technique and some with relatively short follow-up periods and few patients.

SYNOPSIS

There is no strong evidence that any of the variations in surgical technique described in this review for placing implants have superior success rates.

Missing teeth can sometimes be replaced with dental implants into the jaw. A crown, bridge or denture can then be attached to the implant. Many modifications in the surgical techniques for placing dental implants have been developed to try to improve the success rate of implants and reduce the side effects of surgery. However, this review found there is not enough evidence from trials to demonstrate superiority of any particular surgical technique.

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 jaw bones to support a dental prosthesis and are retained because of the intimacy of bone growth onto their surface. This direct structural and functional connection between living bone and implant surface, termed osseointegration, was first described by Branemark (Branemark 1977) and has undoubtedly been one of the most significant scientific breakthroughs in dentistry over the past 20 years.

Teeth may have been lost through dental disease or trauma or be congenitally absent. In addition, there are a number of people who have more extensive loss of oral and facial tissues following extensive cancer surgery for whom osseointegrated implants may offer an improvement over previous treatment modalities.

Implant treatment is becoming more widely known by patients and consequently their expectations of receiving this type of treatment are increasing. A multitude of implant designs have been marketed over recent years, and the clinical situations in which osseointegrated implant retained prostheses are used have expanded enormously. The variety of surgical techniques used to place implants has also increased. Many variations have strong proponents with surgeons claiming that a particular technique offers improved implant success. However, there is frequently disagreement and this area is controversial. Modifications in surgical technique include:

- Time of placement

Implants may be placed at the time of tooth removal (immediate placement), at about six to eight weeks later when the soft tissues have healed (delayed immediate placement), or at some later time point.

- One-stage and two-stage surgery

Implants may be placed with overlying soft tissues closure and then allowed a healing period before uncovering again (two-stage technique), or placed and left uncovered during the healing phase (one-stage technique).

- Number of implants

The number of implants placed to support a similar sized prosthesis may vary.

- Soft tissue flap design

Variations in the position of the incision and design of the soft tissue access flap for implant placement.

- Depth of implant placement

There are variations in the depth of placement of implants. Some are placed so that they are slightly submerged below the level of the surrounding bone.

- Implant placement instrumentation

Implants may be placed using various drills to shape a hole in the bone or by using various hand instruments to condense the bone and thereby shape a suitable hole.

- Platelet Rich Plasma

A concentrate of growth factors is made from a sample of blood taken from the patient and used to accelerate bone growth about the implants.

This review aims to compare different surgical techniques for placing implants.

OBJECTIVES

To test the null hypothesis of no difference in the success, function, morbidity, patient satisfaction and cost-effectiveness of different surgical techniques for placing dental implants, against the alternative hypothesis of a difference.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of studies

All randomised controlled clinical trials comparing surgical techniques for placing dental implants.

Types of participants

Patients with missing teeth who require implant treatment.

Types of intervention

Different surgical techniques for placing the same type of dental implants, for example, one-stage versus two-stage surgical treatment.

Types of outcome measures

- Prosthetic failure (binary)
- Implant failure (mobility and removal of stable implant dictated by progressive marginal bone loss) (binary)
- Marginal bone levels on intraoral radiographs taken with the parallel technique (continuous)
- Morbidity (including pain, swelling, nerve injury) (both binary and continuous)
- Patient satisfaction of speech, function of denture, looseness of denture and social function (both binary and continuous on VAS scale)
- Cost-effectiveness

SEARCH STRATEGY FOR IDENTIFICATION OF STUDIES

See: Oral Health Group search strategy

For the identification of studies included or considered for this review a detailed search strategy was developed for each database searched. These were based on the search strategy developed for MEDLINE but revised appropriately for each database. The search strategy combined a sensitive search strategy for RCTs revised from phases one and two of the Cochrane Sensitive Search Strategy for randomised controlled clinical trials (RCTs) (as published in Appendix 5c in the Cochrane Reviewers' Handbook). The subject search used a combination of controlled vocabulary and freetext terms based on the following search strategy for searching MEDLINE:

