Interventions for replacing missing teeth: maintaining and re-establishing healthy tissues around dental implants

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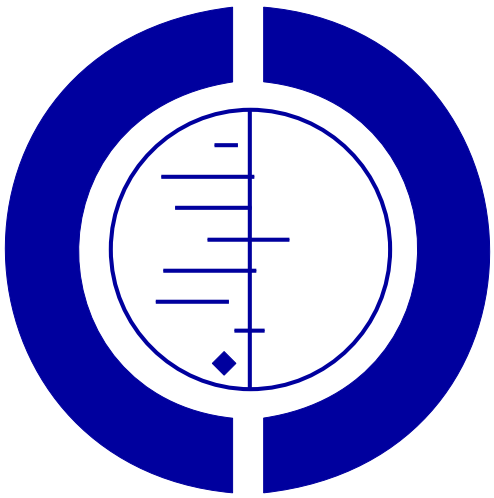

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ABSTRACT

Background
To maintain healthy tissues around oral implants it is important to institute an effective preventive regimen (supportive therapy) and when a pathologic condition of the tissue around implants is diagnosed, an intervention should be initiated as soon as possible. Different maintenance regimens and treatment strategies for failing implants have been suggested, however it is unclear which are the most effective.

Objectives
To test the null hypothesis of no difference between different interventions for maintaining or re-establishing healthy tissues around dental implants.

Search strategy
The Cochrane Oral Health Group Specialised Register, The Cochrane Controlled Trials Register, MEDLINE and EMBASE were searched. Hand searching included several dental journals. In addition, authors of all identified trials, fifty-five oral implant manufacturers and two extensive personal libraries (ME and AJ) were consulted.

Selection criteria
All randomised controlled trials of oral implants comparing agents or interventions for maintaining or re-establishing healthy tissues around dental implants.

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

Main results
Nine RCTs were identified. Five of these trials, which reported results from a total of 127 patients, were suitable for inclusion in the review.

Reviewers' conclusions
There is only a little reliable evidence for which are the most effective interventions for maintaining health around peri-implant tissues. There was no evidence that the use of powered or sonic toothbrushes was superior to manual toothbrushing. There is a weak evidence that Listerine mouthwash, used twice a day for 30 seconds, as adjunct to routine oral hygiene is effective in reducing plaque formation and marginal bleeding around implants. There was no evidence that phosphoric etching gel offered any clinical advantage over mechanical debridement. These findings are based on RCTs having short follow-up periods and few subjects. There is not any reliable evidence for the most effective regimens for long-term maintenance. For the treatment of failing implants (peri-implantitis) there is not any reliable evidence for preferring one therapeutic regimen over another. More RCTs should be conducted in this area. In particular, there is a definite need for trials investigating which is the most effective approach for the treatment of peri-implantitis and for trials with longer follow-up for maintenance. Such trials should be reported according the CONSORT guidelines (http://www.consort-statement.org/).

SYNOPSIS

Antibacterial mouth rinses may help prevent plaque and bleeding around dental implants, but there is no evidence that electronic toothbrushes are better than ordinary toothbrushes.

Missing teeth can sometimes be replaced with a dental implant, as the bone in the jaw can grow around it. However, keeping the gums around the implant healthy is important, as there is an increased chance they can be eroded by plaque and inflammation. The review found that there is no evidence from trials that powered or sonic toothbrushes are better than manual brushes, or that phosphoric gel is better for removing plaque than scraping and polishing. However, there is some evidence that Listerine antibacterial mouthwash, used twice a day (as well as brushing) can help keep the gums healthy.

BACKGROUND

Missing teeth and supporting oral tissues have traditionally been replaced with removable dentures or fixed bridges permitting restoration of masticatory, phonetic function, and aesthetics. In 1977, Branemark presented his research work carried out over 10 years showing that bone can grow intimately onto the surface of titanium implants (Branemark 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.

Teeth may have been lost through dental diseases (caries and periodontitis) or trauma or be congenitally absent. In addition, there are a number of people who have more extensive loss of oral and facial tissues following surgery for malignant disease for whom osseointegrated implants may offer an improvement over previous treatment modalities. Oral implants are extensively used for replacing missing teeth in partially and totally edentulous patients.

