

Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants (Review)

Grusovin MG, Coulthard P, Jourabchian E, Worthington HV, Esposito M



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[Intervention Review]

Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

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ABSTRACT

Background

It is important to institute an effective supportive therapy to maintain or recover soft tissue health around dental implants. Different maintenance regimens have been suggested, however it is unclear which are the most effective.

Objectives

To test the null hypotheses of no difference between different interventions (1) for maintaining healthy peri-implant soft tissues, and (2) for recovering soft tissue health, against the alternative hypothesis of a difference.

Search strategy

We searched the Cochrane Oral Health Group's Trials Register, the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE and EMBASE. Handsearching included several dental journals. We checked the bibliographies of the identified randomised controlled trials (RCTs) and relevant review articles for studies outside the handsearched journals. We wrote to authors of all identified RCTs, to more than 55 oral implant manufacturers and to an internet discussion group to find unpublished or ongoing RCTs. No language restrictions were applied. The last electronic search was conducted on 13 June 2007.

Selection criteria

All randomised controlled trials comparing agents or interventions for maintaining or recovering healthy tissues around dental implants.

Data collection and analysis

Screening of eligible studies, assessment of the methodological quality of the trials and data extraction were conducted in duplicate and independently by two review authors. Results were expressed as random-effects models using standardised mean differences for continuous data and risk ratios for dichotomous data with 95% confidence intervals.

Main results

Eighteen RCTs were identified. Nine of these trials, which reported results from a total of 238 patients, were included. Follow ups ranged between 6 weeks and 1 year. No meta-analysis could be made since every RCT tested different interventions. Listerine mouthwash

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showed a reduction of 54% in plaque and 34% in marginal bleeding compared with a placebo. Two trials evaluated the efficacy of powered and sonic toothbrushes compared to manual toothbrushing and showed no statistically significant differences, though more patients liked the sonic brush. No statistical differences were found between brushing with a hyaluronic or a chlorhexidine gel, between cleaning with an etching gel or manually, between injecting a chlorhexidine or a physiologic solution inside the implant's inner part and between submucosal minocycline and a chlorhexidine gel. When an amine fluoride/stannous fluoride (AmF/SnF₂) mouthrinse was compared with a chlorhexidine one, no statistically significant differences were found for implant failures and staining index while patients preferred and had less taste change with the AmF/SnF₂ mouthrinse. Self administered subgingival chlorhexidine irrigation resulted in statistically significantly lower plaque and marginal bleeding than a chlorhexidine mouthwash, however the mouthwash was given at a suboptimal dosage.

Authors' conclusions

There was only little reliable evidence for which are the most effective interventions for maintaining or recovering health of peri-implant soft tissues. The included RCTs had short follow-up periods and few subjects. There was not any reliable evidence for the most effective regimens for long term maintenance. This should not be interpreted as current maintenance regimens are ineffective. There was weak evidence that Listerine mouthwash, used twice a day for 30 seconds, as an adjunct to routine oral hygiene, is effective in reducing plaque and marginal bleeding around implants. More RCTs should be conducted in this area. In particular, there is a definite need for trials powered to find possible differences, using primary outcome measures and with much longer follow up. Such trials should be reported according to the CONSORT guidelines (www.consort-statement.org/).

PLAIN LANGUAGE SUMMARY

Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Antibacterial mouthrinses may help reduce plaque and bleeding around dental implants, but there is no evidence that electronic toothbrushes are better than ordinary toothbrushes or that brushing with a certain gel is better than another.

Missing teeth can be replaced by dental implants. However, keeping the gums around the implants healthy is important, as they can be negatively affected by dental plaque and its induced inflammation. Prevention for this may include daily implant cleaning techniques by patients and regular cleaning by hygienists or dentists. This review found that there is no evidence from trials that powered or sonic toothbrushes are better than manual brushes and that brushing with a hyaluronic gel outdoes brushing with a chlorhexidine gel. Among the professionally administered treatments there is no evidence that phosphoric acid excels scaling and polishing, that chlorhexidine enclosed in the inner part of implants is superior to physiologic solution and that a topical antibiotic inserted submucosally is better than a chlorhexidine gel. However, there is some evidence that Listerine antibacterial mouthrinse, used twice a day after brushing can help to keep gums healthy.

BACKGROUND

Missing teeth and supporting oral tissues have traditionally been replaced with removable dentures or fixed bridges to allow for restoration of masticatory and phonetic function, as well as aesthetics. In 1977, Brånemark presented his research work carried out over 10 years showing that bone can grow intimately onto the surface of titanium implants (Brånemark 1977). The now well-accepted concept, termed osseointegration, has undoubtedly been one of the most significant scientific breakthroughs in dentistry over the past 30 years. A multitude of implant designs have been marketed since, and the clinical situations in which osseointegrated implant retained prostheses are used have expanded enormously.

One of the key factors for the long term success of dental implants is the maintenance of healthy tissues around them. With one-stage implant placement and with immediately loaded implants, maintenance begins in the earliest stages of implant treatment.

A cause-effect relationship between bacterial plaque accumulation and the development of inflammatory changes in the soft tissues surrounding dental implants has been shown (Pontoriero 1994). The reversible inflammatory reaction in the soft tissues surrounding a functioning implant is called peri-implant mucositis (Albrektsson 1994) and it can be defined as a chronic plaque-induced infection of the marginal peri-implant soft tissues without appreciable bone loss (Esposito 1999). If this condition is left untreated, it may lead to the progressive destruction of the tissues supporting an implant (peri-implantitis) and ultimately to its failure (Mombelli 1999). In the literature data regarding biological complications are underreported (Berglundh 2002). Peri-implant mucositis can be a common situation in subjects not following a proper maintenance programme: a long term (9 to 14 years) follow-up study on Brånemark implants (Roos-Jansäker 2006) reported the presence of peri-implant mucositis lesions in 76.6% of the subjects. It is important to institute an effective preventive regimen (supportive therapy) for maintaining healthy soft tissues around dental implants and when a pathologic condition is diagnosed, a therapeutic intervention should be initiated as soon as possible (Esposito 1999). Different maintenance regimens and treatment strategies for peri-implant mucositis and peri-implantitis have been suggested, however it is unclear which are the most effective (Orton 1989; Esposito 1999).

In general similar oral hygiene methods are advocated for teeth and implants and they can be self or professionally administered or both. One of the main concerns for dental implants, derived from *in vitro* studies, is that the metal instruments used for cleaning root surfaces can damage the metallic surface of abutments or implants, thus increasing the chance for bacterial colonisation (Thomson-Neal 1989; McCollum 1992; Speelman 1992).

For daily self administered maintenance procedures, various mechanical means for bacterial plaque removal have been proposed including soft toothbrushes, nylon coated interproximal brushes

and specially designed cleaning instruments made in hard plastic to avoid the roughening and metal 'contamination' of the implant-abutment surface (Balshi 1986), powered toothbrushes and flossing cords to facilitate cleaning in less accessible areas. Adjunctive twice-daily rinsing with antimicrobial agents such as chlorhexidine or Listerine have been recommended for individuals with physical impairment. Powered subgingival irrigation with antimicrobials has also been proposed as an adjunct to routine brushing by the patient.

Professionally administered maintenance consists of removal of dental plaque and calculus from the implant-abutment surface. This can be accomplished in several ways, but special procedures have been recommended for dental implants, such as polishing with rubber cup and fine abrasive polishing paste (flour of pumice, Nupro fine, tin oxide), subgingival irrigation with antimicrobial agents, phosphoric acid gel application. Adjunctive use of local or systemic antibiotics have been advocated in the case of deep pockets (Lang 2000). Plastic scalers were also recommended to avoid galvanic corrosion and contamination of metallic implants (Dmytryk 1990; Jensen 1991; Bragger 1994).

Another systematic review was published to investigate whether more than 10 years of maintenance procedures could prevent biological complications and implant loss (Hultin 2007). Nine uncontrolled studies were included with inconclusive results.

OBJECTIVES

- (1) To test the null hypothesis of no difference between interventions for maintaining soft tissue health around osseointegrated dental implants, against the alternative hypothesis of a difference.
- (2) To test the null hypothesis of no difference between interventions for recovering soft tissue health around osseointegrated dental implants, against the alternative hypothesis of a difference.

Both healthy peri-implant soft tissues and peri-implant mucositis lesions were considered. Peri-implant mucositis was defined as: a chronic plaque-induced infection of the marginal tissues without appreciable bone loss (Esposito 1999).

The efficacy of the interventions to treat peri-implantitis (plaque-induced progressive marginal bone loss with clinical signs of infection of the peri-implant soft tissues) was evaluated in another Cochrane review (Esposito 2006).

METHODS

Criteria for considering studies for this review

Types of studies

All randomised controlled trials of dental implants, including studies with parallel group, split-mouth and cross-over designs.

Types of participants

People who have dental implants.

Types of interventions

Interventions were divided into two groups:

- (1) Interventions for maintaining peri-implant soft tissue health
 - (a) Self administered
 - (b) Professionally administered.
- (2) Interventions for recovering peri-implant soft tissue health
 - (a) Self administered
 - (b) Professionally administered.

Active agents: defined as oral hygiene procedures, local or systemic therapeutic agents as well as any other interventions aimed to the maintenance or the recovery of peri-implant oral health.

Control: may be placebo or no treatment, or another active intervention.

Types of outcome measures

- Implant failure, defined as implant mobility of previously clinically osseointegrated implants and removal of non-mobile implants because of progressive marginal bone loss or infection.
- Radiographic marginal bone level changes on intraoral radiographs taken with a parallel technique. If these were not presented or it was not possible to estimate them, the final scores if available were used.
- Changes in probing 'attachment' level. If these were not presented or it was not possible to estimate them, probing 'attachment' level data were used.
- Changes in probing pocket depth. If these were not presented or it was not possible to estimate them, probing pocket depth data were used.
- Marginal bleeding recorded by gently running or sweeping a periodontal probe in the peri-implant sulcus (no bleeding on probing).
- Plaque.
- Side effects.
- Ease of maintenance.
- Patient satisfaction.
- Cost.
- Treatment time.