#1 randomized controlled trial.pt.
#2 controlled clinical trial.pt.
#3 randomized controlled trials.sh.
#4 random allocation.sh.
#5 double blind method.sh.
#6 single blind method.sh.
#7 latin square.ti,ab.
#8 crossover.ti,ab.
#9 (split adj (mouth or plot)).ti,ab.
#10 or/1-9
#11 (ANIMAL not HUMAN).sh.
#12 10 not 11 #
#13 clinical trial.pt.
#14 exp clinical trials/
#15 (clin$ adj25 trial$).ti,ab.
#16 ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).ti,ab.
#17 placebos.sh.
#18 placebo$.ti,ab.
#19 random$.ti,ab.
#20 research design.sh.
#21 or/13-20
#22 21 not 11
#23 22 not 12
#24 12 or 22
#25 exp Dental Implants/
#26 exp Dental Implantation/ or dental implantation.mp.
#27 exp Dental Prosthesis, Implant-Supported/
#28 ((osseointegrated adj implant$) and (dental or oral)).mp. [mp=title, abstract, registry number word, mesh subject heading]
#29 dental implant$.mp. [mp=title, abstract, registry number word, mesh subject heading]
#30 (implant$ adj5 dent$).mp. [mp=title, abstract, registry number word, mesh subject heading]
#31 dental-implant$.mp. [mp=title, abstract, registry number word, mesh subject heading]
#32 (((overdenture$ or crown$ or bridge$ or prosthesis or prostheses or restoration$) near (Dental or oral)) and implant$).mp. [mp=title, abstract, registry number word, mesh subject heading]
#33 "implant supported dental prosthes*".mp. [mp=title, abstract, registry number word, mesh subject heading]
#34 ("blade implant$" and (dental or oral)).mp. [mp=title, abstract, registry number word, mesh subject heading]
#35 ((endosseous adj5 implant$) and (dental or oral)).mp. [mp=title, abstract, registry number word, mesh subject heading]
#36 ((dental or oral) adj5 implant$).mp. [mp=title, abstract, registry number word, mesh subject heading]
#37 25 - 36
#38 24 and 37

SEARCHED DATABASES

- Cochrane Oral Health Group Trials Register
- The Cochrane Central Register of Controlled Trials: The Cochrane Library Issue 3, 2002
- MEDLINE 1966 - September 2002
- EMBASE 1974 - September 2002

The bibliographies of identified RCTs and review articles were checked for studies outside the handsearched journals. PubMed was independently searched using the 'related articles' feature. Personal references (ME, AJ) were also searched.

LANGUAGE
There were no language restrictions.

UNPUBLISHED STUDIES
Authors of the identified RCTs were written to in order to obtain further information about the trial and to attempt to identify unpublished or ongoing studies. In addition, we wrote to 55 producers of implant systems.

HANDSEARCHING

Details of the journals being handsearched by the Oral Health Group's ongoing programme are given on the web site: http://www.cochrane-oral.man.ac.uk. The following journals were identified as being important to be handsearched for this review: British Journal of Oral and Maxillofacial Surgery, Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, 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 the American Dental Association, Journal of Biomedical Materials Research, 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 had not already been searched as part of the Cochrane journal handsearching programme, the journals were handsearched by the reviewers (ME, AJ).

METHODS OF THE REVIEW

STUDY SELECTION

The titles and abstracts (when available) of all reports identified through the electronic searches were scanned independently by two reviewers (ME, PC). For studies appearing to meet the inclusion criteria, or for which there was 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 reviewers (ME, PC) to establish whether the studies met the inclusion criteria or not. Disagreements were resolved by discussion. Where resolution was not possible a third reviewer (HW) was consulted. All studies meeting the inclusion criteria then underwent a validity assessment and data extraction. Any studies rejected at this or subsequent stages were recorded in the table of excluded studies, and reason for exclusion recorded.

QUALITY ASSESSMENT

The quality assessment of the included trials was undertaken independently and in duplicate by the two reviewers as part of the data extraction process (ME, PC).

Three main quality criteria were examined: randomisation and allocation concealment (recorded as adequate, unclear, inadequate and not used); blind outcome assessment (recorded as yes, no, unclear and not possible); and completeness of follow-up (is there a clear explanation for withdrawals and drop-outs in each treatment group?). The quality assessment criteria were pilot tested using several articles. The agreement between the quality assessments was measured using the kappa statistic. Further quality assessment was carried out to assess baseline comparability between treatment groups and a note of whether a priori calculation for sample size had been undertaken.

DATA EXTRACTION

Data was extracted by two reviewers (HW, PC) 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 to be discussed and a third reviewer (ME) consulted where necessary. Authors were contacted for clarification or missing information whenever possible.

For each trial the following data were recorded:

Date of the study, 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 on the type of intervention.

Details of the outcomes reported, including method of assessment, and time intervals.

DATA SYNTHESIS

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

Clinical heterogeneity was to be assessed by examining the types of participants, interventions and for all outcomes in each study if more studies had been included. Only if there were studies of similar comparisons reporting the same outcome measures was meta-analysis to be attempted. Relative risks were to be combined for dichotomous data, and weighted mean differences for continuous data, using a random effects model.

It was planned to undertake sensitivity analyses to examine the effect of allocation concealment and blind outcome assessment on the overall estimates of effect. In addition, the effect of including unpublished literature on the review's findings was to be examined, however there were insufficient studies to undertake this.

Where possible, subgroup analyses was to be undertaken in respect of the different surgical techniques.

DESCRIPTION OF STUDIES

See "Characteristics of included studies table".

See "Characteristics of excluded studies table".

