



Manual versus powered toothbrushing for oral health

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ABSTRACT

Background

Specific oral bacteria, generically known as 'dental plaque' are the primary cause of gingivitis (gum disease) and caries. The removal of dental plaque is thought to play a key role in the maintenance of oral health. There is conflicting evidence for the relative merits of manual and powered toothbrushing in achieving this.

Objectives

To compare manual and powered toothbrushes in relation to the removal of plaque, the health of the gingivae, staining and calculus, dependability, adverse effects and cost.

Search strategy

We searched the Cochrane Oral Health Group's Trials Register (to 22/8/02); the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library Issue 3, 2002); MEDLINE (January 1966 to week 5 2002); EMBASE (January 1980 to week 3 July 2002) and CINAHL (January 1982 to June 2002). Manufacturers of powered toothbrushes were contacted for additional published and unpublished trials.

Selection criteria

Trials were selected if they met the following criteria: design-random allocation of participants; participants-general public with uncompromised manual dexterity; intervention- unsupervised manual and powered toothbrushing for at least 4 weeks; primary outcomes-the change in plaque and gingivitis over that period.

Data collection and analysis

Six reviewers independently extracted information in duplicate. Indices for plaque and gingivitis were expressed as standardised values for each study. The effect measure for each meta-analysis was the standardised mean difference (SMD) with the appropriate 95% confidence intervals (CI) using random effects models. Potential sources of heterogeneity were examined, along with sensitivity analyses for the items assessed for quality and publication bias.

Main results

Twenty-nine trials, involving 2547 participants, provided data for the meta-analysis.

Brushes that worked with a rotation oscillation action removed more plaque and reduced gingivitis more effectively than manual brushes in the short and long term. For plaque at 1 to 3 months the SMD was -0.44 (95% CI: -0.66 to -0.21), for gingivitis SMD -0.45 (95% CI: -0.76, -0.15). These represented an 11% reduction on the Quigley Hein plaque index and a 6% reduction on the Löe and Silness gingival index. At over 3 months the effects were SMD for plaque -1.15 (95% CI: -2.02,-0.29) and SMD for gingivitis -0.51 (95% CI: -0.76, -0.25). These represented a 7% reduction on the Quigley Hein Plaque Index and a 17% reduction on the Ainamo Bay Bleeding on Probing Gingival Index. The heterogeneity found in these meta-analyses for short term trials was caused by one trial that had exceptionally low standard deviations. Sensitivity analyses revealed the results to be robust when selecting trials of high quality. There was no evidence of any publication bias.

No other powered brush designs were consistently superior to manual toothbrushes.

In these trials, data on cost, reliability and side effects were inconsistently reported. Those side effects that were reported on in the trials were localised and temporary.

Reviewers' conclusions

Powered toothbrushes with a rotation oscillation action achieve a modest reduction in plaque and gingivitis compared to manual toothbrushing.

Observation of methodological guidelines and greater standardisation of design would benefit both future trials and meta-analyses.

BACKGROUND

Pathogenic bacteria are the primary cause of gingivitis (gum inflammation) and are implicated in the progression to periodontitis (loss of bone around the teeth) although the link between the two is complex and not well understood (Löe 1965).

Plaque is also one of the main causal factors in dental caries, although the evidence of a relationship between oral cleanliness and caries is not clear-cut (Richardson 1977; Addy 1986). When teeth are brushed with a fluoride toothpaste ample evidence of a caries preventative effect is available, but this is due more to the effect of fluoride than brushing per se (Chesters 1992).

Good oral hygiene (the removal of plaque) by effective toothbrushing has a key role in oral health. Effective toothbrushing depends on a number of factors including motivation, knowledge and manual dexterity.

Powered brushes simulate the manual motion of toothbrushes with lateral and rotary movements of the brush head. More recently, there has been a progression towards rotary action brushes (van der Weij 1993a). Brushes which operate at a higher frequency of vibration have also been introduced (Johnson 1994; Terezhalmay 1995b).

Powered toothbrushes were first introduced commercially in the early 1960s (Chilton 1962a; Cross 1962; Hoover 1962; Elliot 1963) and have become established as an alternative to manual methods of toothbrushing. In the UK the volume of sales of powered toothbrushes has nearly doubled each year between 1999 and 2001, increasing from 2% of total sales of all toothbrushes in 1999 to 7% in 2001 (Personal communication, R Davies 2002).

One study has shown that 36 months after purchase, 62% of people were using their electric toothbrushes on a daily basis (Stålneke 1995). The compliance level was high and was unrelated to any social factors of the population studied.

As the powered toothbrush is so popular the common question raised is which is better, the powered or manual?

OBJECTIVES

To compare manual and powered toothbrushes in everyday use, by people of any age, in relation to:

- (1) removal of plaque;
- (2) inflammation of the gingivae;
- (3) removal of staining and calculus;
- (4) dependability and cost;
- (5) adverse effects.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of studies

The review is confined to randomised controlled trials comparing manual and powered toothbrushes. It excludes trials confined to comparisons between different kinds of powered brushes or those comparing different kinds of manual brushes.

Cross-over trials were eligible. Split mouth trials were excluded, as these were not considered representative of 'everyday use'.

Types of participants

Individuals of any age with no reported disability that might affect toothbrushing were included. Individuals wearing orthodontic appliances were also included.

Types of intervention

The toothbrushes included in the review were all forms of manual brushes and all forms of powered brushes with a mechanical movement of the brush head.

Trials instituting combined interventions, e.g. brushing combined with the use of mouthrinses or irrigation, were excluded. However, trials where participants were permitted to continue with their usual adjuncts to oral hygiene, such as flossing, were included.

Trials were excluded, where the brushing intervention was carried out or was supervised by a professional within 28 days prior to a follow-up assessment.

Trials of 28 days and over were eligible, and a subgroup analysis was carried out on the duration of trials for the different outcome measurements.

Powered toothbrushes were divided into six groups according to their mode of action.

Side to side action, indicates a brush head action that moves laterally side to side.

Counter oscillation, indicates a brush action in which adjacent tufts of bristles (usually 6 to 10 in number) rotate in one direction and then the other, independently. Each tuft rotating in the opposite direction to that adjacent to it.

Rotation oscillation, indicates a brush action in which the brush head rotates in one direction and then the other.

Circular, indicates a brush action in which the brush head rotates in one direction.

Ultrasonic, indicates a brush action where the bristles vibrate at ultrasonic frequencies (> 20 kHz).

Unknown, indicates a brush action that the reviewers have been unable to establish based on the trial report or confirm with the manufacturers.

It was agreed that, analysis of filament arrangement, orientation, size, shape and flexibility, brush head size and shape along with

presence or absence and characteristics of a timer would prove difficult to define across time and brush types.

Types of outcome measures

The primary outcome measures employed were quantified levels of plaque and/or gingivitis. Values recorded on arrival at the assessment were used. Measures taken after participants had been instructed to brush their teeth at the assessment visit were not used.

Secondary outcome measures sought were levels of calculus and staining; dependability and cost of the brush used, including mechanical deterioration; and adverse effects such as hard or soft tissue injury and damage to orthodontic appliances and prostheses.

SEARCH STRATEGY FOR IDENTIFICATION OF STUDIES

The search followed the Cochrane Oral Health Group search strategy (<http://www.update-software.com/cochrane/>).

The search attempted to identify all relevant randomised controlled trials (RCTs) irrespective of language.

We searched the following databases:

The Cochrane Oral Health Group's Trials Register (to 22/8/02)

The Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library Issue 3, 2002)

MEDLINE (1966 to week 5 2002)

EMBASE (1980 to week 3 July 2002)

CINAHL (1982 to June 2002).

For the identification of trials included in, or considered for this review, detailed search strategies were developed for each database. These were based on the search strategy developed for MEDLINE but revised appropriately for each database to take account of differences in controlled vocabulary and syntax rules.

