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Invited Review Paper
Pre-Implant Surgery

What is the quality of the evidence base for pre-implant surgery of the atrophic jaw?☆

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Abstract. This review aimed to evaluate the level of evidence for bone augmentation preimplant surgery for atrophic jaws in studies which measure outcome. Medline, Embase, Cochrane library and online journal searches were performed with a defined search strategy and the abstracts screened against selection criteria. The resultant papers were sorted by study design using the Cochrane study design algorithm, analysed for clinical/statistical homogeneity and graded with the Oxford Centre of Evidence-based Medicine levels of evidence. The initial online Medline search yielded 1194 results and the Embase search yielded 490 results. Using the selection criteria, 10 studies were identified. Additionally, 5 articles were identified from bibliography and online searches, giving a total of 15 studies for grading. All 15 studies were graded as level 4 evidence. No meta-analysis of outcomes was possible with the low level of evidence and degree of heterogeneity found. The best grade of recommendation that can be made for a particular preimplant surgical bone augmentation procedure, from these level 4 studies, is Grade C. Benchmarking studies by assessing quality of evidence can be helpful to inform future study designs with respect to reporting study outcomes with a higher level of evidence.

Keywords: preimplant surgery; preprosthetic surgery; surgery; oral; endosteal implants; dental implants; osseointegrated implants; evidence-based medicine; review; rehabilitation; procedures; maxillofacial.

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Preimplant surgery can be defined as surgery to allow for favourable endosteal implant placement of optimal size and position. This ensures the best possible implant-associated prosthetic rehabilitation and applies to any situation where implants may be required to restore dental function and appearance. This includes patients that are edentulous, partially dentate and patients with hard or soft tissue deficits due to disease, trauma or deformity. This review focuses on bone augmentation of the atrophic jaw, the commonest indication for preimplant surgery.

Following the introduction of endosteal implants, a large volume of literature has been published in relation to preimplant surgery and many assertions have been made. The quality of this literature varies and it is sometimes difficult to draw firm conclusions or to make recommendations for best practice in preimplant surgery. Recommendations about interventions should be based on well-designed studies, implying that the quality of individual studies needs to be assessed and in such a way that is seen to be valid. One such method is to use the Oxford Centre of Evidence-based Medicine (CEBM) levels of evidence[23] (Tables 1 and 2).

The aim of this review was to apply the CEBM system to evaluate the level of evidence for bone augmentation preimplant surgery for atrophic jaws in studies that measure outcome. The intent was to benchmark the best studies to date in this area against a recognised system of measuring strength of evidence. It was not the

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Table 1. Centre of Evidence Based Medicine criteria for levels of evidence for therapeutic interventions[23].

Level	Therapy
1a	Systematic review (with homogeneity*) of randomised controlled trials (RCTs)
1b	Individual RCT (with narrow Confidence Interval)
1c	All or none§
2a	Systematic review (with homogeneity*) of cohort studies
2b	Individual cohort study (including low quality RCT; e.g., <80% follow-up)
2c	'Outcomes' research; ecological studies
3a	Systematic review (with homogeneity*) of case-control studies
3b	Individual case-control study
4	Case-series (and poor quality cohort and case-control studies§§)
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or ''first principles''

* By homogeneity the authors mean a systematic review that is free of worrisome variations (heterogeneity) in the directions and degrees of results between individual studies. Not all systematic reviews with statistically significant heterogeneity need be worrisome, and not all worrisome heterogeneity need be statistically significant. Studies displaying worrisome heterogeneity should be tagged with '-' at the end of their designated level.

§ Met when all patients died before the treatment became available, but some now survive on it; or when some patients died before the treatment became available, but none now die on it.

§§ By poor quality cohort study the authors mean one that failed to clearly define comparison groups and/or failed to measure exposures and outcomes in the same (preferably blinded), objective way in both exposed and non-exposed individuals and/or failed to identify or appropriately control known confounders and/or failed to carry out a sufficiently long and complete follow-up of patients. By poor quality case-control study the authors mean one that failed to clearly define comparison groups and/or failed to measure exposures and outcomes in the same (preferably blinded), objective way in both cases and controls and/or failed to identify or appropriately control known confounders.