One of the key factors for the long-term success of oral implants is the maintenance of healthy tissues around them. A cause-effect relationship between bacterial plaque accumulation and the development of inflammatory changes in the soft tissues surrounding oral implants has been shown (Pontoriero 1994). 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). For maintaining healthy tissues around oral implants it is important to institute an effective preventive regimen (supportive therapy) and when a pathologic condition of the tissues around implants is diagnosed a therapeutic intervention should be initiated as soon as possible (Esposito 1999). Different maintenance regimens and treatment strategies for peri-implantitis (failing implants) have been suggested, however it is unclear which are the most effective (Orton 1989; Esposito 1999).

With regard to the 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 metallic 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 have been recommended for individuals with physical impairment. Powered subgingival irrigation 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 oral implants. The main concern, mainly derived from in vitro studies, was that metallic instruments used for mechanical debridement roughen the metallic surface, thus increasing the chance for bacterial colonization (Thomson-Neal 1989; Speelman 1992; McCollum 1992). The advocated procedures to clean implant abutments included polishing with rubber cup and fine abrasive polishing paste (fluor of pumice, Nupro fine, tin oxide), plastic or titanium scalers, subgingival irrigation with antimicrobial agents, phosphoric acid gel application. Plastic scalers were also recommended to avoid galvanic corrosion and contamination of metallic implants (Dmytryk 1990; Jensen 1991; Bragger 1994).

In case of peri-implantitis, various interventions (often combined) have been suggested including: a) mechanical debridement, b) pharmaceutical therapy (subgingival chlorhexidine irrigation, local or systemic antibiotics), c) surgical procedures including: open flap debridement aimed at 1) removing bacteria (also using soft lasers) 2) smoothing the implant surface (to decrease surface roughness) and removing unsupported implant threads that protect bacterial plaque 3) "decontamination" or "detoxification" of the implant surface using various chemical agents or laser beam. After the primary goal of surgical intervention (i.e. bacteria-free

implant surface) has been achieved it may be necessary to correct the anatomic conditions for improving plaque control and for eliminating the favourable environment for anaerobic bacteria (elimination of pathological peri-implant pockets). This may be achieved either with resective procedures or alternatively with bone regenerative procedures (including guided bone regeneration, autologous or allogenic bone grafts).

OBJECTIVES

To test the null hypothesis of no difference between different interventions for maintaining or re-establishing oral health around osseointegrated oral implants.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of studies

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

Types of participants

People who have oral implants.

Types of intervention

Active agents: defined as oral hygiene procedures, self or professionally administered, local or systemic therapeutic agents as well as any other interventions (i.e. surgical interventions including tissue regenerative procedures) 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

- Plaque
- Marginal bleeding recorded by gently running or sweeping a periodontal probe in the peri-implant sulcus (no bleeding on probing)
- Probing pocket depth
- Probing "attachment" level
- Radiographic marginal bone level changes on intra-oral radiographs taken with a parallel technique
- 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
- Side effects
- Ease of maintenance (including time)
- Cost (treatment time plus material costs)

SEARCH STRATEGY FOR IDENTIFICATION OF STUDIES

See: search strategy
For the identification of studies included or considered for this review detailed search strategies were developed for each database searched. These were based on the search strategy developed for MEDLINE but revised appropriately for each database. The search strategy combined a sensitive search strategy for RCTs revised from phases 1 and 2 of the Cochrane Sensitive Search Strategy for RCTs (as published in Appendix 5c in the Cochrane Reviewers' Handbook). The subject search used a combination of controlled vocabulary and freetext terms based on the following search strategy for searching MEDLINE:
#1 randomised controlled trial.pt.
#2 controlled clinical trial.pt.
#3 randomised controlled trials.sh.
#4 random allocation.sh.
#5 double blind method.sh.
#6 single blind method.sh.
#7 latin square.ti,ab.
#8 crossover.ti,ab.
#9 (split adj (mouth or plot)).ti,ab.
#10 or/1-9
#11 (ANIMAL not HUMAN).sh.
#12 10 not 11
#13 clinical trial.pt.
#14 exp clinical trials/
#15 (clin$ adj25 trial$).ti,ab.
#16 ((singl$ or doubl$ or trebl$ or tripl$) adj25 (blind$ or mask$)).ti,ab.
#17 placebos.sh.
#18 placebo$.ti,ab.
#19 random$.ti,ab.
#20 research design.sh.
#21 or/13-20
#22 21 not 11
#23 22 not 12
#24 12 or 22
#25 exp Dental Implants/
#26 exp Dental Implantation/ or dental implantation.mp.
#27 exp Dental Prosthesis, Implant-Supported/
#28 ((osseointegrated adj implant$) and (dental or oral)).mp. [mp=title, abstract, registry number word, mesh subject heading]
#29 dental implant$.mp. [mp=title, abstract, registry number word, mesh subject heading]
#30 (implant$ adj5 dent$).mp. [mp=title, abstract, registry number word, mesh subject heading]