CHARACTERISTICS OF THE TRIAL SETTING AND INVESTIGATORS

Of the nine eligible trials (Barber 1996; Batenburg 1998a; Batenburg 1998b; Heydenrijk 2000; Hunt 1996; Ivanoff 2001; Kemppainen 1997; Moberg 2001; Wismeijer 1997), five trials (Barber 1996; Batenburg 1998b; Ivanoff 2001; Kemppainen 1997; Moberg 2001) were excluded due to methodological problems. Of the four included trials (Batenburg 1998a; Heydenrijk 2000; Hunt 1996; Wismeijer 1997), three were conducted in The Netherlands

(Batenburg 1998a; Heydenrijk 2000; Wismeijer 1997) and one in the USA (Hunt 1996). Various aspects of one study (Wismeijer 1997) were reported in three publications. Three trials had a parallel group study design and one had a split-mouth study design (Hunt 1996). One trial received support from industry (Batenburg 1998a). All studies included adults. Two trials were conducted at university dental departments (Batenburg 1998a; Heydenrijk 2000), one in a non-university hospital (Wismeijer 1997) and one in a Naval dental clinic (Hunt 1996).

CHARACTERISTICS OF THE INTERVENTIONS

Two of the four included studies (Batenburg 1998a; Wismeijer 1997) compared the efficacy of placing different numbers of implants to support a mandibular overdenture. The other two studies (Heydenrijk 2000; Hunt 1996) compared the vestibular incision versus the crestal incision for flap design for placement of dental implants.

- Two versus four implants to support a mandibular overdenture

In one study (Batenburg 1998a) patients received either two or four IMZ type implants to the anterior mandible. After three months, overdentures were constructed, supported by round bar and clip attachments. In the other study (Wismeijer 1997) patients received two implants with ball attachments or two implants with bar connection or four implants with a bar connection. In this study, only the latter two groups were compared and the first group is not reported in this review. Hollow ITI type implants were mainly used, although a solid screw ITI type implant was used if the hollow cylinder did not show sufficient primary stability.

- Crestal versus vestibular incision for implant placement

Two studies compared the vestibular incision with the crestal incision. One trial (Hunt 1996) used a split mouth design while the other (Heydenrijk 2000) used a parallel group design. For the crestal incision technique, an incision was made longitudinally along the crest of the alveolar bone through gingiva and periosteum. For the vestibular incision technique, an initial incision was made in the vestibule with the ends extending to the crest of the alveolar bone. A split-thickness mucosal flap was dissected towards the alveolar bone and the periosteum incised just beneath the crest to permit exposure of the crest. In the split mouth study where no teeth were present to separate the two flap designs, a vertical incision was made to connect the two incisions.

CHARACTERISTICS OF OUTCOME MEASURES

- Two versus four implants to support a mandibular overdenture

One study (Batenburg 1998a) reported implant failure, marginal bone level and altered sensation in the area supplied by the mental nerve at 12 months. A second study (Wismeijer 1997) reported patient satisfaction and altered sensation at 16 months. Patient satisfaction of speech, function of mandibular denture, looseness of mandibular denture and social function were reported.

- Crestal versus vestibular incision for implant placement

Morbidity in one trial (Hunt 1996) included wound dehiscence, primary coverage (described as dehiscence involving the implant) pain, oedema and erythema at 1, 7, 14 and 30 days after incision. It would have been of interest to include some of these morbidity measures in this review but we were unable to obtain the data in a suitable form (taking the pairing into account) from the authors. Radiographic marginal bone level was recorded in this trial at second stage surgery at four to six months but the data were not presented. We wrote to the authors requesting this data, again taking the pairing into account, but received no reply. Implant failure at second stage surgery at four to six months as manual testing of mobility was reported and included in this review. Outcome measures in the other study (Heydenrijk 2000) were plaque, calculus, bleeding score, pocket probing depth, modified 'gingiva' score, recession and width of attached mucosa at one year after placement of the prosthesis. The following outcomes were measured at 2, 6 and 12 weeks after implant insertion: implant loss, degree of peri-implant inflammation, mucosal level (recession or overgrowth). Radiographic marginal bone level was recorded in this trial at one year but the data were not presented. We wrote to the authors requesting this data but received no reply. Implant loss at 2, 6, 12 weeks and one year was reported and included in this review.

METHODOLOGICAL QUALITY

RANDOMISATION AND ALLOCATION CONCEALMENT

- Two versus four implants to support a mandibular overdenture

The method of randomisation and allocation concealment was unclear in the articles describing both studies (Batenburg 1998a; Wismeijer 1997) but described as adequate following receipt of further information from the authors indicating computer generation of randomisation code and independent investigator providing code.

- Crestal versus vestibular incision for implant placement

The method of randomisation and allocation concealment was considered unclear for both studies. Further information was requested from the authors but no reply was received.

BLINDING OF OUTCOME ASSESSMENT

- Two versus four implants to support a mandibular overdenture

It is not possible to blind the patients and outcome assessors to the number of implants placed. However it is possible for an independent assessor to undertake the radiographic evaluations. The outcome assessor was independent in one study (Batenburg 1998a) but it was unclear in the other (Wismeijer 1997).