The MEDLINE search strategy combined the subject search with phases one and two 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 free text terms and is published in full below. Details of search strategies applied to other databases are available from the contact reviewer.

The search strategy for MEDLINE via OVID:

1.exp Toothbrushing/

2.toothbrush\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

3.((tooth or teeth) adj3 clean\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

4.1 or 2 or 3

5.manual\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

6.conventional\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

7.handbrush\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

8.5 or 6 or 7

9.power\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

10.mechanical\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

11.electric\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

12.electronic\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

13.ultrasonic\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

14.sonic\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

15."motor driven".mp. [mp=title, abstract, registry number word, mesh subject heading]

16."battery operated".mp. [mp=title, abstract, registry number word, mesh subject heading]

17.automatic\$.mp. [mp=title, abstract, registry number word, mesh subject heading]

18.9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17

19.4 and 8 and 18

The following journals were identified as sources of frequently cited articles in the electronic search:

Journal of Clinical Dentistry (9 citations); American Journal of Orthodontics and Dentofacial Orthopedics (8 citations); American Journal of Dentistry (8 citations); Journal of Clinical Periodontology (20 citations); Journal of Periodontology (17 citations); Journal of Dental Research (42 citations). As these journals are included in the Oral Health Group's ongoing hand searching programme (<http://www.cochrane-oral.man.ac.uk/>), no further handsearching was undertaken.

All references cited in the included trials were checked. Identified manufacturers were contacted and additional published or unpublished trial reports requested.

The review is to be updated every 2 years using CENTRAL, the Cochrane Oral Health Group's Trials Register, MEDLINE and EMBASE.

Date of the most recent search was August 2002 (CENTRAL) (The Cochrane Library Issue 3, 2002).

METHODS OF THE REVIEW

Two reviewers independently reviewed the titles and abstracts identified in the search. If in the opinion of both reviewers an article clearly did not fulfil the defined exclusion criteria it was considered ineligible. Full reports of all trials of possible relevance were obtained for assessment. On receipt of the full article, two reviewers assessed each study independently using specifically designed data extraction forms.

DATA EXTRACTION

Data extraction was performed independently by all reviewers on 10 pilot articles. The reviewers reported back on the design of the data extraction forms and their interpretation of the inclusion and exclusion criteria along with their understanding of the outcome measures. On the basis of this feedback the data extraction forms were altered and the inclusion, exclusion and outcome measures redefined to avoid misinterpretation.

The final data extraction protocol extracted the following information:

- (1) Bibliographic details of the study.
- (2) Funding source for the trial.
- (3) Inclusion eligibility.
- (4) Baseline characteristics of the participants in the study, including age, number of participants in the study and gender. Also, specific groups, such as dental students or orthodontic patients were noted, where mentioned.
- (5) Intervention characteristics including type of brush and its mode of action, duration of use and delivery of instructions.
- (6) Outcomes including plaque and gingivitis indices.

A trial was considered to have adequately generated a random sequence of allocation, if it fully reported the type of allocation generation and it satisfied the CONSORT guidelines as true randomisation (<http://www.consort-statement.org/>).

A trial was considered to have adequate blinding, if it stated that the method of outcome assessment did not allow the recording clinician to know to which group the participants had been allocated, with no other contradicting statement.

Attrition was considered to have been adequately reported if there was a clear indication of how many withdrawals occurred in each group during the trial and an attempt made to give reasons why the withdrawals occurred.

A trial was considered to have been funded by a brush manufacturer if it was reported that any material sponsorship from the manufacturer occurred, including the donation of brushes. It was considered unclear, if there was no statement on funding. A trial was only considered to be unsponsored by a manufacturer if it clearly stated so.

Trials were considered as 'short term' or 'long term'. 'Short term' data includes follow up between 28 days and 3 months. 'Long term' data includes follow up beyond 3 months. Within each category of long term and short term, where a trial reported multiple end points, only the latest data were extracted.

Data from trials that reported follow up before, and after 3 months were included in the pre- and post-3 month meta-analysis. This was the only circumstance when data from the same trial were considered twice.

Many different indices of plaque and gingivitis were used across trials and some trials reported multiple indices. A frequencies table was prepared of the indices used and they were ranked based on common usage and simplicity. For plaque we

extracted, where possible, data reported as the Turesky et al modification of the Quigley-Hein plaque index of 1962 (Quigley 1962;Turesky 1970). For gingival inflammation we extracted where possible data reported as the gingival index of L oe and Silness (L oe 1963) or, if unavailable, bleeding on probing (Ainamo 1975). Data for 'Russell's periodontal index' were excluded because this index fails to distinguish between gingivitis and periodontitis (Russell 1967).

Where available, data were extracted for whole mouth scores as opposed to part mouth scores. Where only part mouth scores were reported in a study, they were extracted and a sensitivity analysis carried out to consider their impact on the results of the review. Part mouth scoring was said to have occurred if plaque and or gingivitis were not recorded around all erupted teeth, except third molars.

Completed data extraction forms were compared. Where there was disagreement between reviewers with regard to any part of the extraction details it was resolved by discussion between the reviewers and a note made on the data collection forms. Any disagreement, unresolved between the two reviewers, was settled by majority vote of the entire panel of six reviewers. Authors were contacted for clarification where necessary.

METHODOLOGICAL QUALITY

Quality assessment was carried out independently in duplicate at the same time as data was extracted. Particular emphasis was placed on allocation concealment ranked using the Cochrane criteria: Grade A: Adequate, B: Unclear, C: Inadequate, and D: Not used.

Consideration was also given to:

- (1) Generation of randomisation sequence
- (2) A priori calculation of sample size
- (3) Blind outcome assessment
- (4) Comparability of groups at baseline
- (5) Duration of study
- (6) Attrition bias
- (7) Reliability tests for outcome measures.

Agreement between reviewers, concerning methodological quality, was assessed by calculating kappa values for full mouth recording; adequate allocation concealment; adequate random number generation; adequate blinding of outcome assessor and adequate reporting of attrition.

Numerical data extracted from the included trials was checked by a third reviewer for accuracy and entered into RevMan (version 4.1).

DATA SYNTHESIS

Choice of summary statistic and estimate of overall effect.

Different indices for plaque measure the same concept on different scales, with high correlation between the different indices. The same is true for gingivitis. As it is not possible to combine the results from different indices, the effects were expressed as standardised values, which have no units, before combining. The standardised mean difference (SMD) was

therefore calculated along with the appropriate 95% confidence intervals (CI) and was used as the effect measure for each meta-analysis. As these mean differences for the groups have no inherent clinical value, to express an estimate of the degree of clinical effect they represent, it is necessary to apply them using any one study as an example. Such examples are given later in the discussion. Random effects models were performed throughout.

Assessment of heterogeneity and investigation of reasons for heterogeneity

Heterogeneity was assessed by inspection of a graphical display of the estimated treatment effects from the trials along with their 95% CI and by Cochran's test for homogeneity undertaken before each meta-analysis. Subgroup analyses were undertaken for assessments based on full-mouth recording versus those based on a partial recording and to examine the effects of concealed allocation, randomisation generation and blind outcome assessment on the overall estimates of effect for important outcomes.

Cross-over trials

It was planned to combine the data from cross-over trials with that of similar parallel group trials, using the techniques described by Elbourne et al (Elbourne 2002). Due to insufficient data this was not possible.

Investigation of publication and other biases

A funnel plot (plots of effect estimates versus the inverse of their standard errors) was drawn. Asymmetry of the funnel plot may indicate publication bias and other biases related to sample size, though it may also represent a true relationship between trial size and effect size. A formal investigation of the degree of asymmetry was performed using the method proposed by Egger et al (Egger 1997). A further method proposed by Begg and Mazumdar which tests for publication bias by determining if there is a significant correlation between the effect estimates and their variances was also carried out (Begg 1994). Both methods were carried out using Stata version 7.0 (Stata Corporation, USA) using the program Metabias.