Table 2. Grades of recommendation from Centre for Evidence Based Medicine[23].

A	consistent level 1 studies
B	consistent level 2 or 3 studies **or** extrapolations from level 1 studies
C	level 4 studies **or** extrapolations from level 2 or 3 studies
D	level 5 evidence **or** troublingly inconsistent or inconclusive studies of any level

intention to carry out a meta-analysis on reported outcomes from studies selected in this review, unless they were studies providing high levels of evidence.

Material and methods

Medline, Embase and Cochrane library searches were performed in May 2006 using a modification of the search strategy of the Cochrane review by COULTHARD *et al.*[9] to include a search for the term 'bone graft' in line 37 (Fig. 1). On the advice of a librarian from the British Medical Association, modifications were made to line 11 of the search changing '(ANIMAL not HUMAN)sh.' to 'ANIMAL/not HUMAN/', and line 33 was changed from 'prosthes*' to 'prosthes#s'. Where the websites were enabled, the following 42 journals were searched for the keywords 'prospective', 'randomized'/'randomised' and 'implant': Adv Dent Res, Ann Perio, Ann Plast Surg, Arch Oral Biol, Br Dent J, Br J Oral Max Surg, Br J Plast Surg, Chin J Dent Res, Clin Impl Dent Rel Res, Clin Oral Impl Res, Clin Oral Investig, Compendium, Crit Rev Oral Biol Med, Dent Clin N Amer, Eur J Dent Educ, Eur J Oral Sci, Eur J Plast Surg, Implant Dent, Int J Oral Max Impl, Int J Oral Max Surg, Int J Prosthod, J Am Dent Ass, J Clin Period, J Craniofac Surg, J Craniomax Surg, J Dent, J Dent Res, J Evid-based Dent Pract, J Oral Impl, J Oral Max Surg, J Oral Rehabil, J Periodont, J Prosthet Dent, J Prosthodont, Odontol, Oral Biosci Med, Oral Health & Prevent Dent, Oral Max Surg Clin N Am, Oral Oncol, Oral Radiol, Oral Surg Oral Med Oral Path Oral Rad & Endo, Quintessence International.

The abstracts and, where necessary, full-text articles were then screened on two separate occasions by one reviewer (TKB) applying the following selection criteria, which were devised by the authors: randomised controlled clinical trials, longitudinal cohort studies, case controls and case series both prospective and retrospective; patients with atrophic or severely atrophic jaws: maxilla, mandible or both; patients undergoing bony augmentation surgery; follow-up duration of $\geq$ 3 years[35]; $\geq$10 subjects; minimum outcome measures including a report on either (or both) of the following: implant loss and/or implant failure and prosthesis failure due to implant failure.

The subset of studies fulfilling the selection criteria were then divided into studies of preimplant surgery for the maxilla or for the mandible and graded using the Oxford Centre for Evidence-based Medicine Levels of Evidence 2001 (Tables 1 and 2)[23]. The 'therapy' level of evidence CEBM template was judged to be the appropriate classification for preimplant surgery studies. For this purpose, it was necessary to classify each non-randomised study as a case series, case-control or cohort study using the Cochrane design algorithm for studies of healthcare interventions[30]. It was then necessary to evaluate the quality of each cohort or case-control study according to CEBM definitions. The four main CEBM parameters (Table 1, superscript §§) that determine whether a case-control or cohort study is good quality are that: comparison groups should be clearly defined; exposures and outcomes should be measured in the same standard (ideally blinded) objective way in both exposed and non-exposed individuals; known confounders should be identified or appropriately controlled (the minimum confounders considered of sufficient importance to be reported in the published studies were: smoking status, age, gender, radiotherapy or chemotherapy treatment, application of an atrophic jaw classification); the follow-up of patients should be sufficiently long and complete (the authors interpreted this definition as if it was stated that: the subjects were recruited consecutively; with explanations as to why any subjects were

Table 3. The following methodological or outcome data were charted.