#31 dental-implant$.mp. [mp=title, abstract, registry number word, mesh subject heading]
#32 (((overdenture$ or crown$ or bridge$ or prosthesis or prostheses or restoration$) adj10 (Dental or oral)) and implant$).mp. [mp=title, abstract, registry number word, mesh subject heading]
#33 "implant supported dental prosthesis".mp. [mp=title, abstract, registry number word, mesh subject heading]
#34 ("blade implant$" and (dental or oral)).mp. [mp=title, abstract, registry number word, mesh subject heading]
#35 ((endosseous adj5 implant$) and (dental or oral)).mp. [mp=title, abstract, registry number word, mesh subject heading]
#36 ((dental or oral) adj5 implant$).mp. [mp=title, abstract, registry number word, mesh subject heading]
#37 or/25 - 36
#38 24 and 37

SEARCHED DATABASES:

Cochrane Oral Health Group Specialised Register
The Cochrane Controlled Trials Register: Cochrane Library (Issue 1, 2002)
MEDLINE 1966 - May 2002
EMBASE 1974 - May 2002
Date of the most recent electronic search: 8th May 2002
The bibliographies of papers and review articles were checked for studies outside the handsearched journals. Personal references were searched. PubMed was independently searched using "related articles" feature.

LANGUAGE:

Non-English papers were to be included in the search but none were identified.

UNPUBLISHED STUDIES:

Authors of RCTs identified and fifty-five oral implant manufacturers were written to in order to obtain further information about the trials and to attempt to identify unpublished or ongoing studies.

HANDSEARCHING:

The list of the dental journals handsearched by the Cochrane Collaboration can be found at http"":www.cochrane-oral.man.ac.uk

METHODS OF THE REVIEW

STUDY SELECTION

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

QUALITY ASSESSMENT

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

Three main quality criteria were examined:

1) Allocation concealment, recorded as
(A) Adequate
(B) Unclear
(C) Inadequate
(D) Not used
as described in the Cochrane Reviewers' Handbook.

2) Treatment blind to patients and outcomes blind to assessor
(A) Yes
(B) No
(C) Unclear
(D) Inadequate

3) Completeness of follow-up (is there a clear explanation for withdrawals and drop-outs in each treatment group?) assessed as:
(A) None
(B) Yes
(C) No

Further quality assessment were carried out to assess definition of exclusion/inclusion criteria, adequate definition of success criteria and comparability of control and treatment groups at entry. The quality assessment criteria were pilot tested using several articles.

DATA EXTRACTION

Data were extracted by two reviewers (ME and HW) 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 reviewer (PC) consulted where necessary. 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 estimate of effect of an intervention was expressed as relative risks together with 95% confidence intervals. For continuous outcomes, means and standard deviations were used to summarise the data.

It was planned to assess clinical heterogeneity by examining the types of participants, interventions and outcomes in each study.

Only if there were studies of similar comparisons reporting the same outcome measures a meta-analysis was attempted. Relative risks were combined for dichotomous data, and standardised mean differences for continuous data, using a fixed effects model. It was planned to assess the significance of any discrepancies in the estimates of the treatment effects from the different trials by means of Cochran's test for heterogeneity. If any significant statistical heterogeneity (P<0.1) was detected, it was planned to re-assess the significance of the treatment effects by using a random effects model.

Split-mouth and cross-over studies were included in this review. It was planned to combine the treatment effects from these studies, where appropriate, with parallel group studies, using Stata. 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.

If appropriate we planned to undertake a sensitivity analyses to examine the effect of randomisation, allocation concealment and blind outcome assessment on the overall estimates of effect.

It was planned to take into account the effect of including unpublished literature on the review's findings, however none was found.

DESCRIPTION OF STUDIES

See "Characteristics of included studies table".

See "Characteristics of excluded studies table".

Characteristics of the trial settings and investigators

Of the nine eligible trials, four trials were excluded due to problems with the data presented (Jeffcoat 1995; Lavigne 1994; Truhlar 2000; Bach 2000). One paper presented no data (Bach 2000), the number of patients was unclear in two trials (Jeffcoat 1995; Lavigne 1994), and the analysis was inappropriate in one trial (Truhlar 2000).