DESCRIPTION OF STUDIES

The search identified 354 trials of which 139 were considered to be ineligible from the information provided in the title or abstract. Full articles were obtained for the remaining 215. From the full articles 152 trials proved ineligible. From the abstracts and full articles 29 trials had insufficient detail to be able to convincingly allocate them to the category of included or excluded trials. Thirty-six trials were eligible. Of these eligible trials, five cross-over and two parallel trials provided insufficient information for the data to be used in a meta-analysis, and were excluded. Twenty-nine trials fulfilled all inclusion criteria and had results that could be entered for meta-analysis.

The authors of 36 trials with insufficient information were contacted and asked to provide the missing details required to include or exclude the data.

One reason for the exclusion of each study is given in the 'Characteristics of excluded studies' table. Many trials were ineligible for more than one reason. Trials or abstracts which proved to be duplicates of included studies are tabulated here, but entered in the included study references list, as such. For trials where authors had been contacted for further information and where no reply was received after 3 months, the study was considered ineligible for insufficient data available. Should the required data be supplied such trials will be addressed in the next review. A summary of the reasons for exclusion is given in 'Additional Table 01'.

Of the 29 included trials, 21 were conducted in North America (Lobene 1964a; Soparkar 1964; Glass 1965; Baab 1989; Walsh 1989; Emling 1991; Khocht 1992; Barnes 1993; Wilson 1993; Yukna 1993b; Johnson 1994; Terezhalmly 1995a; O'Beirne 1996; Tritten 1996; Yankell 1996; Ho 1997; Yankell 1997; Cronin 1998; Forgas-B 1998; Warren 2001; Dentino unpublished); seven in Europe (McAllan 1976; Stoltze 1994; van der Weijden 1994; Ainamo 1997; Clerehugh 1998; Heasman 1999a; Lazarescu unpublished) and one in Israel (Stabholz 1996).

Two trials were unpublished. The remainder were published between 1964 and 2001; three in the 1960s; one in the 1970s; two in the 1980s; 20 in the 1990s and one in the 2000s. At least 19 were funded in some part by the manufacturer of one of the powered toothbrushes, the remainder were unclear about sponsorship.

The combined total number of participants included in the trials was 2547. The number of patients reported lost to follow up was 239 (9.4%).

CHARACTERISTICS OF PARTICIPANTS

For each study the inclusion criteria are noted in the 'Characteristics of included studies' table and in 'Additional Table 02'. Out of the 29 eligible trials the four most frequently stated inclusion criteria were adults (66% of trials), no relevant medical history (72%), a stated minimal number of teeth required (59%) and at least a minimal gingival, periodontal or plaque pre-treatment measure (55%). Exclusion criteria for included trials were noted and summarised in 'Additional Table 03'.

CHARACTERISTICS OF INTERVENTIONS

The powered toothbrushes, included:

Braun, Interplak, Braun Plaque Remover with OD5 head, Braun Oral B 3D, Braun Oral B D9, PlaK Trac, Ultrasonex, GEC, Braun Oral B D7, Phillips Jordan HP 735, Sonicare ultrasonic, Philips Sonicare, Epident, Braun Oral B D5, Philips 550, Touchtronic Teledyne Aqua Tec, Ronson, Dominion, Pulse Plaque Remover, Broxodent, Plaq and White, LPA/Broxo, Braun D17, Rowenta Dentiphant, Rowenta, Plaque

Dentacontrol Plus. These are summarised in 'Additional Table 04'.

Powered toothbrush, mode of action.

The powered toothbrushes were subdivided into six groups according to their mode of action.

Side to side action.

Philips Sonicare and Sonicare brushes (Sonicare c/o Philips Oral Healthcare, 35301 SE Center Street, Snoqualmie, WA 98065; <http://www.sonicare.com/>);

Philips 550 (Phillips Jordan, P.O. Box 324, 5500 AH Veldhoven, The Netherlands; <http://www.philips-jordan.com/>).

Counter oscillation.

Interplak brush (Interplak Conair Corporation, 1 Cummings Point Road, Stamford, CT 06904 <http://www.conair.com/products/>).

Rotation oscillation.

Braun Oral B 3D, D17, Plaque Remover with OD5 head, Oral B D9, Oral B D7, Oral B D5 (Braun Oral-B Consumer Services, 1 Gillette Park, South Boston, MA; <http://www.oralb.com/>); Phillips Jordan HP 735 (Phillips Jordan P.O. Box 324, 5500 AH Veldhoven, The Netherlands; <http://www.philips-jordan.com/>).

Circular.

Rowenta Dentiphant, Rowenta, Plaque Dentacontrol Plus (Rowenta Werke GmbH, Franz Alban, Stützer, Germany; <http://www.products.rowenta.de/row/index.html>);

Teledyne Aqua Tech brushes (Corporate Headquarters 12333 West Olympic Boulevard Los Angeles, CA 90064; <http://www.waterpik.com/oralhealth/>).

Ultrasonic.

Ultrasonex brush (Salton-Maxim 1801 N. Stadium Boulevard, Columbia, MO 65202; <http://www.salton-maxim.com/salton/ultrasonex/ultrasonex.asp>).

The names and addresses of the manufacturers have changed over the years and those quoted above are correct at the time of the present review. Some of the trials were conducted when another company made the powered toothbrush. Some companies are no longer operational or complete details of their toothbrushes reported on are not easily found. The following toothbrushes fall into this latter category: PlaK Trac, GEC, Epident, Touchtronic, Ronson, Dominion, Broxodent, Plaq and White, LPA/Broxco.

Eight trials including 627 participants at the end of the trial compared manual brushing versus side to side powered toothbrushing. Four trials provided data on 184 participants at the end of the trial compared manual brushing versus counter oscillating toothbrushing. Ten trials with 867 participants at the end of the trial compared manual brushing versus rotation oscillation powered brushing. Three trials including 168 participants at the end of the trial compared manual brushing versus circular powered brushing and two trials of 108

participants at the end of the trial compared manual brushing versus ultrasonic powered brushing. Two trials with 295 participants at the end of the trial compared manual brushing and a powered toothbrush with an unknown action.

Summary of trials by tooth brush action

The trials that compared manual with a side to side action powered brush were: (Glass 1965; Johnson 1994; Tritten 1996; Yankell 1997; Ho 1997; Lobene 1964a; Walsh 1989; O'Beirne 1996). Counter oscillation: (Khocht 1992; Stabholz 1996 (not included in meta-analysis); Wilson 1993; Yukna 1993b; Baab 1989). Rotation oscillation: (Barnes 1993; Cronin 1998; Dentino unpublished; Heasman 1999; Ainamo 1997; Clerehugh 1998; Stoltze 1994; van der Weijden 1994; Warren 2001; Yankell 1997; Lazarescu unpublished). Circular: (Khocht 1992; McAllan 1976; Yankell 1996). Ultrasonic: (Forgas-B 1998; Terezhalmay 1995a) and unknown (Emling 1991; Soparkar 1964).

CHARACTERISTICS OF OUTCOME MEASURES

Twenty-six trials (1787 participants at the end of the trial) reported plaque at 1 to 3 months and 10 trials (796 participants at the end of the trial) at longer than 3 months. Twenty-nine (2307 participants at the end of the trial) reported gingivitis at 1 to 3 months and 10 (796 participants at the end of the trial) at greater than 3 months.

Sixteen trials recorded whole mouth scores for plaque and gingivitis; seven trials recorded part mouth scores for both variables. One trial recorded part mouth scores for plaque and whole mouth scores for gingivitis and four trials recorded whole mouth scores for plaque and part mouth scores for gingivitis.