- Edentulous or partially edentulous status of subjects
- Number of subjects and implants placed
- Type of preimplant surgery performed
- 1 or 2 stage implant placement i.e. immediate with bone augmentation (1 stage) or interval implant placement following bone augmentation healing (2 stage)
- Delayed or immediate implant loading
- Bone graft failure
- Type of implant system used
- Type of prosthetic rehabilitation
- Mean bone graft height loss (magnification-adjusted orthopantomogram)
- Mean implant marginal bone loss (using the long cone paralleling technique)
- Use of resonance frequency analysis in objectively recording implant stability
- Method of calculating implant survival/success rates (e.g. absolute/life table/Kaplan–Meier analysis[14])
- Statistical analyses used and whether these were patient-based or implant-based
- Patient satisfaction or quality of life data

1 randomized controlled trial.pt. (217354)
2 controlled clinical trial.pt. (71630)
3 randomized controlled trials.sh. (42882)
4 random allocation.sh. (55576)
5 double blind method.sh. (86955)
6 single blind method.sh. (9922)
7 latin square.ti,ab. (2256)
8 crossover.ti,ab. (24300)
9 (split adj (mouth or plot)).ti,ab. (689)
10 or/1-9 (378136)
11 ANIMAL/ not HUMAN/ (2962375)
12 10 not 11 (354261)
13 clinical trial.pt. (428181)
14 exp clinical trials/ (179160)
15 (clin$ adj25 trial$).ti,ab. (116328)
16 ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).ti,ab. (85423)
17 placebos.sh. (24890)
18 placebo$.ti,ab. (95655)
19 random$.ti,ab. (337943)
20 research design.sh. (43737)
21 or/13-20 (783472)
22 21 not 11 (728359)
23 22 not 12 (391299)
24 12 or 22 (745560)
25 exp Dental Implants/ (7669)
26 exp Dental Implantation/ or dental implantation.mp. (11288)
27 exp Dental Prosthesis, Implant-Supported/ (2463)
28 ((osseointegrated adj implant$) and (dental or oral)).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (916)
29 dental implant$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (15177)
30 (implant$ adj5 dent$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (16045)
31 dental-implant$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (15177)
32 (((overdenture$ or crown$ or bridge$ or prosthesis or restoration$) adj5 (Dental or oral)) and implant$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (5090)
33 "implant supported dental prosthes#s.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (4)
34 ("blade implant$" and (dental or oral)).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (296)
35 ((endosseous adj5 implant$) and (dental or oral)).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (8587)
36 ((dental or oral) adj5 implant$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (16184)
37 ((bone adj5 graft$) and (dental or oral)).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (1646)
38 or/25-37 (17306)
39 24 and 38 (1194)

Fig. 1. Medline search strategy (with numbers of articles detected) May 2006. A 3-tiered approach was used: searches 1–10 and 13–20 defining the study design terms; searches 11,12, 22–24 confining the search to human literature; searches 25–39 combining with an interrogation for subject-specific words.

excluded from the outcome data; and/or mean follow-up was $\geq$3 years or >50% of subjects followed-up for >3 years).

In order to be able to consider homogeneity of the selected studies, the methodological or outcome data listed in Table 3 were charted.

Results

The initial online Medline search yielded 1194 results and the Embase search yielded 490 results (Fig. 2). Following application of the selection criteria, 10 studies were identified and none of these were prospective randomised controlled clinical trials. Additionally, 5 articles were identified from bibliography and online searches, giving a total of 15 studies[1–3,11,13,15–17,20,22,26,34,36–38] for grading. Most were retrospective cohort or case-series studies. 13 studies related to maxillary and 3 to mandibular preimplant surgery (Tables 4 and 5); one study (Schliephake *et al*. 1997)[26] contained data for both mandibular and maxillary sites. One study was excluded because it did not report whether the site(s) pertained to the maxilla, mandible or both (Christensen *et al*. 2003)[7]. Allocation of study design type, followed by evaluation of the quality of the studies, resulted in all 15 studies being assigned an evidence level of 4 (Table 6).

The subset of selected studies was found to have considerable clinical and statistical heterogeneity. There was clinical heterogeneity in terms of the method, for example Becktor *et al*.[3] included both 1 and 2 stage bone grafting and in terms of the objective outcome measures used different definitions for implant success. There was also statistical heterogeneity in that some studies based the analysis at the implant level rather than at the more acceptable patient level and some studies reported implant success in terms of absolute survival rate rather than with a more acceptable cumulative method (e.g. after Kaplan and Meier[14]).