Of the five included studies, three were conducted in USA (Ciancio 1995, Felo 1997; Wolff 1998), one in the Netherlands (Strooker 1998) and one in New Zealand (Tawse-Smith 2002). Three trials had a parallel group study design, one a split-mouth design (Strooker 1998) and one a cross-over design (Tawse-Smith 2002). Four trials were conducted at university dental clinics and one in a hospital (Strooker 1998). All five trials received support from industry. All studies were conducted on adults. All trials were testing the effectiveness of methods for maintaining oral health of tissues around implants. No trial assessed the effectiveness of treatments for peri-implantitis.

Characteristics of interventions

Self administered

Powered versus manual toothbrushing (Tawse-Smith 2002).

Sonic versus manual toothbrushing (Wolff 1998).

Listerine versus placebo mouthwashes (Ciancio 1995).

Subgingival chlorhexidine irrigation versus chlorhexidine rinsing (Felo 1997).

Professionally administered

Etching gel versus mechanical debridement (Strooker 1998).

Characteristics of outcome measures

Plaque was recorded in all studies. 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) and the Mombelli index (Mombelli 1987) in one trial (Tawse-Smith 2002).

Marginal bleeding, recorded by running or sweeping a periodontal probe in the peri-implant sulcus was recorded in two trials (Ciancio 1995; Felo 1997) using a slightly modified index of Ainamo and Bay (Ainamo 1975). Bleeding indexes where a gentle probing of the pocket was used (bleeding on probing) (Strooker 1998; Wolff 1998; Tawse-Smith 2002) were excluded since they may give too many false positive scores (for a review see Esposito 1998).

Probing pocket depth measurements were used in three trials (Ciancio 1995; Strooker 1998; Wolff 1998) and probing "attachment" levels in one trial (Ciancio 1995).

Side effects (pain after treatment) and treatment time was recorded in one trial (Strooker 1998). Ease of maintenance was recorded in one trial (Wolff 1998).

No study used radiographic marginal bone level changes or implant failures as outcome measures.

METHODOLOGICAL QUALITY

The concealment of allocation was adequate for two of the trials (Ciancio 1995; Felo 1997), and the method of randomisation was considered adequate for all studies.

It was not possible to blind the patients to the interventions in four trials, however this was done in one trial (Ciancio 1995). The outcome assessor was blinded to the interventions for four trials, however this was not done in one trial (Strooker 1998).

No patients withdrew from four of the trials, and four patients withdrew from one trial (Tawse-Smith 2002), the reporting of withdrawals was adequate for all trials.

No trials reported on power calculation.

The percent agreement and kappa scores between the two raters were: 100%, 1.0 for allocation concealment, 60%, 0.38 for blinding of patients, 60%, 0.17 for blinding of outcome assessor and 100%, 1.0 for withdrawals.

RESULTS

For the five trials included in the review the results are based on 127 patients. No implant failures were reported.

Powered versus manual toothbrushing (not shown in Metaview)

One study (Tawse-Smith 2002) with a cross-over design compared powered versus manual toothbrushing. There was no baseline imbalance for mean plaque scores. At six weeks there was no significant difference in mean plaque scores, mean difference = 0.1 (95% CI: -0.66 to 0.86). No other outcomes were included in this review. However, only thirty-six patients were assessed.

Sonic versus manual toothbrushing (Comparison 01)

One study (Wolff 1998) with a parallel group design compared sonic versus manual toothbrushing, and the 12 week data were used. There was no baseline imbalance for all outcomes reported. At 12 weeks there were no statistically significant differences for plaque or probing pocket depth. Comparison of the number of participants who did not find toothbrushing easy was not significant, RR = 2.82 (95% CI: 0.12 to 64.39). Although all these findings were based only on thirty-one patients.

Antiseptic mouthwashes: Listerine versus placebo (Comparison 02)

One study (Ciancio 1995) compared Listerine versus a placebo mouthwash. There was no baseline imbalance for all outcomes reported. After three months statistically significantly less plaque and marginal bleeding were found in the Listerine group, with mean difference for plaque = -0.88 (95% CI -0.93 to -0.83) and 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 differences were found for probing "attachment" levels. These results were based on a well designed study including only 10 patients in each group, demonstrating reduction of 54% in plaque and 34% in marginal bleeding compared with a placebo.

Subgingival irrigation: chlorhexidine irrigation versus chlorhexidine mouthwash (Comparison 03)

One study (Felo 1997) compared subgingival chlorhexidine irrigation versus chlorhexidine mouthwash. There was no baseline imbalance for all outcomes reported. At three 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). The study quality was good although the patients could not be blinded, however, the result were based only on 24 patients.