METHODOLOGICAL QUALITY

The agreement between the reviewers was generally good with kappa values for adequacy of allocation concealment 0.49, adequate outcome assessor blinding 0.72, adequacy of reporting and handling of attrition 0.70 and mention of manufacturer funding 1.00.

SELECTION BIAS

The generation of randomisation sequence was adequate for two (6.9%) of the 29 trials, and unclear for 27 trials (93.1%). The concealment of allocation was adequate for 10 trials (34.5%), unclear for 17 (58.6%) and inadequate for two (6.9%).

DETECTION BIAS

The outcome assessor was adequately blinded in 26 trials (89.7%). The adequacy of blinding was unclear in two trials (6.9%). Blinding was not reported in one trial (3.4%).

ATTRITION BIAS

Withdrawals were adequately reported in 22 trials (76%) and inadequately reported in seven (24%).

The reported drop out rate was 9.4%. Trials with follow up of less than 3 months had a drop out rate of 5.3%. Trials with follow up of greater than 3 months had a drop out rate of 13.2%.

SPONSORSHIP

Funding by a manufacturer of one of the brushes under investigation was stated in 22 (76%) of the trials and unclear in seven (24%).

RESULTS

As mentioned earlier in the data synthesis section of the methods of the review, the differences in plaque and gingivitis reduction between the powered and manual brushes were expressed as standardised mean differences (SMDs) for both short term and long term studies. Significant differences in SMDs are reported below. To improve the appreciation of clinical significance, SMDs have also been converted to equivalent values in commonly used plaque and gingivitis indices.

SIDE TO SIDE POWERED TOOTHBRUSHES ('Comparison 01' 'Outcomes 01-04')

There were six trials comparing side to side powered brushes included in the meta-analysis for 1 to 3 month plaque, eight for 1 to 3 month gingivitis and only two trials included in both the meta-analyses for measures after 3 months. There was no statistically significant difference between powered toothbrushes whose action was side to side and manual brushes with regard to the removal of plaque or reduction of gingivitis for both time periods.

COUNTER OSCILLATION POWERED TOOTHBRUSHES VERSUS MANUAL ('Comparison 02' 'Outcomes 01-04')

There were four trials included in the meta-analysis for 1 to 3 month plaque, four for 1 to 3 month gingivitis and only two trials included in both the meta-analyses for measures after 3 months. There was no evidence that powered toothbrushes whose action was counter oscillation were more effective than manual brushes for the removal of plaque or reduction of gingivitis with the exception of being associated with less plaque in the long term, where the SMD was -0.63 (95% confidence interval (CI): -1.11, -0.14).

ROTATIONAL OSCILLATION POWERED TOOTHBRUSHES VERSUS MANUAL ('Comparison 03' 'Outcomes 01-04')

This comparison contained the greatest number of trials, with 10 trials included in both the meta-analyses for early plaque and gingivitis, and four trials included in the long term comparisons. Brushes that worked with a rotation oscillation action removed more plaque and reduced gingivitis more effectively than manual brushes in both the short and long term. For plaque at 1 to 3 months the SMD was -0.44 (95% CI: -0.66, -0.21), for gingivitis SMD -0.45 (95% CI: -0.76, -0.15). These differences converted to a reduction of 0.20 or 11% on the Quigley Hein plaque index and a reduction of 0.09 or 6% on the Löe and Silness gingival index. At over 3 months the effects were SMD for plaque -1.15 (95% CI: -2.02, -0.29) and SMD for gingivitis -0.51 (-0.76, -0.25). These differences converted to a reduction of 0.5 or 7% for the Quigley Hein plaque index

and a 0.04 or 17% reduction on the Ainamo Bay bleeding on probing index. There was considerable heterogeneity between the trials in the meta-analyses for the short term follow up, which is reported later in this section.

CIRCULAR POWERED TOOTHBRUSHES VERSUS MANUAL ('Comparison 04' 'Outcomes 01-04')

Three trials were included in both these analyses for early plaque and gingivitis evaluation, and only one trial in each of the meta-analyses for longer follow up. There was no evidence that brushes with a circular action removed plaque or reduced gingivitis more effectively than manual brushes in either time period.

ULTRASONIC TOOTHBRUSHES VERSUS MANUAL ('Comparison 05' 'Outcomes 01-02')

There were only two trials for each of the meta-analyses for the short term assessments of plaque and gingivitis, and one trial in both long term meta-analyses. The short term comparison between ultrasonic and manual brushes reached borderline statistical significance for plaque removal with SMD -0.45 (-0.90, 0.00). No other statistically significant differences were noted between manual and ultrasonic brushes.

INVESTIGATION OF HETEROGENEITY

The heterogeneity in the short term meta-analyses comparing rotation oscillation powered and manual brushing for both plaque and gingivitis was caused by one study with exceptionally low standard deviations for all indices (Stoltze 1994).

SENSITIVITY ANALYSES

Sensitivity analyses were conducted for trials: where a full mouth index had been used, where adequate concealment of randomisation occurred, where there was adequate generation of randomisation sequence, with blinding of the outcome assessor, mentioning no commercial funding, with adequate information about attrition, with comparable brushing instruction given to all groups and for trials that were not restricted to participants only wearing fixed orthodontic appliances. These analyses were limited to the meta-analyses for rotational oscillation powered toothbrushes versus manual ('Comparison 03' 'Outcomes 01 and 02') which showed significant effects and contained the greatest number of trials. The revised meta-analyses yielded similar effect estimates to the overall estimates, indicating that the results are robust and not distorted by the lesser quality trials. ('Additional Table 05').

PUBLICATION BIAS

Publication bias was assessed for the meta-analyses for rotational oscillation powered toothbrushes versus manual for the 1 to 3 month assessments. The funnel plots for each appeared symmetric with no evidence of bias for either plaque or gingivitis using the Egger (weighted regression) method ($p = 0.78, 0.52$ respectively), or using the Begg (rank correlation) method ($p = 0.72, 0.41$).

SECONDARY OUTCOMES

Cost

None of the included trials reported on the relative costs of manual compared with powered toothbrushes.

Reliability

One trial reported a mechanical failure of one of the 48 powered toothbrushes used (Clerehugh 1998) and one trial reported mechanical failure in four of 20 powered brushes (Yukna 1993b). No other mechanical failures were reported.

Calculus

Three trials (Dentino unpublished; Glass 1965; van der Weijden 1994) reported on calculus, two reporting that there was no significant difference between the brush types (van der Weijden 1994; Glass 1965) and one reporting that, compared to the manual brush, the powered brush group showed a significant favourable difference in the accumulation of calculus at 6 months $p = 0.0078$ (Dentino unpublished).

Stain

Three trials reported that there was no difference in the degree of staining on the teeth between the brush types (Dentino unpublished; Glass 1965; Walsh 1989).

Soft tissue trauma

Eighteen trials reported on soft tissue side effects. Ten trials reported no soft tissue side effects for any of the brush types under investigation. Five trials reported no difference in soft tissue effects between the brush types. Three trials reported a difference in soft tissue trauma between the brushes used. Of these one reported five cases of gingival abrasion in the manual and one case of abrasion in the powered group (Tritten 1996), another reported 12 cases of gingival abrasion in the manual and five cases of gingival abrasion in the powered group (van der Weijden 1994). One trial reported seven soft tissue abnormalities in six participants in the manual group and 10 abnormalities in seven participants in the powered group (Johnson 1994).

DISCUSSION

We brush our teeth for many reasons: to feel fresh and confident; to have a nice smile; to avoid bad breath and to avoid disease. The selection of one's toothbrush is largely a matter of personal preference, affordability, availability and professional recommendation. Powered toothbrushes may have a particular appeal to some because they represent a newer 'high tech' solution to an everyday task.

This systematic review has found that powered toothbrushes with a rotation oscillation action removed plaque and reduced gingivitis more than manual brushes in both the long and short term. Other forms of powered brushes produced a less consistent reduction of plaque and gingivitis.