- Crestal versus vestibular incision for implant placement

It is not possible to blind the patients and outcome assessors to the site of incision since this may be identified from the scar. However, it would be possible for an independent assessor to undertake the radiographic evaluations. Any attempt at blinding was unclear in both studies (Heydenrijk 2000; Hunt 1996).

COMPLETENESS OF FOLLOW-UP

- Two versus four implants to support a mandibular overdenture

One study (Batenburg 1998a) had a clear explanation of withdrawal and drop-outs in each treatment group and the other study (Wismeijer 1997) did not have a clear explanation.

- Crestal versus vestibular incision for implant placement

There were no withdrawals in either study.

SAMPLE SIZE
None of the studies included in this review undertook a priori calculation for the sample size.

BASELINE COMPARABILITY BETWEEN TREATMENT GROUPS
There did not appear to be any baseline differences between groups for patient sex, age, period of edentulism or number of previous dentures in one of the parallel group studies (Wismeijer 1997). Any difference at baseline was not clear for the other two studies (Batenburg 1998a; Heydenrijk 2000).

AGREEMENT OF QUALITY ASSESSMENT
The percentage agreement and kappa scores between the two raters was: 50% agreement and kappa 0.33 for blinding, 100% agreement and kappa 1.00 for allocation concealment and 75% agreement and kappa 0.50 for reporting of attrition. The agreement was poor for blinding as different outcomes could be blinded and the assessors assessed different outcomes. The agreement for allocation concealment was perfect as this was unclear in all studies.

RESULTS

Four randomised controlled clinical trials (RCTs) (six publications) were suitable for inclusion in this review of the nine RCTs (11 publications) identified as eligible. Two different aspects of implant surgical technique were reported in these RCTs. These were, two versus four implants to support a mandibular overdenture and crestal versus vestibular incision for implant placement.

- Two versus four implants to support a mandibular overdenture

One trial (Batenburg 1998a) with a parallel group design compared two IMZ versus four IMZ implants to support a mandibular overdenture in 60 patients. One implant was lost in a patient in the two implant group prior to exposure surgery with associated prosthesis failure (comparison 01, outcome 01,02). No significant difference was reported for marginal bone loss between groups (comparison 01, outcome 03). None of the study patients showed any sensory deficit (comparison 01, outcome 04). At the patient level there was no statistically significant difference between groups with regard to prosthesis failure, implant function, marginal bone level or altered sensation in the lip and chin (comparison 01, outcomes 01,02,03,04). The study authors are now evaluating the five-year results.

A second trial (Wismeijer 1997) with a parallel design compared three different treatments: two ITI type dental implants with ball attachments versus two ITI type implants with interconnecting bar versus four ITI implants with interconnecting bar to support a mandibular overdenture. The data from the two groups with two ITI implants were combined. No significant difference was found in patient satisfaction of speech, function of mandibular denture, looseness of mandibular denture and social function between the two implant group and the four implant group (comparison 01, outcomes 05,06,07,08). Three patients reported altered sensation in the lower lip before treatment and an additional three after surgery (one received two implants and two received four implants). There were 73 patients in the two implant group and 37 patients in four implant group.

- Crestal versus vestibular incision for implant placement

The split mouth study with ten patients (Hunt 1996) reported no implant failures in either the crestal incision or vestibular incision technique group at implant exposure surgery approximately four to six months after placement of the implant. There were no withdrawals during the period of the study. In the parallel group study with ten patients (Heydenrijk 2000) one patient in the crestal incision group showed mobility and loss of an implant at week two after implant placement (comparison 02, outcome 01).

DISCUSSION

Only four randomised controlled clinical trials (RCTs) investigating two aspects of surgical technique were identified and suitable for inclusion in this review. This review therefore provides a rather limited view of the many modifications of surgical techniques practiced when placing dental implants. The outcomes reported in these RCTs were also limited and there were no studies investigating cost effectiveness. For surgeons to make valid decisions about the choice of surgical technique they require more information than this review is currently able to offer. However, this review is useful in indicating what types of surgical techniques have already been investigated and offers advice on continuing clinical research in this area.

Of the two studies investigating whether two or four implants may be preferable for the support of a mandibular overdenture, one study (Batenburg 1998a) failed to show any significant difference in implant failure or marginal bone levels about implants, and the

other (Wismeijer 1997) failed to show any significant difference in patient satisfaction. Both studies also reported morbidity as regards altered sensation in the lower lip and chin region supplied by the mental nerve and both failed to demonstrate any significant difference. During implant placement surgery to the mandible it is possible to cause altered sensation by trauma to either the mental nerve in the anterior or inferior alveolar nerve in the posterior mandible. This is an important aspect of postoperative morbidity. One of the studies (Wismeijer 1997) reported altered sensation in a number of patients before placement of implants. It was suggested that this may have been caused by pressure on the denture bearing area in the region of the mental foramen.