Phosphoric etching gel versus mechanical debridement (not shown in Metaview; see Table 1)

One study (Strooker 1998) with a split-mouth design compared etching gel with mechanical debridement. There was no baseline imbalance for all outcomes reported. The report did not give the SD of the differences for the two outcomes, Silness and Loe plaque index and probing pocket depth, however when contacted the authors supplied this. At five months there was no evidence of a difference between the treatment groups for plaque or probing pocket depth. However, when the treatment was administered for the first time, nine out of 16 patients reported slight (7) to moderate (2) pain at the side subjected to etching gel treatment compared to none in the debridement group (P<0.001). At five months, no patient complained of pain. There was no statistically significant difference between the two techniques in cleaning time. Based on the quality assessment criteria used, this study was found to be poor and was only based on 16 patients.

DISCUSSION

The aims of the review could only be partially accomplished. This review only included RCTs as these are known to provide the most reliable level of evidence (Clarke 2002). In particular we were not able to identify any RCTs on the treatment of peri-implantitis. Readers may be surprised to note that only five RCTs on maintenance were included, and no meta-analysis was conducted as each trial assessed different interventions. The generalisibility of the included trials is likely to be high as most adult patients with implants are included. However, it should be considered that these results were obtained following the strict protocols of clinical trials. As the duration of these trials was short, with a maximum follow-up of five months (Strooker 1998), the effectiveness of maintenance interventions has still to be assessed in long-term trials. 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.

Ideally, the primary outcome measure of interest would have been implant failure, but surrogate outcomes (such as radiographic bone level changes, attachment levels, probing depths, marginal bleeding and plaque scores) 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. 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 reduc-

ing 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 significant 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.

REVIEWERS' CONCLUSIONS

Implications for practice

There is only a little reliable evidence for the most effective interventions for maintaining health around peri-implant tissues. There is no evidence that the use of powered or sonic toothbrushes is superior to manual toothbrushing. There is weak evidence that Listerine mouthwash, used twice a day for 30 seconds, as adjunct to routine oral hygiene is effective in reducing plaque formation and marginal peri-implant bleeding. There is no evidence that phosphoric etching gel offers any clinical advantage over mechanical debridement and polishing. These findings are based on trials having short follow-up periods (five months or less) and limited numbers of subjects. There is not any reliable evidence for which are the most effective maintenance regimens in a long-term perspective. For the treatment of failing implants (peri-implantitis) there is no reliable evidence for preferring one therapeutic regimen over another.

Implications for research

More RCTs should be conducted in this area. In particular, there is a definite need for trials investigating which is the most effective approach for the treatment of peri-implantitis and for trials with longer follow-up for maintenance. Such trials should be reported according the Consolidated Standards of Reporting Trials (CONSORT) guidelines (http://www.consort-statement.org/) and should include sample size calculations.

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POTENTIAL CONFLICT OF INTEREST

None known.

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- NIOM (Scandinavian Institute of Dental Materials) NORWAY
- University of Manchester UK
- University of Oslo NORWAY

REFERENCES

References to studies included in this review

Ciancio 1995 *{published and unpublished data}*

* Ciancio SG, Lauciello F, Shibly O, Vitello M, Mather M. The effect of an antiseptic mouthrinse on implant maintenance: plaque and peri-implant gingival tissues. *Journal of Periodontology* 1995;**66**:962–5.

Felo 1997 *{published and unpublished data}*

* Felo A, Shibly O, Ciancio SG, Lauciello FR, Ho A. Effects of subgingival chlorhexidine irrigation on peri-implant maintenance. *American Journal of Dentistry* 1997;**10**:107–10.

Strooker 1998 *{published and unpublished data}*

* Strooker H, Rohn S, Van Winkelhoff AJ. Clinical and microbiological effects of chemical versus mechanical cleansing in professional supportive implant therapy. *International Journal of Oral and Maxillofacial Implants* 1998;**13**:845–50.

Tawse-Smith 2002 *{published and unpublished data}*

Tawse-Smith A, Duncan WJ, Payne AGT, Thomson WM, Wennstrom I. Relative effectiveness of powered and manual toothbrushes in elderly patients with implant-supported mandibular ovedentures. Journal of Clinical Periodontology [in press].