Few data were reported on the costs or reliability of the brushes or the side effects of their use. When reported, injuries to the gums were minor and transient. Randomised controlled trials

may not be the best research design for investigating these adverse outcomes. Expert groups have suggested that powered toothbrushes are safe if used correctly but further research is required in these areas (Lang 1998).

There is overwhelming evidence that toothbrushing reduces gingivitis (Lang 1973). It may prevent periodontitis and certainly prevents tooth decay if carried out in conjunction with fluoride toothpaste. These benefits occur whether the brush is manual or powered and the results of this review do not indicate that toothbrushing is only worthwhile with a powered toothbrush.

As mentioned in the results section, standardised mean differences (SMDs) may be converted to the corresponding values of particular clinical indices. The plaque scores in short term trials of rotation oscillation brushes was -0.44 . Using this level of effectiveness as an example, in the trial by Cronin (Cronin 1998) a similar standardised mean difference (-0.45) corresponded to a mean difference in the Turesky modification of the Quigley Hein index of 0.27 . The mean plaque score among those using manual brushes in the trial by Cronin was 2.55 and thus the difference is 11% .

For gingival scores the SMD in short term trials of rotation oscillation brushes was -0.45 . Again, using this level of effectiveness, in the trial by Heasman (Heasman 1999) the SMD of -0.42 corresponded to a mean difference in the Löe and Sillness gingival index of 0.09 . The mean gingival index score for those using manual brushes in the trial was 1.64 and thus the difference is 6% .

The same approach can be used to assess the effect of rotation oscillation powered toothbrushes on long term reductions in plaque and gingivitis, and indicates benefits of 7% and 17% respectively. Had a weighted mean difference method been used for pooling the data rather than a standardised mean difference, similar results and conclusions would have been reached.

This raises the question, what level of plaque removal and reduction in gingivitis will result in clinically significant improvements in oral health?

The results of the review can be related to destructive periodontal disease (periodontitis) only with some difficulty. Some authorities have advocated the use of arbitrary thresholds to make superiority claims for a specific product. For example, Imrey has proposed that a product cannot be claimed to be superior unless it provides a 20% improvement in performance (not the case for any types of brush in this review, in terms of long term plaque removal) (Imrey 1992; Imrey 1994). However, other authors have criticised the use of arbitrary thresholds and prefer a threshold for clinical significance to be decided in advance and selected on clinical grounds (D'Agostino 1992).

Many factors are associated with the occurrence of periodontitis including plaque, tobacco use and individual medical factors. Periodontitis takes many years to develop and the trials have

much shorter follow up. The evidence that plaque and gingivitis are reliable proxies for long term destructive disease is not compelling and it is difficult to estimate a clinical threshold for significant plaque reduction. We conclude that rotation oscillation brushes provide reductions for plaque removal but the clinical significance of these reductions cannot be assessed.

The apparent significant long term effects of counter oscillational brushes on plaque may be a spurious finding. It was the only outcome associated with the use of these brushes out of four studied.

One possible weakness of this review was the grouping of toothbrushes by their modes of action. Whilst this approach allowed more powerful meta-analysis it is possible that toothbrushes whose actions had subtle differences were more or less effective. Similarly, so many factors may influence the effectiveness of toothbrushes including filament arrangement, orientation, size, shape and flexibility, brush head size and shape along with presence or absence and characteristics of a timer, that not all of them could be isolated and analysed. Whether the brush has a battery or rechargeable power source may also be important.

Publication bias seems likely to be present in the reporting of these trials as manufacturers would like to have scientific support for the effectiveness of their powered toothbrushes. However there was no evidence of this when publication bias was examined statistically, and no evidence of a difference in effect estimates when a sensitivity analysis was conducted for trials which did not mention commercial funding. It should be noted that the methods for detecting publication bias are relating effect size to sample size, and in this review the trials tend to be of similar size. Therefore other methods may be required to examine publication bias in short term, low cost studies.

Five eligible cross-over trials had to be excluded from the review as the data presented did not include the standard deviation of the paired differences, or alternative statistics which would enable this value to be estimated (Elbourne 2002). Attempts were made to contact all the trialists however they were unable to supply the necessary data. It is important that trialists analyse the data from cross-over trials appropriately and present relevant data in reports of trials.

REVIEWER'S CONCLUSIONS

Implications for practice

This review has found that compared with manual toothbrushes, powered toothbrushes whose action is rotation oscillational reduce plaque and gingivitis by 7 and 17% respectively at greater than 3 months. The clinical significance of these reductions is not known.

The trials available for the review were too short term to demonstrate whether these effects achieve a reduction in destructive periodontal disease.

Individuals who prefer the 'feel' of using a powered toothbrush can be assured that powered toothbrushing is at least as effective as manual brushing and that there is no evidence that it will cause any more injuries to the gums than manual brushing.

As none of the trials we found compared the durability, reliability and cost of using manual versus powered brushes, it is presently not possible to make a clear recommendation on toothbrush superiority.

Implications for research

Trials of longer duration are required to fully evaluate powered toothbrushes. There are few adequate trials reporting over more than 3 months. Data on the long term benefits of powered toothbrushes would be valuable in their own right and could be used to trial other outcomes such as the adverse effects and benefits in the prevention of periodontitis and dental caries. Moreover, more trials would lend greater power to systematic reviews of the effectiveness of powered toothbrushes.

The review revealed many idiosyncrasies in the design of the trials, in some cases data could not be included in this review. Whilst many of the trials were conducted before the current emphasis on experimental design, even the most recent trials lacked power calculations and had not been analysed on an intention to treat basis. Researchers in this field would be advised to study guidance on the design and reporting of clinical trials such as that provided in the CONSORT statement (<http://www.consort-statement.org/>).

Specific guidance exists for trials in the treatment or prevention of periodontal diseases (Imrey 1994) but greater standardisation of both the follow-up intervals and the indices used would benefit both trials and future meta-analyses. Thought should also be given to when the mouth should be examined in relation to when the teeth were last cleaned.

Some research designs created an artificial research environment that may have undermined the generalisability of the findings. In particular the external validity was questionable in trials with split mouth designs where participants are asked to clean each side of their mouth with a different brush, in trials where interventions were used in combination and those where toothbrushing was supervised. Hence their exclusion from this meta-analysis.

More research with improved rigour is also needed on the relative benefits of powered and manual toothbrushes to prevent or remove extrinsic staining of the teeth and calculus.

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brush heads rotate in one direction and then the other) is better than manual toothbrushes at removing plaque and reducing gum inflammation, and is no more likely to cause injuries to gums. Long term benefits of this for dental health are unclear.

POTENTIAL CONFLICT OF INTEREST

Bill Shaw and Helen Worthington were co-researchers on a randomised controlled trial sponsored by Braun AG (Clerehugh 1998) through a grant to the University of Manchester. Damien Walmsley was a consultant and undertook laboratory trials of powered toothbrushes sponsored by Braun AG through a grant to the University of Birmingham.