Only two studies were available for inclusion in this review that investigated choice of incision for implant placement surgery. Both of these studies provided information relating to implant failure alone and both studies failed to demonstrate any significant difference between the crestal and vestibular incision for implant placement. Both studies were small, each having only ten patients and the randomisation and allocation concealment procedures were unclear in both studies.

Three studies excluded from this review because of problems with study design were evaluating one-stage versus two-stage surgical techniques (Batenburg 1998b; Kemppainen 1997; Moberg 2001). It would obviously be preferable for the patient to undergo one surgical episode rather than two if equivalent outcomes could be demonstrated. All three studies were confounded by the type of implant used. Ideally studies investigating surgical techniques should attempt to limit other variables such as type of implant and type of prosthetic restoration.

It was not possible to combine any of the studies investigating a particular aspect of surgical technique and carry out a meta-analysis of the results because different outcomes or time points were used. None of included studies undertook a sample size calculation and it may be that significant difference was not detected between groups because the studies lacked power. The analysis of split mouth studies did not take the pairing into account. The outcome data from both split mouth and parallel group studies were analysed at the level of the implant rather than at the level of the patient and therefore did not take into account the clustering of the implants within a patient. The design and analysis of these studies is frequently complex and it is recommended that statisticians are involved in the initial planning stages and protocol writing. It has been shown elsewhere that the design, analysis and reporting of RCTs on oral implants has been generally poor (Esposito 2001). Investigators should design studies carefully deciding on the intervention of interest and then attempt to limit as many other variables as possible. The randomisation and allocation concealment procedures were unclear in two of the studies (Heydenrijk 2000; Hunt 1996). As it has been shown that the treatment effect is over estimated where these are inadequate (Schultz 1995a; Shultz 1995b), it is recommended that these aspects of trial methodology and reporting should be improved.

AUTHORS' CONCLUSIONS

Implications for practice

This review included studies evaluating the surgical techniques of two versus four implants to support a mandibular overdenture and crestal versus vestibular incision for implant placement. Based on the available results of randomised controlled clinical trials (RCTs), there is no evidence supporting superior success with one or other of the alternative techniques for either of these two aspects of surgical techniques. These conclusions are based on a few RCTs for each aspect of surgical technique and some with relatively short follow-up periods and few patients.

Implications for research

In order to understand if there is a surgical technique that is able to significantly improve the effectiveness of oral implants more well designed long-term trials are needed. Such trials should be reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Moher 2001) (http://www.consort-statement.org/). Ideally studies investigating surgical techniques should attempt to standardise all other parameters such as type of implant and prosthetic restoration. It would be of interest for future studies to investigate time of implant placement in relation to tooth removal, one-stage versus two-stage surgical technique, platelet rich plasma and effect of implant placement instrumentation such as undertaking osteotomy with drills or bone condensors.

POTENTIAL CONFLICT OF INTEREST

None known.

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Internal sources of support

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- The Sahlgrenska Academy at Goteborg University SWEDEN
- University of Oslo NORWAY

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Schultz 1995a
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Shultz 1995b
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* *Indicates the major publication for the study*

TABLES

Characteristics of included studies

Study	**Batenburg 1998a**
Methods	One-year follow-up parallel group randomised trial with 60 patients. Independent outcome assessor. Two withdrawals: one died in the two implant group and one moved in the four implant group.
Participants	Patients were included if they had been edentulous for at least 2 years and had a severely resorbed mandible. Adults treated in the University Hospital of Groningen, The Netherlands. 60 patients were enrolled (30 patients in the two-implant group and 30 in the four-implant group). The age range was 38 to 81 years.
Interventions	2 IMZ (Friatec) type dental implants versus 4 IMZ (Friatec) type dental implants to support a mandibular overdenture.
Outcomes	Implant failure as loss and mobility tested with Periotest and tapping at baseline (6 weeks after attaching the overdenture to the implants), 6 months after baseline and 12 months after baseline. Marginal bone level changes on standardised intra-oral radiographs at the same time points. Morbidity as altered sensation in the region supplied by the mental nerve at the same time points. Periodontal parameters as plaque score, calculus score, bleeding score, gingiva score, width of attached gingiva, pocket probing depth, and gingival recession. These periodontal parameters were not included in this review.
Notes	
Allocation concealment	A

Study	**Heydenrijk 2000**
Methods	One-year follow-up parallel group randomised trial with 10 patients. No withdrawals.
Participants	Patients were included if they had a severely resorbed mandible resulting in impaired stability and retention of their lower denture. Adults treated in the University Hospital of Groningen, The Netherlands. 10 patients were enrolled (5 in the vestibular incision group and 5 in the crestal incision group). The age range was 44 to 79 years.
Interventions	Vestibular incision versus crestal incision for flap design during placement of 2 IMZ implants. Implant placement for one stage technique.
Outcomes	Implant failure at 2, 6 and 12 weeks after implant insertion and at one year after placement of prosthesis as mobility. Radiographic marginal bone level at one year but data not presented. Other outcome measures at one year were plaque, calculus, bleeding score, pocket probing depth, modified 'gingiva' score, recession, width of attached mucosa. The following outcomes were measured at 2, 6 and 12 weeks after implant insertion: implant loss, degree of peri-implant inflammation, mucosal level (recession or overgrowth).
Notes	