Search methods for identification of studies

For the identification of studies included or considered for this review, we developed detailed search strategies for each database to be 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 phases 1 and 2 of the Cochrane Sensitive Search Strategy for Randomised Controlled

Trials (RCTs) as published in Appendix 5b.2 of the *Cochrane Handbook for Systematic Reviews of Interventions* 4.2.6 (updated September 2006) (Higgins 2006) and amended by the Cochrane Oral Health Group. See Appendix 1.

Searched databases

The Cochrane Oral Health Group's Trials Register (to 13 June 2007)

The Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2007, Issue 2)

MEDLINE (1966 to 13 June 2007)

EMBASE (1980 to 13 June 2007).

The most recent electronic search was undertaken on 13 June 2007.

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.

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 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 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.

Quality assessment

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

Four main quality criteria were examined:

(1) Allocation concealment, recorded as:

- (A) Adequate
- (B) Unclear
- (C) Inadequate.

Allocation concealment was considered adequate if it was centralised (e.g. allocation by a central office unaware of subject characteristics); pharmacy-controlled randomisation; pre-numbered or coded identical containers which were administered serially to participants; on-site computer system combined with allocation kept in a locked unreadable computer file that can be accessed only after the characteristics of an enrolled patient have been entered; sequentially numbered, sealed, opaque envelopes; and other approaches similar to those listed above, along with the reassurance that the person who generated the allocation scheme did not administer it. Some schemes may be innovative and not fit any of the approaches above, but still provide adequate concealment. Approaches to allocation concealment which were considered clearly inadequate included any procedure that was entirely transparent before allocation, such as an open list of random numbers. Those articles or authors stating that allocation concealment procedures were implemented but did not provide details on how this was accomplished, were coded as 'unclear'.

(2) Treatment blind to patients, recorded as:

- (A) Yes
- (B) No
- (C) Unclear
- (D) Not possible.

(3) Treatment blind to outcome assessors, recorded as:

- (A) Yes
- (B) No
- (C) Unclear
- (D) Not possible.

(4) Completeness of follow up (is there a clear explanation for withdrawals and drop outs in each treatment group?) assessed as:

(A) No drop outs/yes. In the case that clear explanations for drop outs were given, a further subjective evaluation of the risk of bias

assessing the reasons for the drop out was made

(B) No.

After taking into account the additional information provided by the authors of the trials, studies were grouped into the following categories.

(A) Low risk of bias (plausible bias unlikely to seriously alter the results) if all criteria were met.

(B) High risk of bias (plausible bias that seriously weakens confidence in the results) if one or more criteria were not met as described in the *Cochrane Handbook for Systematic Reviews of Interventions* 4.2.6, section 6.7 (Higgins 2006).

Further quality assessment was carried out to assess sample size calculation, definitions of exclusion/inclusion criteria and comparability of control and treatment groups at entry. The quality assessments criteria were pilot tested using several articles.

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. Data were excluded until further clarification was available if agreement could not be reached.

For each trial the following data were recorded.

Year of publication, country of origin and source of study funding.

Details of the participants including demographic characteristics.

Details on the type of intervention.

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

Data synthesis

For dichotomous outcomes, the estimates of effect of an intervention were expressed as risk ratios together with 95% confidence intervals. For continuous outcomes, mean differences and standard deviations were used to summarise the data for each group. The statistical unit was the patient and not the implant(s).

Only if there were studies of similar comparisons reporting the same outcome measures was a meta-analysis to be attempted. Risk ratios were combined for dichotomous data, and standardised mean differences for continuous data, using a random-effects model.

Data from split-mouth studies were combined with data from parallel group trials with the method outlined by Elbourne (Elbourne 2002), using the generic inverse variance method in RevMan. The techniques described by Follmann (Follmann 1992) were used to estimate the standard error of the difference for cross-over and split-mouth studies, where the appropriate data were not presented and could not be obtained.

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 the I^2 statistic, which describes the percentage total variation across studies that is due to

heterogeneity rather than chance. Clinical heterogeneity was to be assessed by examining the types of participants and interventions for all outcomes in each study. 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, but there were insufficient trials to undertake this.

RESULTS

Description of studies

See: [Characteristics of included studies](#); [Characteristics of excluded studies](#).

See [Characteristics of included studies](#) table.

See [Characteristics of excluded studies](#) table.

Characteristics of the trial setting and investigators

Of the 18 eligible trials, nine were excluded due to problems with the data presented ([Lauciello 1993](#); [Lavigne 1994](#); [Jeffcoat 1995](#); [Tarpey 1996](#); [Kokosi 2000](#); [Simoncic 2000](#); [Truhlar 2000](#); [Porrás 2002](#); [Yalcin 2002](#)). Five randomised controlled trials (RCTs) were only available in the form of conference abstracts and presented insufficient data for the analyses ([Lauciello 1993](#); [Tarpey 1996](#); [Kokosi 2000](#); [Simoncic 2000](#); [Yalcin 2002](#)), the number of patients was unclear in two trials ([Lavigne 1994](#); [Jeffcoat 1995](#)), and the analyses were inappropriate in two trials ([Truhlar 2000](#); [Porrás 2002](#)).

Of the nine included studies, three were conducted in USA ([Ciancio 1995](#); [Felo 1997](#); [Wolff 1998](#)), two in The Netherlands ([Strooker 1998](#); [Groenendijk 2004](#)), one in New Zealand ([Tawse-Smith 2002](#)), one in Sweden ([Renvert 2004](#)), one in Israel ([Horwitz 2005](#)) and one in Portugal ([de Araujo Nobre 2007](#)). Six trials had a parallel group study design, two a split-mouth design ([Strooker 1998](#); [Groenendijk 2004](#)) and one a cross-over design ([Tawse-Smith 2002](#)). Six trials were conducted at university dental clinics, two in a hospital ([Strooker 1998](#); [Horwitz 2005](#)) and one in a private practice ([de Araujo Nobre 2007](#)). Seven trials received support from industry, for one funding was unclear ([Groenendijk 2004](#)) and one study was independent ([de Araujo Nobre 2007](#)). All studies were conducted on adults.

Characteristics of the interventions

(1) Interventions for maintaining soft tissue health

(a) Self administered

Mechanical techniques

- Powered versus manual toothbrushing ([Tawse-Smith 2002](#))

Elderly patients with two unsplinted implants in the anterior mandible. Plaque was professionally removed 2 weeks before study

baseline. Detailed video and written instructions: brushing for 30 seconds twice daily for 6 weeks. After a 2-week wash-out period and a second pre-entry visit, each group crossed-over and used the alternate brush for a further 6 weeks.

Antimicrobials

- Hyaluronic gel versus chlorhexidine gel for brushing ([de Araujo Nobre 2007](#))

Patients with four mandibular immediately loaded implants supporting a fixed prosthesis. Hyaluronic gel or chlorhexidine gel were used on a brush as the only mean to maintain oral hygiene for 6 months. Oral hygiene instructions were given on the day of the surgery, at 10 days and at 2, 4, 6 months.

- Amine fluoride/stannous fluoride (AmF/SnF₂) versus chlorhexidine mouthwashes ([Horwitz 2005](#))

Partially edentulous patients. The study initiated just after placement of transmucosal implants. Rinsing for 1 minute with 10 ml of the mouthwashes following routine toothbrushing for 3 months with either chlorhexidine 0.12% or AmF/SnF₂ with a total of 250 ppm fluoride. Antibiotics for 7 days post-surgery. Quarterly maintenance appointments (oral hygiene instructions, hand and ultrasonic instrumentation with non-metal instruments).

(b) Professionally administered

- Etching gel versus mechanical debridement ([Strooker 1998](#))

Patients with four mandibular implants splinted with a bar supporting an overdenture. Supra- and sub-gingival debridement with carbon fibre curettes, polishing with rubber cup and prophylactic paste on one side of the mouth and 35% phosphoric acid gel applied for 1 minute with a syringe in the peri-implant sulcus on the other side. Acid gel on a cotton swab was used to remove any calculus deposit still present. The procedures were repeated at each maintenance visit every month for 5 months.

- Chlorhexidine solution versus physiologic solution in the inner part of implants ([Groenendijk 2004](#))

Fully edentulous patients with an overdenture (Dolder bar) on four mandibular implants. At implant exposure, after cover screw removal, the inner part of the implants was sampled for microorganisms and then rinsed with physiologic solution. In a split-mouth design, test implants were dried with sterile paper points and then about 0.7 microlitre of 0.2% chlorhexidine was injected inside the inner part of the implants, while control sites received saline solution. Patient rinsed twice a day for 2 weeks with chlorhexidine. Patients were seen weekly for clinical measurements for 6 weeks.

(2) Interventions for recovering soft tissue health

(a) Self administered

Mechanical techniques

- Sonic versus manual toothbrushing (Wolff 1998)

Patients with one or more restored implants. Oral and written instructions: brushing for 2 minutes twice daily. Timer was given to manual toothbrush subjects while sonic toothbrushes had an electronic built-in timer. Oral hygiene was reviewed and reinforced at each visit (1, 2, 3 and 6 months).

Antimicrobials

- Listerine versus placebo mouthwashes (Ciancio 1995)

Patients with one or more restored implants. Baseline prophylaxis. Rinsing twice a day for 30 seconds with Listerine or with a 5% hydroalcohol placebo mouthrinse flavoured to taste similar to the antiseptic, in addition to normal oral hygiene regimen. No mouthrinse quantity was indicated. A diary of the product usage was kept and the remaining mouthrinse was returned at each monthly visit to monitor compliance.