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SYNOPSIS

Powered toothbrushes with a rotation oscillation action provide slightly better plaque removal and may provide better protection against gum inflammation than manual toothbrushes

Removing dental plaque by toothbrushing with a fluoride toothpaste helps prevent gum inflammation (gingivitis) and tooth decay. The latter may be largely due to the fluoride. Powered toothbrushes simulate manual toothbrushing in different ways (such as moving side to side or circular motions). The review of trials found that only rotation oscillation (where

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* Indicates the major publication for the study

TABLES

Characteristics of included studies

| Study | Ainamo 1997 |
|------------------------|--|
| Methods | RCT, parallel, single blind, 12 months, n 112 with 1 drop out. |
| Participants | Finland, adults, 20-63 years, 64M:47F, bleeding on probing > 30% sites, no medical problems. |
| Interventions | Braun Oral B Plak Control versus Jordan soft, 2 mins twice daily. |
| Outcomes | Ainamo and Bay Visible Plaque Index and modified gingival bleeding index. 3, 6 and 12 months. Whole mouth recording PI and GI. |
| Notes | No pre-examination instructions reported. |
| Allocation concealment | B |

| Study | Baab 1989 |
|------------------------|---|
| Methods | RCT, parallel, single blind, 1 month, n 41, with 1 drop out. |
| Participants | USA, adults, 18-59 years, 24M 16F, > 20 teeth with moderate gingivitis, no medical problems. |
| Interventions | Interplak versus Butler 411, 3 mins twice daily. |
| Outcomes | O'Leary plaque index, Löe and Silness gingival index, Ainamo and Bay gingival bleeding index. Ramfjord teeth for GI, whole mouth for PI. Gingival abrasion reported to be not significant. Plaque scores awaiting assessment. |
| Notes | Manufacturer funded. No pre-examination instructions reported. |
| Allocation concealment | B |

| Study | Barnes 1993 |
|------------------------|---|
| Methods | RCT, parallel, single blind, 3 months, n 70 with 1 drop out. |
| Participants | USA, adults, 18-65 years, > 20 teeth, gingival index > 1.5, plaque index > 2. |
| Interventions | Braun Oral B Plaque Remover versus Johnson & Johnson Reach, as per normal use. |
| Outcomes | Quigley and Hein (Turesky) Plaque Index, Löe and Silness (Lobene) gingival index at full mouth sites. Soft tissue trauma, no difference between brushes. Whole mouth recording PI and GI. |
| Notes | Manufacturer funded. No pre-examination instructions reported. |
| Allocation concealment | B |

| Study | Clerehugh 1998 |
|--------------|---|
| Methods | RCT, parallel, single blind, 8 weeks, n 84 with 5 drop outs. |
| Participants | UK, children and adolescents, 10-20 years, orthodontic patients in practice, fixed appliances, gingival bleeding at 30% sites, no medical conditions. |

Characteristics of included studies

| | |
|------------------------|--|
| Interventions | Braun Plaque Remover with OD 5 head versus Reach medium compact head, 2 mins twice daily. |
| Outcomes | Orthodontic modification of Silness and Loe plaque index, Eastman bleeding index at all buccal sites at 4,8 weeks. No evidence of trauma. One mechanical brush failed. |
| Notes | Manufacturer funded. Participants asked to brush in the morning and under supervision prior to assessment. |
| Allocation concealment | A |

| | |
|------------------------|--|
| Study | Cronin 1998 |
| Methods | RCT, parallel, single blind, 3 months, n 114, 9 drop outs unclear. |
| Participants | USA, adults, > 18 teeth, no medical problems, 18-65 years. |
| Interventions | Braun Oral B 3D Plaque remover versus standard ADA reference manual, 2 mins twice daily. |
| Outcomes | Quigley and Hein (Turesky) plaque index, Loe and Silness gingivitis and bleeding index, at 14, 35 and 90 days, at all sites. Gingival recession recorded, no change seen. No other adverse effects. Whole mouth recording PI and GI. |
| Notes | Manufacturer funded. Participants asked to refrain from brushing 12-14 hours prior to assessment. |
| Allocation concealment | A |

| | |
|------------------------|---|
| Study | Dentino unpublished |
| Methods | RCT, parallel, single blind, 6 months, n 172 with 15 drop outs. |
| Participants | USA, adults, mild to moderate gingivitis with > 20 teeth, no previous powered brush experience. Excluded if pregnant/lactating. |
| Interventions | Braun Oral B D9 vs ADA accepted standard soft bristle manual, 2 mins twice daily. |
| Outcomes | Quigley and Hein (Turesky) Plaque index and Lobene gingival index at 3 and 6 months. Powered brush removed more calculus. No difference in stain removal reported. PI and GI whole mouth. |
| Notes | Manufacturer funded. Participants asked to brush teeth (non-supervised) immediately prior to 6 month plaque assessment. |
| Allocation concealment | A |

| | |
|---------------|---|
| Study | Emling 1991 |
| Methods | RCT, parallel, single blind, 30 days, n 60 with 3 drop outs. |
| Participants | USA, adults, no medical problems, no current ortho, not pregnant, > 17 teeth, 18 to 60 years. |
| Interventions | Plak trac versus Colgate ADA approved, twice daily. |
| Outcomes | Quigley Hein (Turesky) Plaque index. Yankell, interproximal plaque index, Loe and Sillness gingival index. Ramfjord teeth for both PI and GI. |

Characteristics of included studies

| | |
|------------------------|--|
| Notes | Pre-brushing measurements used. |
| Allocation concealment | B |
| Study | Forgas-B 1998 |
| Methods | RCT, parallel, single blind, 30 days, n 62 with 6 drop outs. |
| Participants | USA, adults, mean age 37 years +/- 10 years, > 16 teeth, plaque index > 2, no medical problems, 21M: 35F. |
| Interventions | Ultrasonex versus manual Oral B, twice daily. |
| Outcomes | Quigley and Hein (Turesky) Plaque index, Eastman gingival bleeding index at 30 days. Ramfjord teeth for PI and GI. Soft tissue trauma reported, no difference between groups. |
| Notes | Manufacturer funded. Participants asked to refrain from brushing for 12-14 hours before assessment. |
| Allocation concealment | B |
| Study | Glass 1965 |
| Methods | RCT, parallel, single blind, 11 months, n 250 with 84 drop outs. |
| Participants | USA, dental students, male, 20-29 years. |
| Interventions | GEC powered versus Pycopay brand manual twice daily. |
| Outcomes | Glass debris and gingival indices at 6 weeks, 7 and 11 months at all sites. Stain and calculus reported to be no different between brush types. Whole mouth recording PI and GI. No soft tissue trauma reported. |
| Notes | Manufacturer funded. No pre-examination instructions reported. |
| Allocation concealment | B |
| Study | Heasman 1999 |
| Methods | RCT, parallel, single blind, 6 weeks, n 75 with 1 drop out. |
| Participants | UK, adult, > permanent 20 teeth, 18-25 years, no medical problems. |
| Interventions | Braun Oral B D7 versus Philips Jordan HP 735 versus Oral B Advantage B35, > 90 secs twice daily. |
| Outcomes | Quigley and Hein (Turesky) plaque index at 24 hours and 6 weeks, Löe and Silness gingival index at 6 weeks, all sites. Whole mouth recording PI and GI. |
| Notes | Assessment done within 3-4 hours of last brushing. Two powered groups combined for meta-analysis. |
| Allocation concealment | B |
| Study | Ho 1997 |
| Methods | RCT, parallel, single blind, 4 weeks, n 24, drop outs unclear. |