Characteristics of included studies (*Continued*)

Allocation concealment	B

Study	**Hunt 1996**
Methods	Six-months follow-up split mouth randomised trial with 10 patients. Two patients were not examined for morbidity at day 14 but all 10 were assessed for implant mobility at 4-6 months.
Participants	The criteria for inclusion are not presented. 9 patients were edentulous and 1 was partially dentate. Adults treated at Naval Dental Clinic, USA. The age range was 37-73 years.
Interventions	Vestibular incision versus crestal incision for flap design during placement of Brånemark implants. Implant placement for two stage technique.
Outcomes	Implant failure at second stage surgery at 4-6 months as manual testing of mobility. Marginal bone level changes at second stage surgery at 4-6 months but data not presented. We wrote to the authors requesting this data, taking the pairing into account, but received no reply. Morbidity at 1, 7, 14 and 30 days after incision: wound dehiscence, primary coverage, pain, oedema and erythema. It would have been of interest to include some of these morbidity measures in this review but we were unable to obtain the data in a suitable form (taking the pairing into account) from the authors.
Notes	
Allocation concealment	B

Study	**Wismeijer 1997**
Methods	Sixteen-month follow-up parallel group randomised trial with 110 patients. Before treatment 2 patients refused the treatment proposition. At 16 months, a further 4 were lost: one had died, one had emigrated and two did not return the questionnaire but not clear according to group.
Participants	Patients were included if they had been edentulous in the mandible or maxilla for at least five years. Patients were excluded if they had received previous preprosthetic surgery or had a physical contra-indication to implant surgery. Adults treated at the Ignatius General Teaching Hospital, Breda, The Netherlands. 110 enrolled (37 patients with 2 implants and bar, 37 with 4 implants and bar and a third group of 36 patients, combined with the 2 implants and bar group, that received 2 implants with ball attachments). The age range was 33 to 81 years.
Interventions	2 ITI type dental implants with interconnecting bar versus 4 ITI type dental implants with interconnecting bar to support a mandibular overdenture. A third group received 2 ITI type dental implants with ball attachments and the data were combined with the 2 implants and bar group data in this review. In most cases hollow cylinder implants were used but full screws were also used.
Outcomes	Morbidity as altered sensation in the region supplied by the mental nerve at sixteen months. Patient satisfaction of speech, function of mandibular denture, looseness of mandibular denture and social function.
Notes	Three patients (2 in the 2 implant group and 1 in the 4 implant group) had altered sensation prior to the surgical intervention and these were not included in the analysis of postoperative altered sensation.
Allocation concealment	A

Characteristics of excluded studies

Barber 1996	Methodological problem: not clear how rotational mobility (outcome) was assessed using a Periotest. No reply to letter.
Batenburg 1998b	Methodological problem: surgical technique confounded by type of implant (one-stage technique with ITI implants and two-stage technique with Brånemark or IMZ implants).
Ivanoff 2001	Methodological problem: type of suture material (intervention) confounded by suture technique. Letter received from authors confirmed that the three suture techniques were not randomly distributed between the two suture type groups.

Characteristics of excluded studies (*Continued*)

Kemppainen 1997	Methodological problem: surgical technique confounded by type of implant (one-stage technique with ITI implants and two-stage technique with Astra implants).
Moberg 2001	Methodological problem: surgical technique confounded by type of implants (one-stage technique with ITI implants and two-stage technique with Brånemark implants).

GRAPHS

Comparison 01. Two versus four implants

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 Prosthesis failure	1	58	Relative Risk (Fixed) 95% CI	3.00 [0.13, 70.74]
02 Implant failure			Relative Risk (Fixed) 95% CI	Totals not selected
03 Marginal bone			Weighted Mean Difference (Fixed) 95% CI	Totals not selected
04 Morbidity: altered sensation			Relative Risk (Random) 95% CI	Totals not selected
05 Patient satisfaction: speech	1	104	Weighted Mean Difference (Fixed) 95% CI	-0.30 [-0.60, 0.00]
06 Patient satisfaction: function of mandibular denture	1	104	Weighted Mean Difference (Fixed) 95% CI	-1.90 [-2.18, -1.62]
07 Patient satisfaction: looseness of mandibular denture	1	104	Weighted Mean Difference (Fixed) 95% CI	0.00 [-0.02, 0.02]
08 Patient satisfaction: social function	1	104	Weighted Mean Difference (Fixed) 95% CI	0.10 [-0.13, 0.33]