Wolff 1998 *{published data only}*

* Wolff L, Kim A, Nunn M, Bakdash B, Hinrichs J. Effectiveness of a sonic toothbrush in maintenance of dental implants. A prospective study. *Journal of Clinical Periodontology* 1998; **25**:821–8.

References to studies excluded from this review

Bach 2000

* Bach G, Neckel K, Mall C, Krekeler G. Conventional versus laser-assisted therapy of periimplantitis: a five-year comparative study. *Implant Dentistry* 2000;**9**:247–51.

Jeffcoat 1995

* Jeffcoat MK, Reddy MS, Wang IC, Meuninghoff LA, Farmer JB, Koth DL. The effect of systemic flurbiprofen on the bone supporting dental implants. *Journal of the American Dental Association* 1995;**126**:305–11.

Lavigne 1994

* Lavigne SE, Krust-Bray KS, Williams KB, Killoy WJ, Theisen F. Effects of subgingival irrigation with chlorhexidine on the periodontal status of patients with HA-coated Integral dental implants. *International Journal of Oral and Maxillofacial Implants* 1994;**9**:156–62.

Truhlar 2000

* Truhlar RS, Morris HF, Ochi S. The efficacy of a counter-rotational powered toothbrush in the maintenance of endosseous dental implants. *Journal of the American Dental Association* 2000;**131**:101–7.

Additional references

Ainamo 1975

Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. *International Dental Journal* 1975;**25**:229–35.

Balshi 1986

Balshi TJ. Hygiene maintenance procedures for patients treated with the tissue integrated prosthesis (osseointegration). *Quintessence International* 1986;**17**:95–102.

Bragger 1994

Bragger U. Maintenance, monitoring, therapy of implant failures. Lang NP, Karring T, editor(s). Proceedings of the 1st European Workshop on Periodontology. London: Quintessence Publishing Co., "ltd, 1994:345–64.

Branemark 1977

Branemark PI, Hansson BO, Adell R, Breine U, Lindstrom J, Hallen O, et al. *Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period*. Stockholm: Almqvist & Wiksell Int, 1977.

Clarke 2002

Clarke M, Oxman AD. Cochrane Reviewers' Handbook 4.1.5 [update April 2002].Review Manager (RevMan) [computer program]. Oxford: The Cochrane Collaboration. Oxford: Update Software, 2002.

Dmytryk 1990

Dmytryk JJ, Fox SC, Moriarty JD. The effect of scaling titanium implant surfaces with metal and plastic instruments on cell attachment. *Journal of Periodontology* 1990;**61**:491–6.

Esposito 1998

Esposito M, Hirsch J-M, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I) Success criteria and epidemiology. *European Journal of Oral Sciences* 1998;**106**:527–51.

Esposito 1999

Esposito M, Hirsch J-M, Lekholm U, Thomsen P. Differential diagnosis and treatment strategies for biologic complications and failing oral implants. A review of the literature. *International Journal of Oral and Maxillofacial Implants* 1999; **14**:473–90.

Esposito 2001

Esposito M, Coulthard P, Worthington HV. In search of truth: the role of systematic reviews and meta-analyses for assessing the effectiveness of rehabilitation with oral implants. *Clinical Implant Dentistry and Related Research* 2001;**3**(2): 62–78.

Follmann 1992

Follmann D, Elliott P, Suh I, Cutler J. Variance imputation for overviews of clinical trials with continuous response. *Journal of Clinical Epidemiology* 1992;**45**:769–73.

Furberg 1991

Furberg CD. Organizing multicenter trials: lessons from cardiovascular prevention trials. *Preventive Medicine* 1991;**20**: 158–61.

Jensen 1991

Jensen RL, Jensen JH. Peri-implant maintenance. *Northwest Dentistry* 1991;**70**:14–30.

McCollum 1992

McCollum J, O'Neal RB, Brennan WA, Van Dyke TE, Horner JA. The effect of titanium implant abutment surface irregularities on plaque accumulation in vivo. *Journal of Periodontology* 1992;**63**:802–5.

Mombelli 1987

Mombelli A, Van Oosten MAC, Schurch E, Lang NP. The microbiota associated with successful or failing titanium osseointegrated implants. *Oral Microbiology and Immunology* 1987;**2**:145–51.

Mombelli 1999
Mombelli A. Prevention and therapy of pery-implant infections. Lang NP, Karring T, Lindhe J, editor(s). Proceedings of the 3rd European Workshop on Periodontology. Implant Dentistry. Berlin: Quintessence Publishing Co., Inc, 1999: 281–303.