- Subgingival chlorhexidine irrigation versus chlorhexidine rinsing (Felo 1997)

Fully edentulous patients restored with overdentures. Baseline prophylaxis. Subgingival irrigation with 100 ml 0.06% chlorhexidine gluconate (0.12% PerioGard diluted 50% with water) with a water pik pocket tip or rinsing with 2 ml 0.12% chlorhexidine gluconate (PerioGard) once a day before going to sleep following normal oral hygiene (soft toothbrush and Colgate dentifrice).

(b) Professionally administered

- Mechanical debridement plus minocycline or chlorhexidine gel (Renvert 2004)

Patients with implants inserted 10 to 12 years before. Oral hygiene instruction and supra- sub-gingival plaque and calculus removal. After cessation of bleeding and isolating/drying, the implants to be treated had submucosally inserted either 1 mg minocycline (Arestin one single dose) or approximately 1 ml of 1% chlorhexidine gel with a disposable 2 ml syringe. Patients were instructed not to brush for 12 hours and avoid interproximal cleaning for 10 days in the treated areas. At the follow-up visits (10, 30, 60, 90, 180, 270 and 360 days) no supportive treatment was given besides requested oral hygiene information.

Characteristics of outcome measures

- Implant failures: two trials (Horwitz 2005; de Araujo Nobre 2007).
- Radiographic marginal bone level changes: one trial (Horwitz 2005), but we could not use the data since presented at implant level.
- Changes in probing 'attachment' levels: one trial (Ciancio 1995) presented probing 'attachment' levels and we could not calculate changes since 3 months means data were adjusted.

- Changes in probing pocket depth: four trials (Strooker 1998; Wolff 1998; Renvert 2004; de Araujo Nobre 2007) gave probing pocket depths. Changes were calculated. One trial (Ciancio 1995) presented probing pocket depths and we could not calculate changes since 3 months means data were adjusted.
- Marginal bleeding: three trials (Ciancio 1995; Felo 1997; de Araujo Nobre 2007). Two trials (Ciancio 1995; Felo 1997) used a slightly modified index of Ainamo and Bay (Ainamo 1975), whereas the other trial (de Araujo Nobre 2007) used the modified bleeding index of Mombelli (Mombelli 1987).
- Plaque was recorded in all but one study (Horwitz 2005). Different plaque indexes were used: the Turesky modification of the Quigley-Hein plaque index (Turesky 1970) was used in two trials (Ciancio 1995; Felo 1997); the Silness and Loe plaque index (Silness 1964) in two trials (Strooker 1998; Wolff 1998); the Mombelli index (Mombelli 1987) in three trials (Tawse-Smith 2002; Groenendijk 2004; de Araujo Nobre 2007); presence or absence of plaque expressed in percentages (Renvert 2004).
- Side effects: three trials: pain after treatment (Strooker 1998; Renvert 2004) and change in taste, tooth staining, unusual side effects and allergies (Horwitz 2005).
- Ease of maintenance: one trial (Wolff 1998).
- Patient satisfaction: two trials (Wolff 1998; Horwitz 2005). In one trial it was expressed as liking of the toothbrush (Wolff 1998) and the other study as desire for future use (Horwitz 2005).
- Cost: no trial.
- Treatment time: one trial (Strooker 1998).

Follow ups were 6 weeks (Tawse-Smith 2002; Groenendijk 2004), 3 months (Ciancio 1995; Felo 1997), 5 months (Strooker 1998), 6 months (Wolff 1998; de Araujo Nobre 2007), 1 year (Renvert 2004; Horwitz 2005). Three-month data were used for one study (Horwitz 2005), since 1-year data were not at patient level and the use of the mouthrinses was discontinued at 3 months.

Risk of bias in included studies

Allocation concealment

After correspondence with the authors of the trials, concealment of allocation was considered adequate for four trials (Ciancio 1995; Felo 1997; Renvert 2004; Horwitz 2005) and unclear in four studies (Strooker 1998; Wolff 1998; Groenendijk 2004; de Araujo Nobre 2007). Allocation was not concealed in one study (Tawse-Smith 2002).

Blinding

After correspondence with the authors of the trials, blinding of the patients and the outcome assessors was done in four trials (Ciancio

1995; Groenendijk 2004; Horwitz 2005; de Araujo Nobre 2007). It was not possible to blind the patients to the interventions in five trials (Felo 1997; Strooker 1998; Wolff 1998; Tawse-Smith 2002; Renvert 2004). Outcome assessors were blinded to the interventions in all trials, but one (Strooker 1998).

Withdrawals

After correspondence with the authors of the trials, the reporting of withdrawals was adequate for all trials.

Sample size

No trial reported on sample size calculation.

Inclusion and exclusion criteria

Main inclusion criteria

Good general health (Ciancio 1995; Felo 1997; Strooker 1998; Horwitz 2005).

Patients have to use only the oral care products supplied (Wolff 1998; Tawse-Smith 2002).

Bleeding on probing of the peri-implant tissues (Ciancio 1995; Felo 1997), together with probing depth > 4 mm with 0.2 Ncm probing force (Renvert 2004).

A minimum of one implant with bone loss \leq 3 mm compared to placement of the prosthesis 10 to 12 years before (Renvert 2004).

Presence of anaerobic and of some periopathogen bacteria detected with DNA probe (Renvert 2004).

Mean modified gingival index > 1.5 (Ciancio 1995; Felo 1997).

Mean plaque index > 1.5 (Felo 1997).

Mean plaque index > 1.7 (Ciancio 1995).

Healthy (ASA classification I) edentulous patients wearing dentures for many years (Groenendijk 2004).

Patient treated with four immediately loaded mandibular implants (two axial and two tilted implants) and a fixed prosthetic rehabil-

itation (de Araujo Nobre 2007).

Partial edentulous patients after placement of transmucosal implants (Horwitz 2005).

Main exclusion criteria

Smokers (Tawse-Smith 2002; de Araujo Nobre 2007).

Orthodontic appliances (Ciancio 1995; Felo 1997).

Subjects requiring prophylactic antibiotic coverage (Ciancio 1995; Felo 1997; Wolff 1998; Renvert 2004).

Used antibiotics within 3 months prior to study and/or antimicrobial mouthrinses (Tawse-Smith 2002; Horwitz 2005; Groenendijk 2004) and/or drugs or mouthrinses with anti-inflammatory properties (Strooker 1998), and/or received professional oral cleaning (Wolff 1998).

Known allergy to the tested products (Renvert 2004; Horwitz 2005).

Medication within 1 month of the screening visit with agents known to affect periodontal status (Renvert 2004).

No exclusion criteria (Groenendijk 2004).

Comparability of control and treatment groups at entry

The various groups were comparable at entry for all trials, except for one (Felo 1997) in which more plaque was present in the test group.

The agreed quality of the included trials after having incorporated the information provided by the authors is summarised in 'Additional Table 1'. For each trial we assessed whether it was at low or at high risk of bias. Four trials were rated at low risk of bias (Ciancio 1995; Felo 1997; Renvert 2004; Horwitz 2005) and five at high risk of bias (Strooker 1998; Wolff 1998; Tawse-Smith 2002; Groenendijk 2004; de Araujo Nobre 2007).

Table 1. Results of quality assessment after correspondence with authors

Study	Allocation	Blinding of patients	Blinding of assessor	Withdrawals	Grade
Ciancio 1995	Adequate	Yes	Yes	None	A
Felo 1997	Adequate	Not possible	Yes	None	A
Strooker 1998	Unclear	Not possible	No	None	B
Wolff 1998	Unclear	Not possible	Yes	None	B
Tawse-smith 2002	Not used	Not possible	Yes	Yes	B

Table 1. Results of quality assessment after correspondence with authors (Continued)

Groenendijk 2004	Unclear	Yes	Yes	Yes	B
Renvert 2004	Adequate	Not possible	Yes	Yes	A
Horwitz 2005	Adequate	Yes	Yes	Yes	A
de Araujo Nobre 2007	Unclear	Yes	Yes	None	B

Effects of interventions

Two hundred and thirty-eight patients were originally included in the nine eligible trials.

(I) Interventions for maintaining soft tissue health

(a) Self administered

Mechanical techniques

- Powered versus manual toothbrushing (Comparison 1)

One study (Tawse-Smith 2002) with a cross-over design compared powered versus manual toothbrushing in 40 patients. There was no baseline imbalance for mean plaque scores. At 6 weeks there was no significant difference in mean plaque scores and in change of probing pocket depths. Four withdrawals. This trial was judged to be at high risk of bias.

Antimicrobials

- Hyaluronic gel versus chlorhexidine gel for brushing (Comparison 2)

One study (de Araujo Nobre 2007) with a parallel design compared brushing with hyaluronic versus chlorhexidine gel in 30 patients with immediately loaded implants. There was no baseline imbalance for the outcomes reported. After 6 months no differences in plaque, marginal bleeding and changes in probing pocket depths were found. No withdrawals. The trial was judged to be at low risk of bias.

- Amine fluoride/stannous fluoride (AmF/SnF₂) versus chlorhexidine mouthwashes (Comparison 3)

One study (Horwitz 2005) with a parallel group design compared rinsing twice daily for 3 months with a 10 ml AmF/SnF₂ mouthrinse versus chlorhexidine mouthrinse after a one stage implant procedure in 33 patients. There was no baseline imbalance for the outcomes reported. No statistical differences in implant failures and tooth staining were found at 3 months. Patients

had more desire for future use (mean difference (WMD) 2.08; 95% confidence interval (CI) 1.52 to 2.64) and less change in taste (WMD -0.55; 95% CI -1.02 to -0.08) with the AmF/SnF₂ mouthrinse. No withdrawals. This trial was judged to be at low risk of bias.