Comparison 02. Crestal versus vestibular incision

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 Implant failure			Relative Risk (Fixed) 95% CI	Totals not selected

INDEX TERMS

Medical Subject Headings (MeSH)

Dental Implantation, Endosseous [methods]; Dental Implants; Randomized Controlled Trials; Tooth Loss [rehabilitation]

Medical MeSH check words

Humans

COVER SHEET

Title Interventions for replacing missing teeth: surgical techniques for placing dental implants

Authors Coulthard P, Esposito M, Jokstad A, Worthington HV

Contribution of author(s)

Conceiving, designing and co-ordination of the review (Paul Coulthard)
Developing the search strategy and undertaking the searches (Marco Esposito, Asbjorn Jokstad, PC)
Screening search results and retrieval of papers against inclusion criteria (ME, PC)
Appraising quality and abstracting data from papers (Helen Worthington, ME, PC)
Writing to authors for additional information (HW, ME, PC)
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Writing the review (PC)

	Providing general advice on the review (ME, HW, AJ) Performing previous work that was the foundation of current study (ME, AJ, HW, PC)
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GRAPHS AND OTHER TABLES

Fig. 1. Comparison 01. Two versus four implants

01.01 Prosthesis failure

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 01 Prosthesis failure

Study	Two implants n/N	Four implants n/N	Relative Risk (Fixed) 95% CI	Weight (%)	Relative Risk (Fixed) 95% CI
Batenburg 1998a	1/29	0/29		100.0	3.00 [0.13, 70.74]
Total (95% CI)	29	29		100.0	3.00 [0.13, 70.74]

Total events: 1 (Two implants), 0 (Four implants)

Test for heterogeneity: not applicable

Test for overall effect z=0.68 p=0.5

Fig. 2. Comparison 01. Two versus four implants

01.02 Implant failure

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 02 Implant failure

Study	Two implants n/N	Four implants n/N	Relative Risk (Fixed) 95% CI	Relative Risk (Fixed) 95% CI
Batenburg 1998a	1/29	0/29		3.00 [0.13, 70.74]

Fig. 3. Comparison 01. Two versus four implants

01.03 Marginal bone

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 03 Marginal bone

Study	Two implants N	Two implants Mean(SD)	Four implants N	Four implants Mean(SD)	Weighted Mean Difference (Fixed) 95% CI	Weighted Mean Difference (Fixed) 95% CI
Batenburg 1998a	29	0.54 (0.98)	29	0.37 (0.87)		0.17 [-0.31, 0.65]

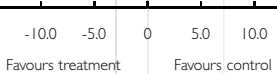

Fig. 4. Comparison 01. Two versus four implants

01.04 Morbidity: altered sensation

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 04 Morbidity: altered sensation

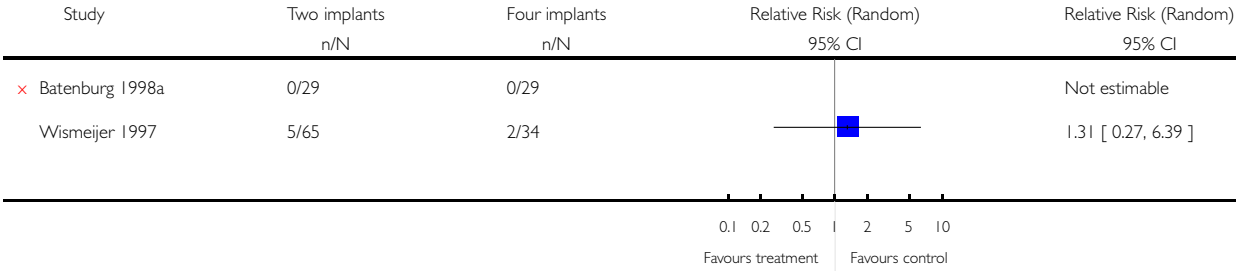

Fig. 5. Comparison 01. Two versus four implants

01.05 Patient satisfaction: speech

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 05 Patient satisfaction: speech

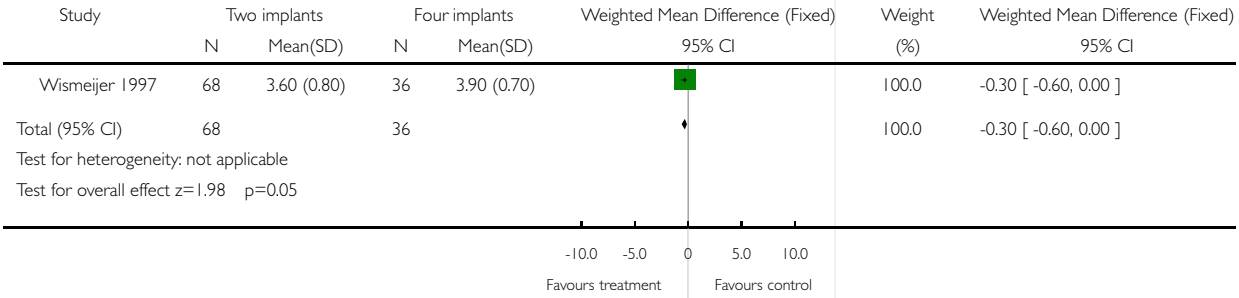

Fig. 6. Comparison 01. Two versus four implants

01.06 Patient satisfaction: function of mandibular denture

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 06 Patient satisfaction: function of mandibular denture