No meta-analysis of outcomes was considered possible with the low level of evidence and degree of heterogeneity found. The best grade of recommendation that can be made for a particular preimplant surgical bone augmentation procedure, from these studies, is Grade C (Table 2).

Discussion

The Oxford CEBM classification of levels of evidence was selected for the following reasons. The United States Agency of Healthcare Research Quality (AHRQ) published a review of 121 systems for analysing quality of evidence in 2002[33]. The CEBM system was one of only seven systems considered to address fully all the important domains that an acceptable quality assessment instrument ought to cover to assess the strength of evidence derived

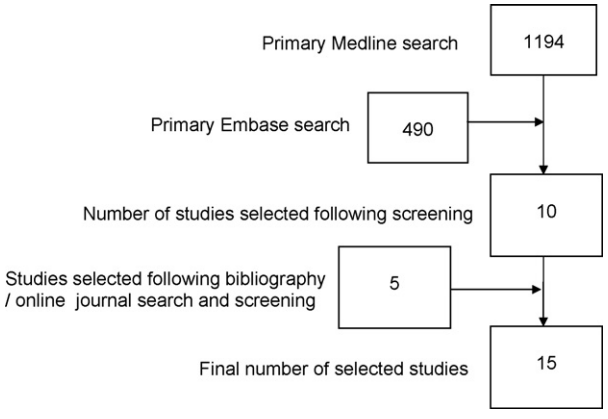

Fig. 2. Flowchart of search results.

Table 4. Publications on maxillary preimplant surgery fulfilling the selection criteria.

Author and year of publication	Study type	Preimplant surgery	Number of subjects/ implants	Duration of follow-up	Implant outcomes/method of calculation; Prosthesis success rate
Adell *et al*. 1990	Retrospective consecutive case-series	1 stage onlay iliac autogenous bone graft	23/124	Mean 4.2 years	Implant survival 75%/absolute survival rate; prosthesis success 75%
Astrand *et al*. 1996	Retrospective consecutive case-series	1 stage onlay iliac crest autogenous bone graft	17/92	≥3 years	Implant survival 75%/absolute survival rate; prosthesis success 88%
Becktor *et al*. 2004	Retrospective cohort study	Mixed 1 or 2 stage; mixed onlay/inlay autogenous bone; mxed anterior/posterior maxilla in graft group	64/437 in graft (G) group; 118/683 in non-graft (NG) group	Mean 68.9 months	Implant survival G = 75%, NG = 84%/ cumulative life table method; prosthesis success G = 87%, NG = 85%
Hallman *et al*. 2005[†]	Prospective interrupted time series study	2 stage sinus graft with autogenous mental bone: xenograft particulate 1:4 mix	20/108	3 years	Implant survival 86%/cumulative survival life table; prosthesis success 95%
Johansson *et al*. 1999	Prospective case series/case-control study (see discussion)	1 stage inlay sinus graft with block autogenous (mandibular or iliac) bone	39/254 in grafted study (S) group; 37/206 in non-grafted (R) reference group	3 years	Implant success rates: S group: 75.3% at grafted sites, 82.2% at non-grafted sites; R group: 93.1%/ cumulative life table method; prosthesis success rate S = 94.9%, R = 97.3%.
Keller *et al*. 1999	Retrospective consecutive case series	Mixed 1 or 2 stage onlay autogenous mixed iliac/calvarial bone graft	32/204	67 months	Implant survival 91% (study group)/ absolute survival rate; prosthesis success 96% (study group)
Lekholm *et al*. 1999	Retrospective cohort study	5 groups with different methods of bone augmentation	150/781 (145 of 150 subjects had maxilla treated)	3 years	Implant survival 80% overall/absolute survival rate; prosthesis success (excluding those that had further implants) 80%
Nystrom *et al*. 2004[*]	Retrospective consecutive case series	1 stage autogenous iliac horseshoe onlay graft	20/120	10 year	Implant survival 83% (study)/actuarial survival rate (Kaplan Meier); prosthesis success 93%
Olson *et al*. 2000	Prospective interrupted time-series study	Mixed 1 or 2 stage sinus-lift (4 variations of graft type)	29/120	Mean 38.2 months	Implant survival 97.5%/absolute survival rate; prosthesis success 100%
Schliephake *et al*. 1997	Retrospective interrupted time-series study	Mixed 1 or 2 stage; mixed onlay or inlay autogenous iliac crest bone graft	137/871 (88 maxillary cases of 147 jaws treated in 137 subjects)	3.2 years	Implant survival 48% 5yr in edentulous max/actuarial survival rate (Kaplan Meier); prosthesis success not stated
Valentini *et al*. 2000	Retrospective non-consecutive case-series	2 stage sinus-lift with bovine xenograft	15/57	Mean 4 yrs	Implant survival 98%/absolute survival rate; prosthesis success 100%
Widmark *et al*. 2001[‡]	Prospective cohort study	Mixed 1 or 2 stage; mixed autogenous iliac crest onlay/membrane-guided with bone chips in the graft group	43/221	>3 years	Implant survival 74% (graft group), 87% (non-graft group)/cumulative survival life table; prosthesis success unclear due to replacement of failed implants
Wiltfang *et al*. 2005	Retrospective cohort study	2 stage comparison between onlay block iliac crest and sinus-lift with particulate iliac crest autogenous bone in the posterior maxilla	100/584	4.5 years	Implant survival 91% (onlay group) 94% (sinus-lift group)/actuarial survival rate (Kaplan Meier); prosthesis success not reported