(b) Professionally administered

- Phosphoric etching gel versus mechanical debridement (Comparison 4)

One study (Strooker 1998) with a split-mouth design compared etching gel with mechanical debridement in 16 patients. There was no baseline imbalance for all outcomes reported. At 5 months there was no statistically significant difference between the treatment groups for plaque or change in probing pocket depth and cleaning time. However, when the treatment was administered for the first time, nine out of 16 patients reported slight (seven patients) to moderate (two patients) pain at the side subjected to etching gel treatment compared to none in the debridement group ($P < 0.001$). At 5 months, no patient complained of pain. No withdrawals. This trial was judged to be at high risk of bias.

- Chlorhexidine solution versus physiologic solution in the inner part of the implants (Comparison 5)

One study (Groenendijk 2004) with a split-mouth design compared the injection of about 0.7 microlitre of 0.2% chlorhexidine inside the inner part of the implants at second stage surgery versus the injection of physiologic solution in 12 patients. There was no baseline imbalance for the outcomes reported. No statistically significant difference in plaque was found between treatments at 6 weeks. No withdrawals. The study was judged to be at high risk of bias.

(2) Interventions for recovering soft tissue health

(a) Self administered

Mechanical techniques

- Sonic versus manual toothbrushing (Comparison 6)

One study (Wolff 1998) with a parallel group design compared sonic versus manual toothbrushing on 31 patients. There was no baseline imbalance for all outcomes reported. After 6 months there were no statistically significant differences for plaque, changes in probing pocket depth and difficulty in brushing, however more patients liked sonic brushing over the other (risk ratio (RR) 1.48; 95% CI 1.03 to 2.13). No withdrawals. This trial was judged to be at high risk of bias.

Antimicrobials

- Antiseptic mouthwashes: Listerine versus placebo (Comparison 7)

One study (Ciancio 1995) with a parallel group design compared Listerine versus a placebo mouthwash in 20 patients. There was no baseline imbalance for all outcomes reported. After 3 months statistically significantly less plaque and marginal bleeding were found in the Listerine group, with mean difference for plaque (Turesky plaque index) = -0.88 (95% CI -0.93 to -0.83), mean difference for marginal bleeding = -0.20 (95% CI -0.25 to -0.15). However, the Listerine group had statistically significantly higher mean probing pocket depth scores, mean difference = 0.15 (95% CI 0.06 to 0.24). No significant differences were found for probing 'attachment' levels. As the 3 months means values were adjusted, changes in probing pocket depth and changes in probing attachment level could not be calculated. Results demonstrated a 54% reduction in plaque and 34% in marginal bleeding compared with a placebo. No withdrawals. This trial was judged to be at low risk of bias.

- Subgingival irrigation: chlorhexidine irrigation versus chlorhexidine mouthwash (Comparison 8)

One study (Felo 1997) compared subgingival chlorhexidine irrigation versus chlorhexidine mouthwash in 24 patients. There was no baseline imbalance for all outcomes reported. At 3 months the group using chlorhexidine irrigation had statistically significantly lower mean plaque scores than the group using chlorhexidine mouthwash with mean difference = -0.20 (95% CI -0.24 to -0.16) and lower marginal bleeding index with mean difference = -0.17 (95% CI -0.19 to -0.15). No withdrawals. This trial was judged to be at low risk of bias.

(b) Professionally administered

- Mechanical debridement plus minocycline or chlorhexidine gel (Comparison 9)

One study (Renvert 2004) with a parallel design compared minocycline versus chlorhexidine gel after mechanical debridement in the treatment of peri-implant mucositis in 32 patients. There was no baseline imbalance for the outcomes reported. At 10 days no statistical differences in soreness of the gums were reported. At 1 year there was no statistical difference in plaque levels

and change of probing pockets depth. Two withdrawals from the chlorhexidine group. This trial was judged to be at low risk of bias.

DISCUSSION

Even if maintenance is widely considered an important part in implant treatment, few randomised controlled trials (RCTs), known to provide the most reliable level of evidence (Higgins 2006), have addressed this topic. Only nine RCTs could be included in this review and no meta-analysis could be conducted as each trial assessed different interventions. We identify five RCTs which were never published as full articles, but only in the form of conference abstracts. Due to insufficient information presented in the abstracts and the lack of author's reply to our request of supplying missing data, we were not able to use them. The reasons why these RCTs were not published as full papers can only be speculated upon. We can only regret this and stress that there is no use of making research if the results, either positive or negative, are not properly shared with the rest of the community. Four more identified studies had problems with the way data were presented. In particular data were often given at implant and not at patient level: the clustering of the implants within a patient was not taken into account. Potentially useful information could not be used. More careful design, analysis and reporting of RCTs on oral implants are needed (Esposito 2001a).

A small trial (Ciancio 1995) including only 10 patients in each group and evaluating the efficacy of Listerine mouthwash compared with a placebo, presented which could be the most relevant clinical information. After 3 months it was found a reduction of 54% in plaque and 34% in marginal bleeding in patients using Listerine. The original statistically significant data were transformed by us into percentages to make the results easier to understand to clinicians. Patients in the Listerine group had statistically significant deeper probing pocket depths at 3 months (0.15 mm) than the placebo group, however such difference is difficult to interpret and is unlikely to have any clinical importance.

One study compared different maintenance procedures on peri-implant soft tissues during healing (de Araujo Nobre 2007). The trial showed statistically significant less marginal bleeding using a hyaluronic acid gel compared to a chlorhexidine gel during the first 2 months of healing. These findings were based only on 15 subjects per group so the result could be due to chance. However at 6 months no difference in plaque, change in probing depth and modified bleeding index was observed.

It is difficult to say to which extent the results of the included trials can be generalized to other populations. It should be considered that these results were obtained following the strict protocols of clinical trials. Many of the patients attended frequent professional

maintenance appointments, where professional cleaning was performed and oral hygiene instruction reinforced. The effect of these additional procedures, which are seldom used in routine clinical practice, might have influenced the levels of oral hygiene obtained. It may also be possible that they may have brought oral hygiene to a level for which it may be difficult to see differences among the tested intervention.

Peri-implantitis has been shown to develop after several years (Roos-Jansåker 2006) and implants are expected to function in the mouth for decades. Only one of the trials included had a follow up of 1 year (Renvert 2004), while the other studies ranged from 6 weeks to 6 months. Longer follow-up studies on the effectiveness of maintenance interventions are needed.

In none of the trials were sample size calculations conducted to determine the number of patients needed to detect a clinically important effect at a specified level of statistical significance. Most of the standard maintenance therapies used nowadays are thus not based on reliable scientific evidence. Whilst, they may be effective, their efficacy needs to be demonstrated in trials also designed to compare their relative costs. Patient preference and ease of maintenance should be considered too, since both factors can play an important role in patient compliance. At the same time patient's preference is not an indication of the efficacy of an instrument: there was no evidence that sonic brush was superior to manual brushing, even if patients liked it more (Wolff 1998).

Side effects should be reported and they can help clinicians in choosing between treatments with similar effectiveness. Efficacy should be evaluated first. One study (Horwitz 2005) reported less changes in taste and more patient desire for future use for an amine fluoride/stannous fluoride mouthrinse versus a chlorhexidine one, but we have no data on its efficacy since plaque and inflammation parameters were not investigated. Records on radiographic bone level could not be used since they were given at implant and not at patient level. Even if implant failure was considered as an outcome measure, the 3 months time during which the mouthrinses were used was too short to have an effect on this aspect.

Ideally, the primary outcome measure of interest would have been implant failure, but surrogate outcomes defined as measures of the disease process were included since they may detect earlier pathological changes allowing an early rescue treatment (Furberg 1991; Esposito 2001). Among surrogate outcomes it is likely that marginal bone level changes on intraoral radiographs taken with the parallel technique are the most reliable for detecting loss of bone support (for a review see Esposito 1998). However, to have meaningful results, assessment of bone level changes (and implant failures) can be applied only to trials of sufficient duration (years). For short term trials parameters such as plaque and marginal bleeding

index may be more appropriate. Since soft tissue health should be evaluated, marginal bleeding (an indicator of plaque-induced inflammation) and plaque (the main causal factor for peri-implant soft tissues diseases) should be considered. The use of probing pocket depths and clinical 'attachment' levels may not provide as accurate results as radiographic assessments (Esposito 1998; Schou 2002), thus being of less importance in clinical trials. However, such parameters could be of great help to clinicians for identifying potential problems during routine maintenance procedures.

Despite the fact that daily self administered subgingival irrigation of chlorhexidine, when used as an adjunct to routine oral hygiene, was found to be more effective than chlorhexidine rinsing in reducing plaque and marginal bleeding around implants (Felo 1997), it is unlikely that this difference bears any clinical significance since the amount of chlorhexidine mouthwash (control) used in the trial (2 ml) was likely to be too small to have any clinical effect. Therefore, there seems not to be any evidence for suggesting any advantage of subgingival irrigation over mouth-rinsing in the maintenance of oral implants.

AUTHORS' CONCLUSIONS

Implications for practice

There is little evidence for the most effective interventions for maintaining and recovering health around peri-implant tissues. There is some evidence from one small randomised controlled trial (RCT) that Listerine mouthwash, used twice a day for 30 seconds, as an adjunct to routine oral hygiene, is effective in reducing plaque formation and marginal peri-implant bleeding. No evidence was found that the use of powered or sonic toothbrushes is superior to manual toothbrushing, though patients liked the sonic brush more, and that brushing with a hyaluronic gel is better than with a chlorhexidine gel. There is no evidence of any clinical advantage regarding the use of phosphoric etching gel over mechanical debridement and polishing, of chlorhexidine gel over a physiologic solution enclosed in implants; and of topical minocycline over chlorhexidine gel in peri-implant pockets. These findings are based on trials having in general short follow-up periods (6 months or less; only one study with 1 year follow up) and limited numbers of subjects. There is not any reliable evidence for which are the most effective maintenance regimens in a long term perspective.