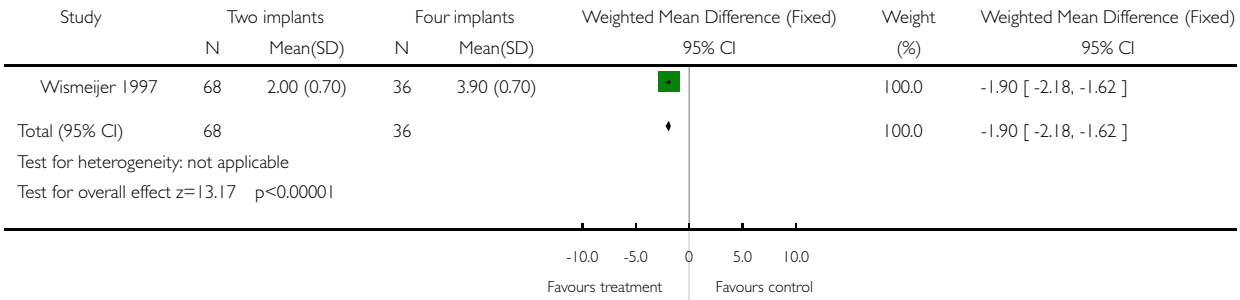

Fig. 7. Comparison 01. Two versus four implants

01.07 Patient satisfaction: looseness of mandibular denture

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 07 Patient satisfaction: looseness of mandibular denture

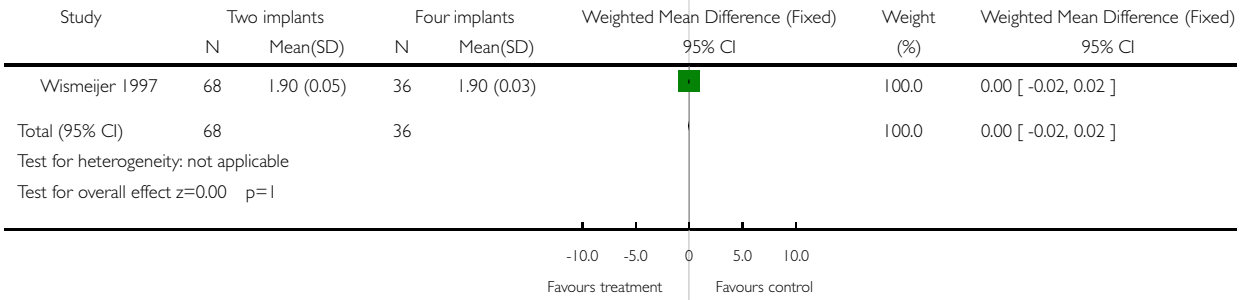

Fig. 8. Comparison 01. Two versus four implants

01.08 Patient satisfaction: social function

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 01 Two versus four implants

Outcome: 08 Patient satisfaction: social function

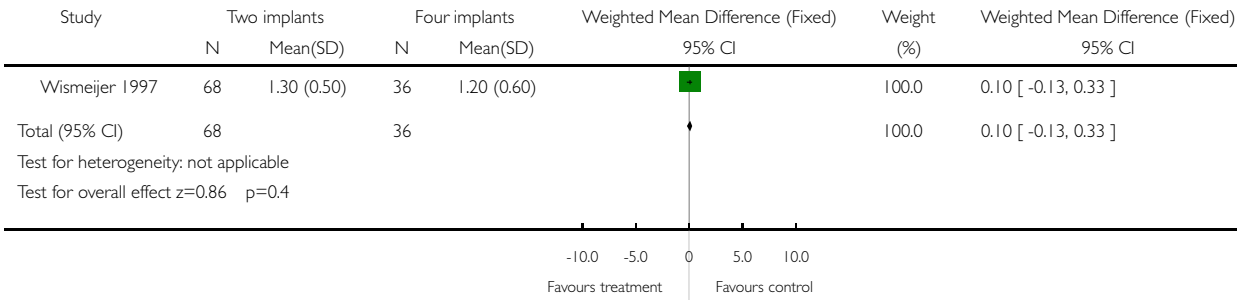

Fig. 9. Comparison 02. Crestal versus vestibular incision

02.01 Implant failure

Review: Interventions for replacing missing teeth: surgical techniques for placing dental implants

Comparison: 02 Crestal versus vestibular incision

Outcome: 01 Implant failure