Orton 1989
Orton GO, Steele DL, Wolinsky LE. The dental professional's role in monitoring and maintenance of tissue-integrated prostheses. *International Journal of Oral and Maxillofacial Implants* 1989;**4**:305–10.

Pontoriero 1994
Pontoriero R, Tonelli MP, Carnevale G, Mombelli A, Nyman SR, Lang NP. Experimentally induced peri-implant mucositis. *Clinical Oral Implants Research* 1994;**5**:254–9.

Schou 2002
Schou S, Holmstrup P, Stolze K, Hjorting-Hansen E, Fiehn N-E, Skovgaard LT. Probing around implants and teeth with healthy or inflamed peri-implant mucosa/gengiva. A histologic comparison in cynomolgus monkeys (Macaca fascicularis). *Clinical Oral Implants Research* 2002;**13**:113–26.

Silness 1964
Silness J, Loe H. Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontologica Scandinavica* 1964;**24**:533–521.

Speelman 1992
Speelman JA, Collaert B, Klinge B. Evaluation of different methods to clean titanium abutments. A scanning electron microscopic study. *Clinical Oral Implants Research* 1992;**3**: 120–7.

Thomson-Neal 1989
Thomson-Neal D, Evans GH, Meffert RM. Effects of various prophylactic treatment on titanium, sapphire, and hydroxyapatite-coated implants: a SEM study. *International Journal of Periodontics and Restorative Dentistry* 1989;**9**:301–11.

Turesky 1970
Tureski S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analog of vitamin C. *Journal of Periodontology* 1970;**41**:41–3.

* *Indicates the major publication for the study*

TABLES

Characteristics of included studies

Study	**Ciancio 1995**
Methods	Randomised, parallel group study. Patients and outcome assessor blind. No withdrawals.
Participants	Adults. 20 enrolled and results given for 20.
Interventions	Two groups. Antiseptic mouthwash (20 ml) (Listerine) rinse twice per day for 30 s versus placebo (5% hydoalcohol). Study duration: 3months.
Outcomes	Turesky modification of Quigley-Hein plaque index, a modification of the Ainamo and Bay bleeding index, 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".
Allocation concealment	A
Study	**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	Two 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.

Characteristics of included studies (*Continued*)

Allocation concealment	A
Study	**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	Two groups. Monthly 35 % phosphoric etching gel (pH1) for one minute versus supra- and subgingival mechanical debridement using carbon fiber curettes and rubber cup. 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, probing pocket depth (mm), microbiological sampling, post-operative pain and treatment time at 1 and 5 months. 5 month data used.
Notes	
Allocation concealment	B
Study	**Tawse-Smith 2002**
Methods	Randomised, cross-over study. Patients cannot be blind, outcome assessor blind. Four withdrawals.
Participants	Adults. 40 enrolled and results given for 36.
Interventions	Two groups. Powered versus manual toothbrushing twice a day for 30 s. Study duration: 6 weeks.
Outcomes	Modified plaque index by Mombelli and modified sulcus bleeding index by Mombelli at 6 weeks.
Notes	
Allocation concealment	C
Study	**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	Two 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. 12 week data used.
Notes	
Allocation concealment	B

Characteristics of excluded studies

Study	**Reason for exclusion**
Bach 2000	No data presented. Written to author but no reply.
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.
Lavigne 1994	Problems with data. 8 patients all having 3 treatments, but n was 10 for each group. Written to author for clarification but have received no reply.
Truhlar 2000	Problems with data. Study designed as cluster randomised controlled trial, however data analysed and means and SD presented on implant basis, ignoring centres. Written to authors requesting new data, but no reply.

ADDITIONAL TABLES

Table 01 Professionally-administered cleaning: phosphoric etching gel versus debridement

Study	n of patients	plaque (SE)	plaque 95% CI	PD (SE)	PD 95% CI
Strooker 1998	16	0.00 (0.17)	-0.34, 0.34	-0.14 (0.15)	-0.43, 0.15

SUMMARY TABLES

01 Self-administered mechanical oral hygiene: sonic versus manual toothbrush

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
Plaque and pocket probing depth (3 months)			Weighted Mean Difference (Fixed) 95% CI	Totals not selected

02 Self-administered antimicrobials: Listerine versus placebo

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
Plaque, marginal bleeding, probing pocket depth, probing "attachment" level			Weighted Mean Difference (Fixed) 95% CI	Subtotals only