Characteristics of included studies

| | |
|------------------------|--|
| Participants | USA, orthodontic patients, with fixed appliances, 11-18 years, gingival index > 2, no medical conditions. |
| Interventions | Sonicare ultrasonic versus Oral B P35, 2 mins twice daily. |
| Outcomes | Silness and Loe gingival and plaque indices on 6 sites per bonded tooth and bleeding on probing all at 4 weeks. Whole mouth recording PI and GI. |
| Notes | Manufacturer funded. No pre-examination instructions reported. |
| Allocation concealment | A |

| | |
|------------------------|--|
| Study | Johnson 1994 |
| Methods | RCT, parallel, single blind, 4 weeks, n 51 with 8 drop outs. |
| Participants | USA, adult, > 20 teeth, gingival index > 1.5 on Ramjford teeth, no medical conditions, 20-54 years. |
| Interventions | Philips sonicare versus Oral B 30, 2 mins twice daily. |
| Outcomes | Quigley and Hein (Turesky) on all sites, Ainamo and Bay gingival index and sulcular bleeding indices on Ramjford at 1, 2, 4 weeks. Soft tissue trauma "abnormalities" 7 sites in 6 subjects for manual and 10 sites in 7 subjects for powered. |
| Notes | Manufacturer funded. Post brushing evaluation. |
| Allocation concealment | B |

| | |
|------------------------|--|
| Study | Khocht 1992 |
| Methods | RCT, parallel, single blind, 4 weeks, n 96 with 1 drop out. |
| Participants | USA, adults, > 15 teeth with no restorations affecting cervical region plaque score > 1.8 and gingival score > 0.9, no medical conditions. |
| Interventions | Epident versus Oral B 40, twice daily. |
| Outcomes | Quigley and Hein (Turesky) Plaque index and Loe and Silness gingivitis index at all sites at 28 days. Whole mouth recording for PI and GI. No reported soft tissue abrasion. |
| Notes | Manufacturer funded. Pre-brushing evaluation. Epident group (experimental brush) excluded from meta-analysis (n=32). |
| Allocation concealment | B |

| | |
|---------------|--|
| Study | Lazarescu unpublsh |
| Methods | RCT, parallel, single blind, 18 weeks, n 80 with 2 drop outs. |
| Participants | Romania, adults, > 20 teeth, medically fit and no previous powered brush experience. |
| Interventions | Philips/Jordan HP 735 versus Oral B 40 manual with normal brushing pattern. |
| Outcomes | Quigley and Hein (Turesky) Plaque index at 6 sites per tooth and gingival bleeding index at proximal smooth surfaces at 18 weeks. Whole mouth recording PI and GI. |

Characteristics of included studies

| | |
|------------------------|---|
| Notes | Manufacturer funded. Assumed pre-brushing evaluation. |
| Allocation concealment | A |
| Study | Lobene 1964a |
| Methods | RCT, parallel, single blind, n 185, 3 months, drop outs unclear. |
| Participants | USA, female college students, aged 17-21 years. |
| Interventions | General electric reciprocating action versus Oral B 40 manual with no instruction. |
| Outcomes | Lobene Gingivitis index at 3 months. Whole mouth recording PI and GI. |
| Notes | Manufacturer funded. No pre-examination instructions reported. |
| Allocation concealment | A |
| Study | McAllan 1976 |
| Methods | RCT, parallel, no blinding, 6 months, n 55 with 15 drop outs. |
| Participants | UK, children and adolescents attending paediatric department, 9-15 years, 24M 31F. |
| Interventions | Touchtronic Teledyne Aqua Tec versus Gibbs short head manual. |
| Outcomes | Silness and Löe plaque whole mouth and Löe and Silness gingival indices at first molars and lateral incisor teeth at 1, 2 and 6 months. |
| Notes | Manufacturer funded. No pre-examination instructions reported. |
| Allocation concealment | C |
| Study | O'Beirne 1996 |
| Methods | RCT, parallel, single blind, n 40, 8 weeks, drop outs unclear. |
| Participants | USA, adults with inflammatory periodontal disease, > 20 teeth and received periodontal treatment, 22M 18F, 18-65 years. |
| Interventions | Sonicare Ultrasonex versus Oral B manual 2 mins twice daily. |
| Outcomes | Löe and Silness gingival index, Barnett papillary bleeding index at 2, 4 and 8 weeks, at all sites. Whole mouth recording PI and GI. Minor gingival trauma seen in one participant in each group. |
| Notes | Part funded by manufacturer. |
| Allocation concealment | A |
| Study | Soparkar 1964 |
| Methods | RCT, parallel, single blinded, 11 weeks, n 270 with 32 drop outs. |
| Participants | USA, college students non-dental. |
| Interventions | Unknown action powered versus manual with normal regime. |
| Outcomes | Quigley and Hein gingival index at 11 weeks. Anterior teeth only. |

Characteristics of included studies

| | |
|------------------------|---|
| Notes | No pre-examination instructions reported. |
| Allocation concealment | B |

| | |
|------------------------|---|
| Study | Stabholz 1996 |
| Methods | RCT, parallel, single blinded, n 56 with 4 drop outs, 60 days. |
| Participants | Israel, general population, no medical conditions. |
| Interventions | Plaq and White A to Z technology versus Oral B 35 as per normal regime. |
| Outcomes | Quigley and Hein (Turesky) and Löe and Silness gingival and Eastman BOP indices on Ramfjord teeth at 15 and 30 days. No difference in soft tissue trauma between brush types. |
| Notes | Participants asked to refrain from brushing for 12 hours prior to each assessment. |
| Allocation concealment | B |

| | |
|------------------------|--|
| Study | Stoltze 1994 |
| Methods | RCT, parallel, unclear blinding method used, n 40 with 2 drop outs, 6 weeks. |
| Participants | Denmark, young adults 18-30 years, with plaque and gingival scores > 1, > 20 teeth, no medical problems. |
| Interventions | Braun Oral B Plak Control D5 versus Tandex 40 manual, 2 mins twice daily. |
| Outcomes | Silness and Löe plaque index, Löe and Silness gingival index at all sites, 1, 2 and 6 weeks. Whole mouth recording PI and GI. No gingival abrasion reported. |
| Notes | No pre-examination instructions reported. |
| Allocation concealment | B |

| | |
|------------------------|--|
| Study | Terezhalmay 1995a |
| Methods | RCT, parallel, single blind, 6 months, n 60 with 14 drop outs. |
| Participants | USA, adults, good health and free of oral pathology. |
| Interventions | Ultra-sonex ultrasonic versus Oral B manual 3 min twice daily. |
| Outcomes | Quigley and Hein (Turesky) plaque index and Löe and Silness gingival index at all sites and Eastman Bleeding on Probing index on contralateral Ramfjord teeth. Assessed at 15 and 30 days and 6 months. No soft tissue trauma. |
| Notes | Participants asked to refrain from brushing 12-14 hours prior to assessment. |
| Allocation concealment | B |

| | |
|---------------|---|
| Study | Tritten 1996 |
| Methods | RCT, parallel, single blind, 12 weeks, n 60 with 4 drop outs. |
| Participants | USA, adults 18-65 years, dental hospital patients, no professional cleaning previous 3 months, minimum 20 teeth, no previous periodontal treatment and unaware of active pregnancy. |
| Interventions | Sonicare versus Butler 311, 2 minutes twice daily. |

Characteristics of included studies

| | |
|------------------------|---|
| Outcomes | Quigley and Hein (Turesky) plaque index all teeth, Löe and Silness gingival index Ramfjord teeth. Gingival abrasion seen in five manual and one powered brush subjects. |
| Notes | Manufacturer funded. Pre-brushing evaluation. |
| Allocation concealment | A |

| | |
|------------------------|---|
| Study | Walsh 1989 |
| Methods | RCT, parallel, single blind, n 108, 6 months, drop outs unclear. |
| Participants | USA, adults from University and Dental clinics, 18-65 years, > 20 teeth, no dental/medical problems, gingival index > 1 on six+ sites of 18 sites probed on Ramfjord teeth. |
| Interventions | LPA/Broxo powered versus Oral B 40 manual, twice daily. |
| Outcomes | Silness and Löe plaque index on Ramfjord teeth, BOP on Ramfjord teeth at 3, 6 months. No soft tissue changes reported. Stain reported as no difference between brush types. |
| Notes | No pre-examination instructions reported. |
| Allocation concealment | C |

| | |
|------------------------|---|
| Study | Warren 2001 |
| Methods | RCT, parallel, single blind, 12 weeks, n 110 with 9 drop outs. |
| Participants | USA, adult volunteers, 18-65 years, > 18 teeth, plaque index > 1.8, non-smokers, with no medical problems. |
| Interventions | Braun Oral B D 17 versus ADA standard manual, 2 mins twice daily. |
| Outcomes | Quigley and Hein (Turesky) plaque index, Löe and Silness gingival index and modified Löe and Silness Bleeding index, on all sites at 1, 3 months. Whole mouth recording PI and GI. No soft tissue changes reported. |
| Notes | Manufacturer funded. Participants asked to refrain from brushing 12-18 hours prior to assessment. |
| Allocation concealment | A |

| | |
|------------------------|--|
| Study | Wilson 1993 |
| Methods | RCT, parallel, single blind, 12 months, n 32 with 3 drop outs. |
| Participants | USA, adults, 18+ years, minimum 20 teeth, at least 50% tooth surface plaque coverage (O'Leary), bleeding score > 0.75. Barnett-Muhleman Bleeding Index, no medical problems, no orthodontics, no untreated perio or pockets > 6mm. |
| Interventions | Interplak, Bausch and Lomb versus Butler 311, 3 minutes. |
| Outcomes | Quigley and Hein (Turesky) plaque index, Barnett Muhleman gingival index on all sites at 1, 2, 6, 9 and 12 months. Whole mouth recording PI and GI. No difference in gingival abrasion found between brush types. |
| Notes | Participants asked to brush one hour prior to assessment. |
| Allocation concealment | B |