[†] Same dataset, reported in an earlier paper.
[*] Progress of same dataset, reported in several earlier papers e.g. by Nystrom *et al*. in 1993[21]; Gunne *et al*. in 1995.[10]
[‡] Progress of same dataset, reported in an earlier paper.

Table 5. Publications on mandibular preimplant surgery fulfilling the selection criteria.

Author and year of publication	Study type	Preimplant surgery	Number of subjects/ implants	Duration of follow-up	Primary outcome/method of calculation
KELLER *et al*. 1995	Retrospective cohort study	Autogenous iliac crest onlay bone graft	61/303	Median 59.5 months	Implant survival 93% in non-bone graft group, 91% in bone graft group/absolute survival rate; prosthesis success 100%
SCHLIEPHAKE *et al*. 1997	Retrospective interrupted time-series study	Mixed 1 or 2 stage; mixed onlay or inlay autogenous iliac crest bone graft	137/871 (59 mandibular cases of 147 jaws treated in 137 subjects)	3.2 years	Implant survival 89% in edentulous mandible/actuarial survival rate (Kaplan Meier); prosthesis success not stated
VERMEEREN *et al*. 1996	Retrospective case-series	Autogenous iliac crest onlay graft anteriorly secured with circummandibular wires/ hydroxyapatite posteriorly	31/78	5 years	Implant survival 89.7%/absolute survival rate; prosthesis success not stated.

from published studies. The CEBM system has a template for therapeutic interventions such as preimplant surgery.

The search and screening method used in this review falls short of the stringent criteria of a Cochrane Collaboration review specific to level 1 evidence, but it is arguably more comprehensive than previous reviews or commentaries[5,28,32]. In this context, using only one person to screen the abstracts on two separate occasions is less rigorous than the Cochrane method of using two reviewers and then assessing the agreement between them. The decision of the authors to use $\geq$10 subjects as a selection criterion is arbitrary, but is considered to be pragmatic.

The authors selected the list of confounders in the material and methods section as a minimum list for a qualitative evaluation of the rigour of the study designs. Other confounders, not used as discriminators, may be equally important, such as: American Society of Anesthesiologists (ASA) health status, the skeletal jaw classification, diabetic status, osteoporosis, xerostomia or Sjögren's syndrome, connective tissue disorders, intake of pharmacological substances: preoperative antibiotics, bisphosphonates, steroids or immunosuppressants in transplant recipients.