Implications for research

More RCTs should be conducted in this area. In particular, there is a definite need for trials powered to detect a difference, using outcome measures such as implant failure, change in radiographic bone level, marginal bleeding and plaque, with data taken at patient level and with follow up of several years. We do acknowledge that such trials will be expensive and difficult to conduct but they are the only ones able to provide a reliable answer.

Such trials should be reported according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (www.consort-statement.org/).

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Esposito M, Worthington HV, Coulthard P, Jokstad A. Interventions for replacing missing teeth: maintaining and re-establishing healthy tissues around dental implants. *Cochrane Database of Systematic Reviews* 2002, Issue 3. [DOI: Art. No: CD003069. DOI: 10.1002/14651858.CD003069]

Esposito 2003

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Esposito M, Worthington HV, Thomsen P, Coulthard P. Interventions for replacing missing teeth: maintaining health around dental implants. *Cochrane Database of Systematic Reviews* 2004, Issue 3. [DOI: Art. No: CD003069. DOI: 10.1002/14651858.CD003069.pub2]

* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Ciancio 1995

Methods	Randomised, parallel group study. Patients and outcome assessor blind. No withdrawals.
Participants	Adults. 20 enrolled and results given for 20.
Interventions	2 groups. Antiseptic mouthwash (20 ml Listerine) rinse twice per day for 30 seconds versus placebo (5% hydroalcohol). Recall every month. Study duration: 3 months.
Outcomes	Turesky modification of Quigley-Hein plaque index, a modification of the Ainamo and Bay bleeding index, probing attachment levels (mm), probing pocket depth (mm) at 1, 2, 3 months. 3-month data used.
Notes	The Ainamo and Bay bleeding index was recorded using a "sweeping motion" and not with a "gentle probing".

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

de Araujo Nobre 2007

Methods	Randomised, parallel group study. Patients and outcome assessors blind. No withdrawals.
Participants	Adults. 30 enrolled and results given for 30.
Interventions	2 groups. 0.2% hyaluronic acid gel (Gengigel) versus 0.2% chlorhexidine gel (Elugel) applied on a toothbrush as only oral hygiene measure. Recall every 2 months. Study duration: 6 months.
Outcomes	Implant failure. Probing pocket depth (mm), modified plaque index (mPI) by Mombelli and modified sulcus bleeding index (mBI) by Mombelli at 10 days, 2, 4 and 6 months. 6-month data used.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Felo 1997

Methods	Randomised, parallel group study. Patients cannot be blind, outcome assessor blind. No withdrawals.
Participants	Adults. 24 enrolled and results given for 24.
Interventions	2 groups. Antiseptic subgingival irrigation (100 ml chlorhexidine 0.06%) once per day versus rinsing (2 ml chlorhexidine 0.12) once daily. Study duration: 3 months.
Outcomes	Turesky modification of Quigley-Hein plaque index, a modification of the Ainamo and Bay bleeding index at 3 months.
Notes	A 2 ml of chlorhexidine (0.12%) once daily is an unusually low concentration. The Ainamo and Bay bleeding index was recorded using a “sweeping motion” and not with a “gentle probing”. Trial described as double-blind, but it was not possible to have patients blind.

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Groenendijk 2004

Methods	Randomised, split-mouth study. Patients and outcome assessors blind. No withdrawals.
Participants	Adults. 12 enrolled and results given for 12.
Interventions	2 groups. About 0.7 microliter 0.2% chlorhexidine (Corsodyl) injected into the inner part of 3i Titamed fixture versus physiologic solution. Abutments immediately connected afterwards. Recall every week. Study duration: 6 weeks.
Outcomes	Microbiological count, gingival index by Loe and Silness, crevicular fluid flow rate, modified plaque index by Mombelli each week for 6 weeks. 6-week data used.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	C - Inadequate

Horwitz 2005

Methods	Randomised, parallel group study. Patients and outcome assessors blind. 3 withdrawals at 1 year, none at 3 months.
Participants	Adults. 33 enrolled and results given for 30.
Interventions	2 groups. Amine fluoride/stannous fluoride mouthwash (10 ml) twice per day for 60 seconds versus chlorhexidine mouthwash following toothbrushing for 3 months. Recall first and third month. Study duration: 12 months (data at 3 months).
Outcomes	Implant failure, bone width, bone to implant distance, radiographic bone height (3 and 12 months), staining index, patient compliance. Patient subjective evaluation questionnaire (visual analog scale): taste, change in taste, desire for future use, overall satisfaction at 3 months. 3-month data used.
Notes	36 packages were randomised, but 33 patients enrolled. Mouthrinses used for 3 months after 1-stage surgery. No indication on plaque and mucosal inflammation parameters. Radiographic data and bone data at implant level.

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	B - Unclear

Renvert 2004

Methods	Randomised, parallel group. Patients cannot be blind, outcome assessors blind. 2 withdrawals at 3 months from the chlorhexidine group.
Participants	Adults. 32 enrolled and results given for 30.
Interventions	2 groups. Mechanical debridement plus 1 mg minocycline (OraPharma) versus 1 ml 1% chlorhexidine (Corsodyl) inserted submucosally. No brushing for 12 hours and no interdental cleaning for 10 days. Recall 1, 2, 3, 6, 9 and 12 months. Study duration: 12 months.
Outcomes	Full mouth plaque score, full mouth bleeding score, local plaque score (presence), probing pocket depths (mm), bleeding on microbial sampling, microbial sampling at 10 days, 1, 2, 3, 6, 9, 12 months. Side effects: soreness in the gum at 10 days. 1-year data used.
Notes	

Risk of bias

Item	Authors' judgement	Description
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Renvert 2004 (Continued)

Allocation concealment?	Yes	A - Adequate
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Strooker 1998

Methods	Randomised, split-mouth study. Patients cannot be blind, outcome assessor not blind. No withdrawals.
Participants	Adults. 16 enrolled and results given for 16.
Interventions	2 groups. Monthly 35% phosphoric etching gel (pH1) for 1 minute versus supra- and sub-gingival mechanical debridement using carbon fibre currettes and rubber cup. Maintenance every month. Study duration: 5 months.
Outcomes	Plaque index by Silness and Loe, calculus index by Bjorby and Loe, a modification of the gingival index by Loe and Silness, change in probing pocket depth (mm), microbiological sampling, post-operative pain and treatment time at 1 and 5 months. 5-month data used.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Tawse-Smith 2002

Methods	Randomised, cross-over study. Patients cannot be blind, outcome assessor blind. 4 withdrawals.
Participants	Adults. 40 enrolled and results given for 36.
Interventions	2 groups. Powered (Braun Oral Plaque Remover 3-D) versus manual toothbrushing (Oral B Squish grip) twice a day for 30 s. Maintenance every 6 weeks. Study duration: 6 weeks.
Outcomes	Modified plaque index by Mombelli and modified sulcus bleeding index by Mombelli at 6 weeks.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	C - Inadequate

Wolff 1998

Methods	Randomised, parallel group study. Patients cannot be blind, outcome assessor blind. No withdrawals.	
Participants	Adults. 31 enrolled and results given for 31.	
Interventions	2 groups. Sonic versus manual toothbrushing twice a day for 2 minutes. Study duration: 24 weeks.	
Outcomes	Plaque index by Silness and Loe, bleeding index by Philstrom, gingival index by Loe and Silness, pocket probing depths (mm), and patient acceptance parameters (questionnaire) at 4, 8, 12, 24 weeks. 24-week data used.	
Notes		
<i>Risk of bias</i>		
Item	Authors' judgement	Description
Allocation concealment?	Unclear	B - Unclear

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

Jeffcoat 1995	Problems with data. It is unclear how many patients in each study group and although author replied to letter requesting further information this is still unclear.
Kokosi 2000	Insufficient information presented. Written to authors but no reply.
Lauciello 1993	Insufficient information presented. Written to authors but no reply.
Lavigne 1994	Problems with data. 8 patients all having 3 treatments, but number was 10 for each group. Written to author but no reply.
Porras 2002	Problems with data. Implants and not patients were the unit of the statistical analyses. Written to authors but no reply.
Simoncic 2000	Insufficient information presented. Written to authors but no reply.
Tarpey 1996	Insufficient information presented. Written to authors but no reply.
Truhlar 2000	Problems with data. Study designed as cluster randomised controlled trial, however data analysed and means and standard deviation (SD) presented on implant basis, ignoring centres. Written to authors requesting new data, but no reply.