03 Self-administered antimicrobials: Chlorhexidine irrigation versus chlorhexidine mouthwash

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
Plaque and marginal bleeding			Weighted Mean Difference (Fixed) 95% CI	Totals not selected

COVER SHEET

Title	Interventions for replacing missing teeth: maintaining and re-establishing healthy tissues around dental implants
Reviewers	Esposito M, Worthington HV, Coulthard P, Jokstad A
Contribution of reviewer(s)	Conceiving, designing and coordinating the review (ME) Developing search strategy and undertaking searches (ME, AJ, PC) Screening search results and retrieved papers against inclusion criteria (ME, PC) Appraising quality and abstracting data from papers (HW, ME) Writing to authors for additional information (HW, ME) Data management for the review and entering data into RevMan (HW, ME) Analysis and interpretation of data (ME, HW) Writing the review (ME, HW) Providing general advice on the review (PC, AJ) Performing previous work that was the foundation of current study (ME, AJ, HW, PC)
Issue protocol first published	2001/2
Review first published	2002/3
Date of most recent amendment	25 February 2003
Date of most recent SUBSTANTIVE amendment	28 May 2002
Most recent changes	Information not supplied by reviewer
Date new studies sought but none found	Information not supplied by reviewer

Date new studies found but not yet included/excluded	Information not supplied by reviewer
Date new studies found and included/excluded	Information not supplied by reviewer
Date reviewers' conclusions section amended	Information not supplied by reviewer
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GRAPHS AND OTHER TABLES

Fig. 01 Self-administered mechanical oral hygiene: sonic versus manual toothbrush

01.Plaque and pocket probing depth (3 months)

Review: Interventions for replacing missing teeth: maintaining health around dental implants

Comparison: 01 Powered versus manual toothbrushing

Outcome: 01 Plaque

Study	mean difference (SE)	mean difference (Fixed) 95% CI	Weight (%)	mean difference (Fixed) 95% CI
Tawse-Smith 2002	0.10 (0.39)		100.0	0.10 [-0.66, 0.86]

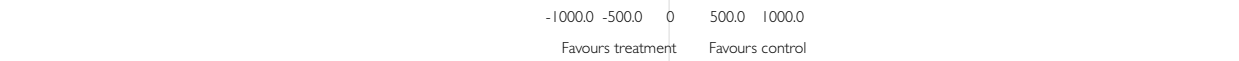

Fig. 02 Self-administered antimicrobials: Listerine versus placebo

02.Plaque, marginal bleeding, probing pocket depth, probing "attachment" level

Review: Interventions for replacing missing teeth: maintaining health around dental implants

Comparison: 02 Self-administered mechanical oral hygiene: sonic versus manual toothbrush

Outcome: 01 Plaque and pocket probing depth (3 months)

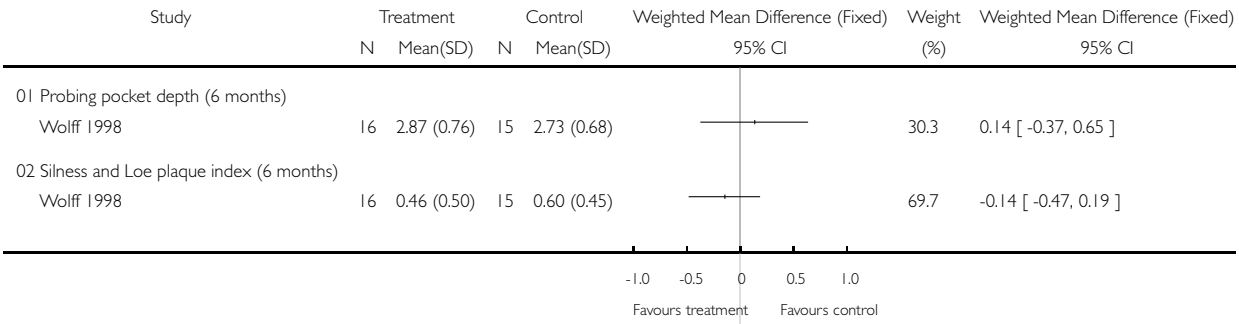

Fig. 03 Self-administered antimicrobials: Chlorhexidine irrigation versus chlorhexidine mouthwash

03.Plaque and marginal bleeding

Review: Interventions for replacing missing teeth: maintaining health around dental implants

Comparison: 03 Self-administered antimicrobials: Listerine versus placebo

Outcome: 01 Plaque, marginal bleeding, probing pocket depth, probing "attachment" level