The process of defining the study type for the 15 studies identified in this review, using the Cochrane design algorithm for studies of healthcare interventions[30] flow-chart, was occasionally very difficult. This is illustrated by the study of JOHANSSON *et al*.[13] They reported the outcome of implant success between grafted and non-grafted sites without defining the null hypothesis clearly. Because the analysis was performed at the level of the implant site, the study could only be classified as a case series (level 4). Had the analysis been performed at the patient level with regard to prosthesis success, the study could have been classified as a prospective case-control study (potentially achieving level 3b evidence).

The gold standard of evidence is a level 1 study, prospective randomised controlled clinical trial where this is practical, ethical and feasible. Recruiting and randomising patients in surgical research is recognised to be difficult compared with other fields of research due to difficulties with the surgeon's and patient's equipoise.[18] The surgeon's equipoise is the prerequisite that the surgeon is genuinely uncertain as to which, of two treatments, is the best. The difficulty is that experienced surgeons may have naturally developed a preference for one of them. The patient's equipoise is the need for the patient to accept that their treatment would be determined by chance and this is difficult if there is a significant difference in initial morbidity of the two treatments offered in a trial (e.g. surgical versus non-surgical). A recent Cochrane literature review revealed 4 randomised controlled

Table 6. Allocation of level of evidence, including primary reason for allocation and a breakdown of the four CEBM quality criteria (as interpreted by the authors) necessary for a case-control/cohort study to avoid classification as a poor quality study (see method and Table 1 superscript §§).

Author	Level of Evidence	Primary reason for allocation of level of evidence	Clearly defined comparison group	Standard (ideally blinded) objective measure of outcome in both groups	Confounders identified and controlled	Follow-up $\geq$3 years for $\geq$50% of subjects
ADELL 1990	4	Case series study	No	No	No	Yes
ASTRAND 1996	4	Case series study	No	No	No	Yes
BECKTOR 2004	4	Does not meet all four quality criteria	Yes	No	No	Yes
HALLMAN 2005	4	Time series study	No	Yes	No	Yes
JOHANSSON 1999	4	Case series study	Yes	No	Yes	Yes
KELLER 1995	4	Does not meet all four quality criteria	No	No	No	Yes
KELLER 1999	4	Case series study	No	No	No	Yes
LEKHOLM 1999	4	Does not meet all four quality criteria	No	No	No	Yes
NYSTROM 2004	4	Case series study	No	No	No	Yes
OLSON 2000	4	Time series study	No	No	No	Yes
SCHLIEPHAKE 1997	4	Time series study	No	No	No	Yes
VALENTINI 2000	4	Case series study	No	No	No	Yes
VERMEEREN 1996	4	Case series study	No	No	No	Yes
WIDMARK 2001	4	Does not meet all four quality criteria	Yes	Yes	No	Yes
WILTFANG 2005	4	Does not meet all four quality criteria	Yes	No	No	Yes

trials on the subject of bone augmentation for dental implant placement.[9] While the length of follow-up in these trials was considered inadequate in this review (none >7 months), one would hope that outcome data with a longer period of observation will be published from these trials in due course.

The need for adequately long follow-up is an essential prerequisite for meaningful conclusions in preimplant surgery and presents a challenge to progress in that studies are prolonged. There may be a role for a study design in which an historical comparison group (retrospective cohort) can provide quality assurance analysis for a prospective cohort within the same overall study (i.e. an 'ambispective' or 'before-and-after' cohort study).

In the context of preimplant surgery, there are ethical limitations in devising control groups to design a level 1 trial for some research questions in preimplant surgery. A level 2b study design may be achievable and this applies to many of the level 4 studies identified in this review. The CONSORT (Consolidated Standards of Reporting Trials) group have produced a flow-chart and checklist of items[8] to facilitate the reporting of a high quality two-group parallel-design study and these are also relevant to wider classes of study designs[4,19].

A key step in assigning the level of evidence in the present review, was interpreting the CEBM quality measures for determining whether a case-control or cohort study was of good quality (see method, Table 1 superscript §§ and Table 6). For instance, some studies (e.g. Wiltfang *et al.*[38]) were allocated as level 4, partly because the comparison groups had been defined on implant site and not on a patient basis. A preferred method could be considered as selecting one implant at random from each subject[39].