(Continued)

Yalcin 2002	Insufficient information presented. Written to authors but no reply.
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DATA AND ANALYSES

Comparison 1. Maintaining health: self administered mechanical: powered versus manual toothbrushing (6 weeks)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Modified plaque index (Mombelli)	1		Mean difference (Fixed, 95% CI)	Totals not selected

Comparison 2. Maintaining health: self administered antimicrobials: hyaluronic acid versus CHX gel (6 months)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Modified plaque index (Mombelli)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Modified bleeding index (Mombelli)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Change in probing pocket depth	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 3. Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Change in taste (visual analog scale)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Staining index	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Patient satisfaction (desire for future use: visual analog scale)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Implant failure	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected

Comparison 4. Maintaining health: professionally: phosphoric etching gel versus mechanical debridement (5 months)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Silness and Loe plaque index	1		Mean difference (Fixed, 95% CI)	Totals not selected
2 Change in probing pocket depth	1		Mean difference (Fixed, 95% CI)	Totals not selected

Comparison 5. Maintaining health: professionally: CHX versus physiologic solution enclosed in implants (6 weeks)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Modified plaque index (Mombelli) (6 weeks)	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 6. Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Silness and Loe plaque index	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Change in probing pocket depth	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Patient satisfaction (liked toothbrush)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
4 Ease of maintenance (easy or very easy to use)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Comparison 7. Recovering health: self administered antimicrobials: Listerine versus placebo (3 months)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Turesky plaque index	1		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
2 Ainamo and Bay marginal bleeding	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Probing attachment level	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Probing pocket depth	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 8. Recovering health: self administered antimicrobials: CHX irrigation versus CHX mouthwash (3 months)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Turesky plaque index	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Ainamo and Bay marginal bleeding	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 9. Recovering health: professionally: topical minocycline versus CHX gel (12 months)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean plaque score	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Change in probing pocket depth	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Soreness in the gums (10 days)	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected

Analysis 1.1. Comparison 1 Maintaining health: self administered mechanical: powered versus manual toothbrushing (6 weeks), Outcome 1 Modified plaque index (Mombelli).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 1 Maintaining health: self administered mechanical: powered versus manual toothbrushing (6 weeks)

Outcome: 1 Modified plaque index (Mombelli)

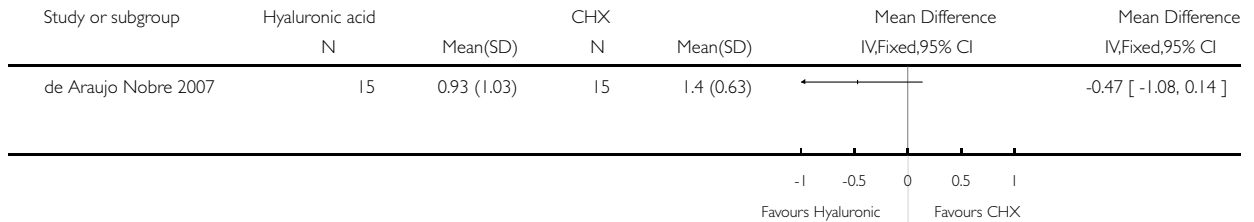


Analysis 2.1. Comparison 2 Maintaining health: self administered antimicrobials: hyaluronic acid versus CHX gel (6 months), Outcome 1 Modified plaque index (Mombelli).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 2 Maintaining health: self administered antimicrobials: hyaluronic acid versus CHX gel (6 months)

Outcome: 1 Modified plaque index (Mombelli)

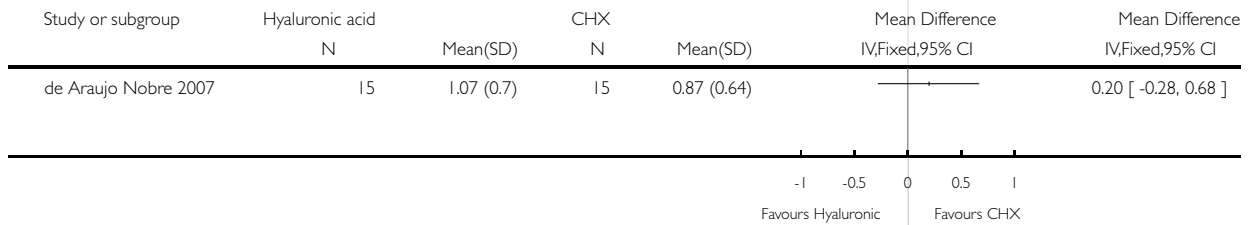


Analysis 2.2. Comparison 2 Maintaining health: self administered antimicrobials: hyaluronic acid versus CHX gel (6 months), Outcome 2 Modified bleeding index (Mombelli).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 2 Maintaining health: self administered antimicrobials: hyaluronic acid versus CHX gel (6 months)

Outcome: 2 Modified bleeding index (Mombelli)

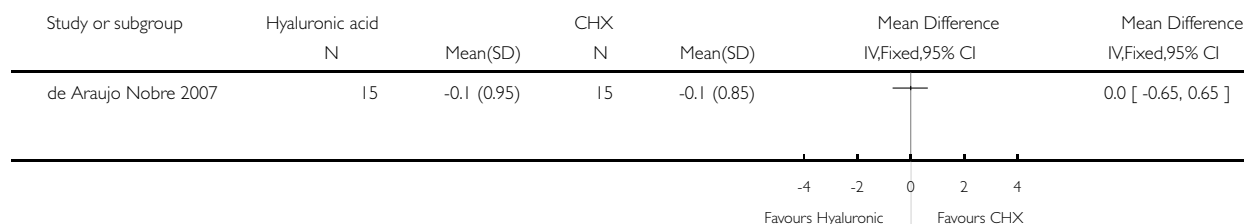


Analysis 2.3. Comparison 2 Maintaining health: self administered antimicrobials: hyaluronic acid versus CHX gel (6 months), Outcome 3 Change in probing pocket depth.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 2 Maintaining health: self administered antimicrobials: hyaluronic acid versus CHX gel (6 months)

Outcome: 3 Change in probing pocket depth

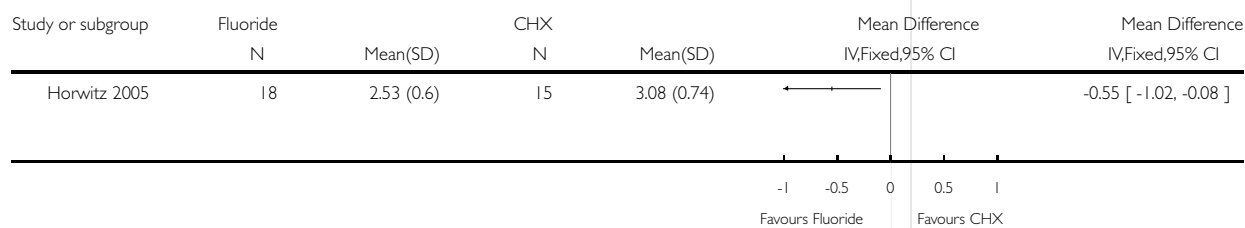


Analysis 3.1. Comparison 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months), Outcome 1 Change in taste (visual analog scale).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months)

Outcome: 1 Change in taste (visual analog scale)

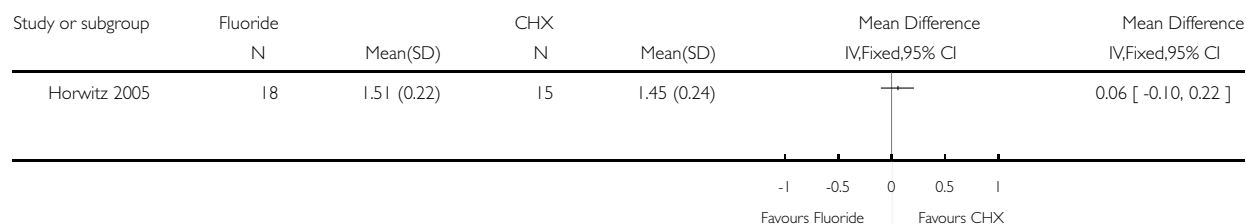


Analysis 3.2. Comparison 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months), Outcome 2 Staining index.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months)

Outcome: 2 Staining index

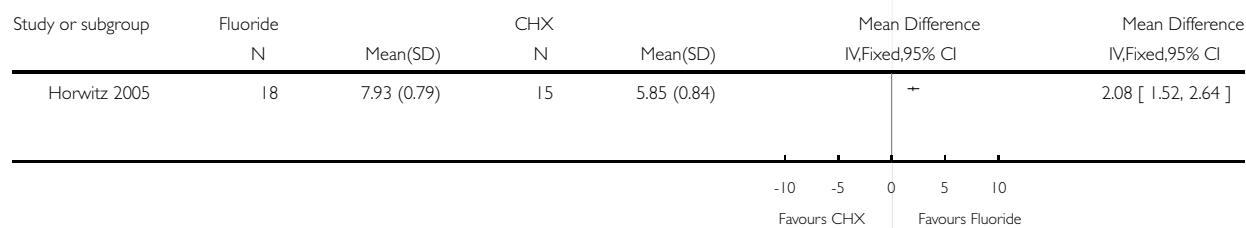


Analysis 3.3. Comparison 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months), Outcome 3 Patient satisfaction (desire for future use: visual analog scale).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months)

Outcome: 3 Patient satisfaction (desire for future use: visual analog scale)

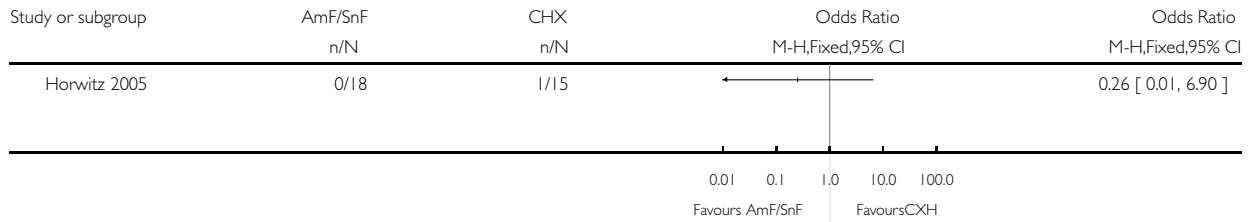


Analysis 3.4. Comparison 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months), Outcome 4 Implant failure.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 3 Maintaining health: self administered antimicrobials: amine fluoride/stannous fluoride versus CHX (3 months)

Outcome: 4 Implant failure

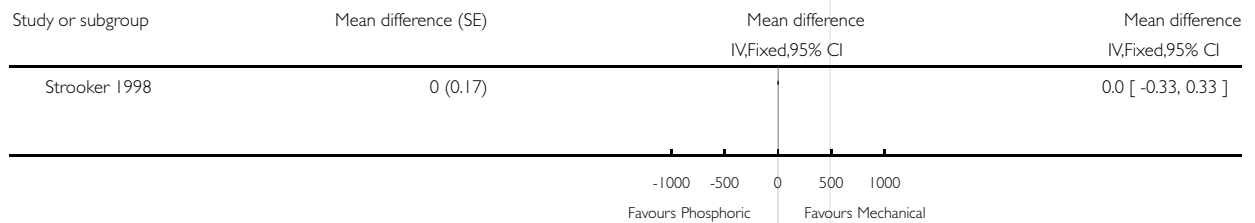


Analysis 4.1. Comparison 4 Maintaining health: professionally: phosphoric etching gel versus mechanical debridement (5 months), Outcome 1 Silness and Loe plaque index.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 4 Maintaining health: professionally: phosphoric etching gel versus mechanical debridement (5 months)

Outcome: 1 Silness and Loe plaque index

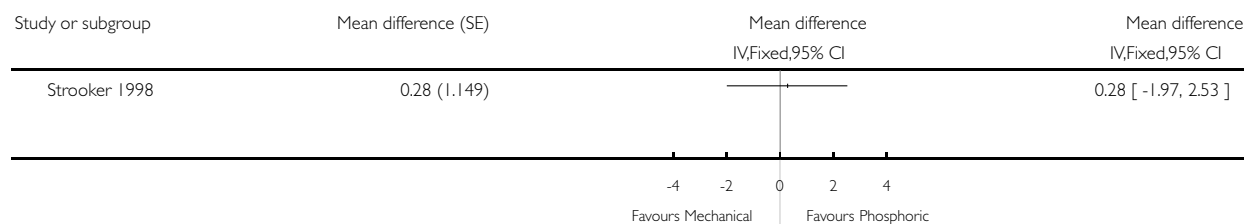


Analysis 4.2. Comparison 4 Maintaining health: professionally: phosphoric etching gel versus mechanical debridement (5 months), Outcome 2 Change in probing pocket depth.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 4 Maintaining health: professionally: phosphoric etching gel versus mechanical debridement (5 months)

Outcome: 2 Change in probing pocket depth

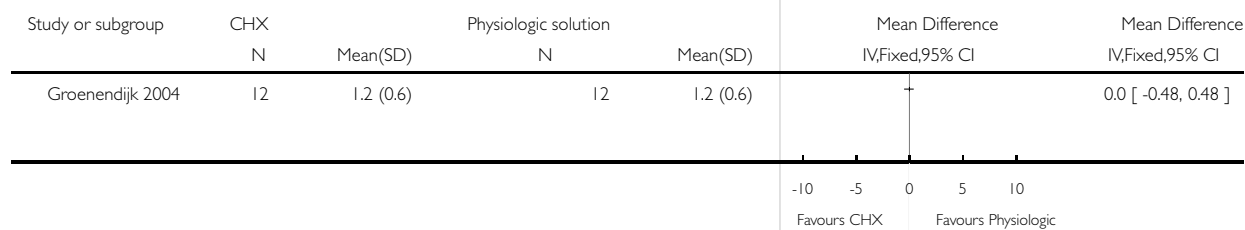


Analysis 5.1. Comparison 5 Maintaining health: professionally: CHX versus physiologic solution enclosed in implants (6 weeks), Outcome 1 Modified plaque index (Mombelli) (6 weeks).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 5 Maintaining health: professionally: CHX versus physiologic solution enclosed in implants (6 weeks)

Outcome: 1 Modified plaque index (Mombelli) (6 weeks)

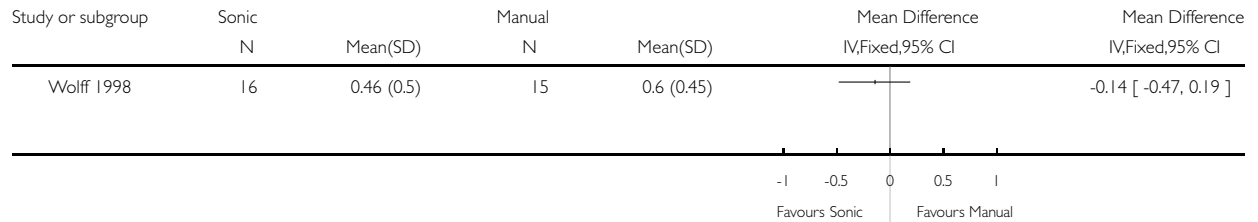


Analysis 6.1. Comparison 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months), Outcome 1 Silness and Loe plaque index.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months)

Outcome: 1 Silness and Loe plaque index

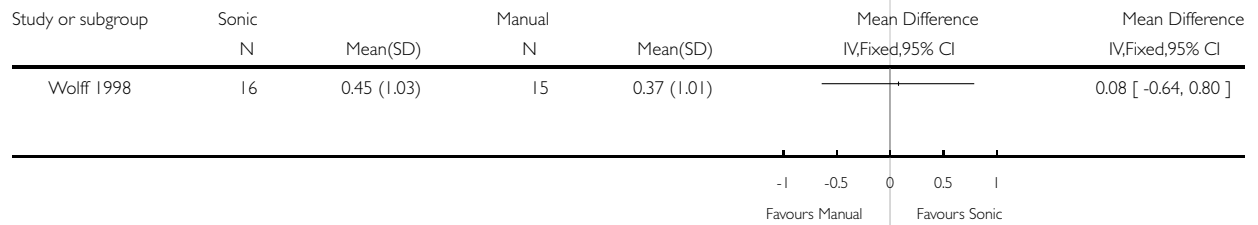


Analysis 6.2. Comparison 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months), Outcome 2 Change in probing pocket depth.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months)

Outcome: 2 Change in probing pocket depth

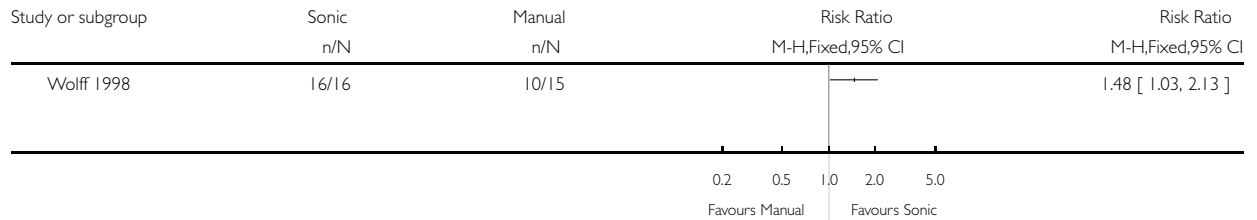


Analysis 6.3. Comparison 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months), Outcome 3 Patient satisfaction (liked toothbrush).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months)

Outcome: 3 Patient satisfaction (liked toothbrush)

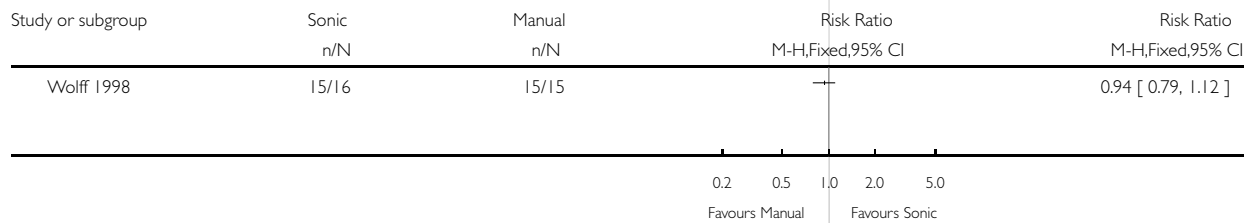


Analysis 6.4. Comparison 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months), Outcome 4 Ease of maintenance (easy or very easy to use).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 6 Recovering health: self administered mechanical: sonic versus manual toothbrush (6 months)

Outcome: 4 Ease of maintenance (easy or very easy to use)

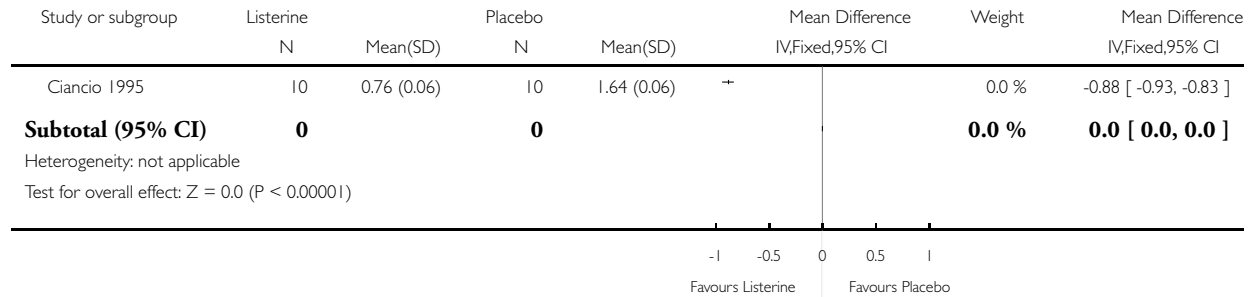


Analysis 7.1. Comparison 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months), Outcome 1 Turesky plaque index.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months)