The selection of studies in this review is likely to be prone to language bias[12] because the search was confined to English literature. Publication bias may also affect this review because, of the 15 studies, 7 had fewer than 30 patients – this is a small number of subjects for any field of investigative research. In comparative studies of outcome for an intervention, a sample of 30 subjects in each comparison group has minimal statistical power even to detect sizeable differences in outcome. As with many published research studies, preimplant surgery reports are often under-powered. A number of reasons may combine to explain the small numbers in the published reports in this review: it may be difficult to recruit subjects; the studies may be difficult to organise or fund; it may be difficult to achieve adequately complete and long term follow-up; there may be a relatively low clinician–patient ratio locally with a low level of engagement in collaborative clinical research in this field; the therapy is not commonly required. When there are many studies with low subject numbers (10–20 subjects) it is likely that the risk of publication bias is greater – in that small studies with negative results may either not be submitted for publication or may be rejected during a journal's peer-review process.

Bias may also arise from conflicts of interest, particularly in non-blinded studies. Literature concerning manufactured products such as endosteal implants is subject to potential commercial conflicts of interest and these should be declared.

The fact that preimplant surgery precedes implant insertion and prosthesis treatment means that 3 separate interventions are being delivered to a patient. It is necessary that study design and reporting takes account of this. Ideally, in the study design, the clinical question (null hypothesis) should address only one of these 3 interventions. This is because the other 2 interventions would need to be standardised for all the subjects to keep the two cohorts being studied as homogenous as possible. The authors propose that results of these three interventions be considered and reported separately using objective measures: preimplant surgery success and complications; endosteal implant success and complications; prosthesis success and complications.

The overriding outcome measure, which is likely to embrace aspects from all 3 components of the treatment, is patient-reported quality of life and functional outcomes[24,25,27,29].

It is inadvisable to perform a meta-analysis on outcome data from case-series or retrospective cohort studies since the results may be misleading[31]. This is because it is difficult to control for confounding factors in non-randomised studies. There is a danger that non-randomised studies (which tend to be bigger than randomised controlled trials) produce very precise but spurious results. Analysis should focus on possible sources of heterogeneity between the results of studies and the reasons for them. The statistical combination of studies should not, in general, be a prominent feature of reviews of non-randomised studies.

The authors are aware of the constraining criteria used in systematic reviews limited to level 1 evidence. They also acknowledge the clinical value of observational studies that show the beneficial effects of some preimplant surgical procedures that have stood the test of time and hardly need 'Cochrane proof'. Examples of such procedures include: bone augmentation to ensure adequate bone volume to support maximum sized implants in cases of severe atrophy of the alveolar bone – which, in the mandible, reduces the risk of pathological fracture; and bone augmentation and/or orthognathic surgery to correct intermaxillary malrelationship, which is accentuated by progressive alveolar resorption prior to placement of endosteal implants.

In conclusion, the level of evidence found in this study is of a low order (level 4). Qualitative aspects of study method and reporting affecting research in preimplant surgery accounts for the low level of evidence. It is important to develop strategies to overcome the difficulties of performing high quality research in surgery[18]. Flow-charts, checklists and published objective methods of standardised exposures, measurement of objective outcome criteria and acceptable statistical analyses exist to enable the construction of robust parallel-designed longitudinal studies. If these can be applied to preimplant surgery research, even where randomisation is not feasible, a higher level of evidence may be obtained. A minimum list of factors to achieve this goal should include the following: a precise clinical question (null hypothesis) confined to one of the 3 component interventions (preimplant surgery, implant placement or prosthesis function); a power analysis to define the number of patients (subjects) needed for the study; the CONSORT checklist is used at the study design stage and study type is defined using a standard flow chart; clear inclusion and exclusion criteria are defined and essential confounding factors identified and recorded from the outset; objective measures of success for the 3 interventions in the tripartite treatment are clearly defined and reported; appropriate quantitative statistical analysis is used (e.g. Kaplan–Meier survival analysis of implant success at the patient (not implant) level); patient-reported treatment outcomes using validated health-related quality of life instruments are collected and reported; there is a minimum of 3 years follow-up for >80% of subjects.

Conflicts of interest

None declared.

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