Outcome: 1 Turesky plaque index

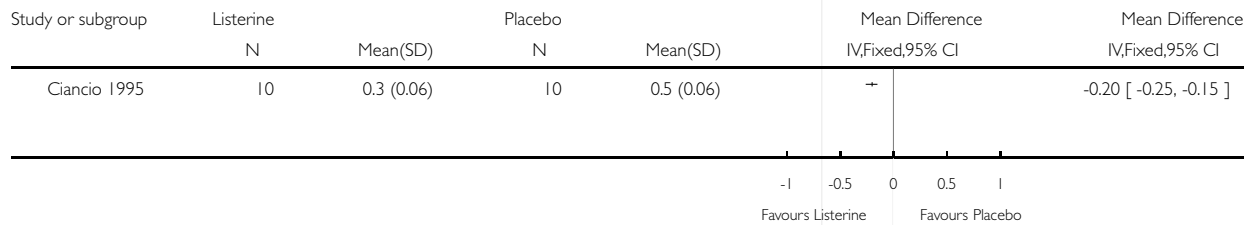


Analysis 7.2. Comparison 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months), Outcome 2 Ainamo and Bay marginal bleeding.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months)

Outcome: 2 Ainamo and Bay marginal bleeding

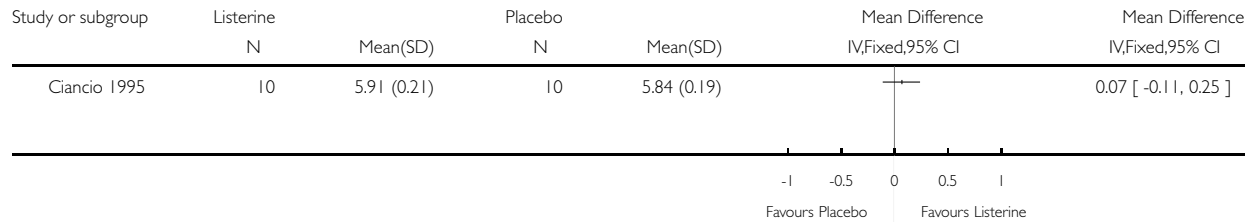


Analysis 7.3. Comparison 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months), Outcome 3 Probing attachment level.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months)

Outcome: 3 Probing attachment level

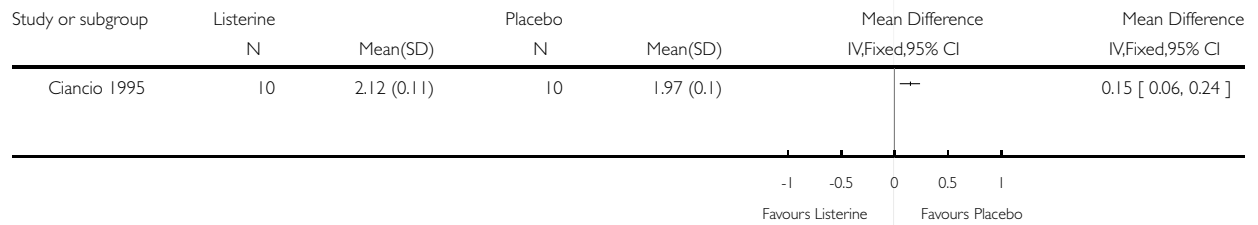


Analysis 7.4. Comparison 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months), Outcome 4 Probing pocket depth.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 7 Recovering health: self administered antimicrobials: Listerine versus placebo (3 months)

Outcome: 4 Probing pocket depth



Analysis 8.1. Comparison 8 Recovering health: self administered antimicrobials: CHX irrigation versus CHX mouthwash (3 months), Outcome 1 Turesky plaque index.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 8 Recovering health: self administered antimicrobials: CHX irrigation versus CHX mouthwash (3 months)

Outcome: 1 Turesky plaque index

Study or subgroup	CHX irrigation		CHX mouthwash		Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
	N	Mean(SD)	N	Mean(SD)		
Felo 1997	12	1.42 (0.05)	12	1.62 (0.05)	+-	-0.20 [-0.24, -0.16]

Analysis 8.2. Comparison 8 Recovering health: self administered antimicrobials: CHX irrigation versus CHX mouthwash (3 months), Outcome 2 Ainamo and Bay marginal bleeding.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 8 Recovering health: self administered antimicrobials: CHX irrigation versus CHX mouthwash (3 months)

Outcome: 2 Ainamo and Bay marginal bleeding

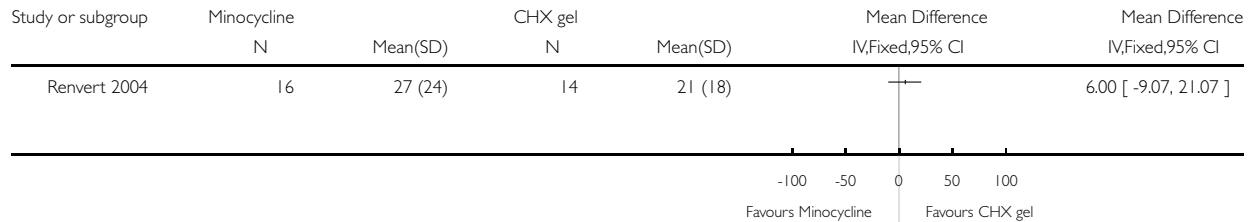
Study or subgroup	CHX irrigation		CHX mouthwash		Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
	N	Mean(SD)	N	Mean(SD)		
Felo 1997	12	0.27 (0.02)	12	0.44 (0.03)	*	-0.17 [-0.19, -0.15]

Analysis 9.1. Comparison 9 Recovering health: professionally: topical minocycline versus CHX gel (12 months), Outcome 1 Mean plaque score.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 9 Recovering health: professionally: topical minocycline versus CHX gel (12 months)

Outcome: 1 Mean plaque score

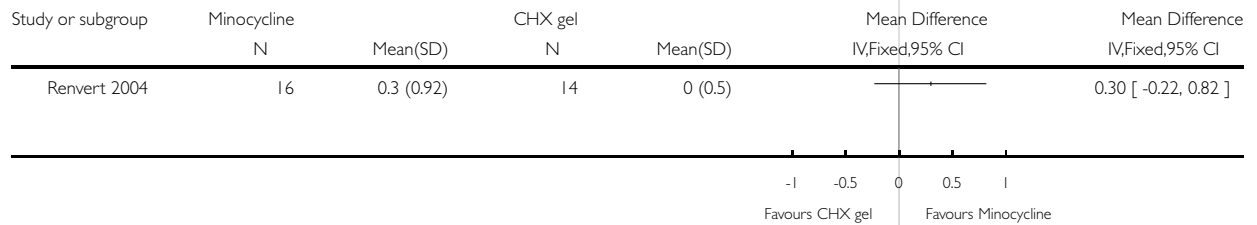


Analysis 9.2. Comparison 9 Recovering health: professionally: topical minocycline versus CHX gel (12 months), Outcome 2 Change in probing pocket depth.

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 9 Recovering health: professionally: topical minocycline versus CHX gel (12 months)

Outcome: 2 Change in probing pocket depth

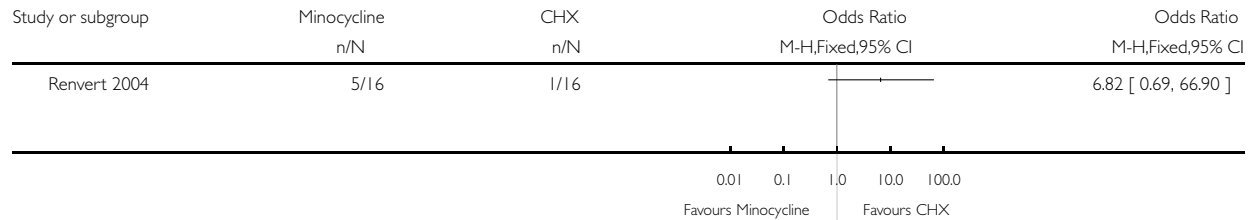


Analysis 9.3. Comparison 9 Recovering health: professionally: topical minocycline versus CHX gel (12 months), Outcome 3 Soreness in the gums (10 days).

Review: Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants

Comparison: 9 Recovering health: professionally: topical minocycline versus CHX gel (12 months)

Outcome: 3 Soreness in the gums (10 days)



APPENDICES

Appendix I. MEDLINE (OVID) search strategy

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

WHAT'S NEW

Last assessed as up-to-date: 5 November 2007.

12 June 2008	Amended	Converted to new review format.
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HISTORY

Protocol first published: Issue 2, 2001

Review first published: Issue 3, 2002

6 November 2007	New citation required and conclusions have changed	Substantive amendment. Title was modified. Primary objective had been divided in two: to test the efficacy of interventions (1) for maintaining and (2) for recovering soft tissue health around implants. Outcome measures were modified (change in probing attachment level (PAL); change in probing pocket depth (PPD); patient satisfaction; treatment time). Four more studies were added. System of bias assessment was simplified. Conclusions were slightly changed.
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CONTRIBUTIONS OF AUTHORS

Conceiving, designing and co-ordinating the review (Marco Esposito (ME), Maria Gabriella Grusovin (GG)).

Developing search strategy and undertaking searches (ME, Paul Coulthard (PC)).

Screening search results and retrieved papers against inclusion criteria (ME, GG, PC).

Appraising quality (ME, GG, Elli Jourabchian (EJ), PC).

Extracting data from papers (Helen Worthington (HW), ME, GG).

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

Data management for the review and entering data into RevMan (HW, GG, ME).

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

Writing the review (ME, GG).

Providing general advice on the review (PC, Peter Thomsen (PT)).

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

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- The University of Manchester, UK.

External sources

- No sources of support supplied

INDEX TERMS

Medical Subject Headings (MeSH)

*Dental Implants; *Dental Restoration Failure; Gingival Diseases [prevention & control; *therapy]; Oral Hygiene [instrumentation; methods]; Randomized Controlled Trials as Topic; Tooth Loss [*rehabilitation]

MeSH check words

Adult; Humans