Characteristics of included studies

| Study | Yankell 1996 |
|------------------------|--|
| Methods | RCT, parallel, single blind, 4 weeks, n 66 with 1 drop out. |
| Participants | USA, children with 4 of 6 Ramfjord teeth present, no medical problems. |
| Interventions | Rowenta Dentiphant versus Oral B 20, 1 min twice daily. |
| Outcomes | Quigley and Hein (Turesky) plaque and Löe and Silness (Lobene) gingival indices on Ramfjord teeth at 2 and 4 weeks. No soft tissue changes reported. |
| Notes | Manufacturer funded. Pre-brushing evaluation. |
| Allocation concealment | B |

| Study | Yankell 1997 |
|------------------------|---|
| Methods | RCT, parallel, single blind, 30 days, n 128 with 13 drop outs. |
| Participants | USA, adults, 18-50 years, > 18 teeth, no current orthodontic bands, no medical problems. |
| Interventions | Rowenta Plaque Dentacontrol Plus versus Sonicare versus Braun Oral B Ultra versus Oral B P35, 2 min twice daily excluded. Rowenta data which was 5 min twice daily. |
| Outcomes | Quigley and Hein (Turesky) plaque and Eastman bleeding indices on Ramfjord teeth and also Löe and Silness (Lobene) gingival index on whole mouth at 4 weeks. No soft tissue changes reported. |
| Notes | Rowenta data excluded due to extended brushing period. Participants asked to refrain from brushing 10-16 hours prior to evaluation. |
| Allocation concealment | B |

| Study | Yukna 1993b |
|------------------------|--|
| Methods | RCT, parallel, single blind, 6 months, n 42 with 2 drop outs. |
| Participants | USA, adults with past periodontal surgical treatment. Excluded if on antibiotics/NSAIDS or orthodontic appliances. |
| Interventions | Interplak, Bausch and Lomb versus unspecified manual brush. |
| Outcomes | Quigley and Hein and O'Leary plaque indices, Lobene gingival index and Bleeding on probing. Whole mouth recording PI and GI. 4 of 20 powered brushes had mechanical failure. |
| Notes | Manufacturer funded. |
| Allocation concealment | B |

| Study | van der Weijden 1994 |
|---------------|--|
| Methods | RCT, parallel, single blind, 8 months, n 87 with 10 drop outs. |
| Participants | Netherlands, non-dental students, bleeding on probing at least 35% of sites and modified gingival index of at least 1, no previous experience of electric toothbrush. Healthy. No ortho. No pockets > 5mm. |
| Interventions | Braun Plak control versus Butler Gum 311 for 2 mins. |

Characteristics of included studies

| | |
|------------------------|--|
| Outcomes | Silness and Löe plaque index, Lobene gingival index at all sites at 1, 2, 5, 8 mths. Whole mouth recording PI and GI. Twelve manual brush subjects and five powered brush subjects with gingival abrasion. Calculus scored no difference in change between groups. |
| Notes | Participants asked to brush thoroughly, but not within one hour of assessment. |
| Allocation concealment | B |

Characteristics of excluded studies

| Study | Reason for exclusion |
|----------------|---|
| Aass 2000 | Less than 28 days |
| Ainamo 1991 | Contacted authors for more information, no reply after 3 months |
| Albers 1988 | Less than 28 days |
| Anaise 1976 | Less than 28 days |
| Andreana 1998 | No movement of powered head |
| Arceneaux 1996 | Less than 28 days |
| Ash 1964 | Not RCT |
| Ash 1967 | Contacted authors for more information, no reply after 3 months |
| Bastos 1995 | Not powered versus manual toothbrushing |
| Borutta 1997 | Less than 28 days |
| Boyd 1989a | Not RCT |
| Boyd 1989b | Not RCT |
| Boyd 1997 | Less than 28 days |
| Braccini 1964 | Not powered versus manual toothbrushing |
| Bratel 1991 | Potential high for compromised self toothbrushing efficacy |
| Buchmann 1987 | Less than 28 days |
| Burch 1994 | Combined intervention |
| Chaikin 1965 | Less than 28 days |
| Chasens 1968 | Not RCT |
| Chilton 1962 | Split mouth |
| Ciancio 1990 | Less than 28 days |
| Ciancio 1998 | Contacted authors for more information, no reply after 3 months |
| Cohen 1964 | Potential high for compromised self toothbrushing efficacy |
| Conroy 1965 | Less than 28 days |
| Conroy 1966 | Less than 28 days |
| Coontz 1983 | Less than 28 days |

Characteristics of excluded studies

| | |
|------------------|---|
| Coontz 1985 | Less than 28 days |
| Crawford 1975 | Not RCT |
| Cronin 1996 | Not powered versus manual toothbrushing |
| Cross 1962b | Less than 28 days |
| Danser 1998 | Less than 28 days |
| Danser 2000 | Less than 28 days |
| Derbyshire 1964 | Less than 28 days |
| Doherty 1998 | Not powered versus manual toothbrushing |
| Doherty 1999 | Less than 28 days |
| Doll 1999 | Less than 28 days |
| Dorfer 2001 | Less than 28 days |
| Dunkin 1975 | Less than 28 days |
| Elliott 1963 | Less than 28 days |
| Fourel 1974 | Split mouth |
| Fraleigh 1965 | Split mouth |
| Galgut 1996 | No mechanical action of brush head |
| Glavind 1986 | Not RCT |
| Golden 1964 | Not powered versus manual toothbrushing |
| Goldman 1975 | Less than 28 days |
| Grossman 1994 | Less than 28 days |
| Grossman 1996 | Less than 28 days |
| Grossman 1997 | Not powered versus manual toothbrushing |
| Haffajee 2001a | Contacted authors for more information, no reply after 3 months |
| Haffajee 2001b | Outcomes not under consideration |
| Hall 1971 | Potential high for compromised self toothbrushing efficacy |
| Hansen 1999 | Laboratory study |
| Heasman 1998 | Not RCT inadequate control |
| Hefti 2000 | Not powered versus manual toothbrushing |
| Heintze 1996 | Combined intervention |
| Hellstadius 1993 | Not powered versus manual toothbrushing |
| Hirsch 1965 | Laboratory study |
| Hoover 1962 | Less than 28 days |
| Horowitz 1992 | Not RCT |
| Hotta 1992 | Less than 28 days |

Characteristics of excluded studies

| | |
|---------------------|---|
| Howorko 1993 | Less than 28 days |
| Isaacs 1999 | Contacted authors for more information, no reply after 3 months |
| Jackson 1991 | Not RCT |
| Jongenelis 1997 | Less than 28 days |
| Kambhu 1993 | Potential high for compromised self toothbrushing efficacy |
| Kaschny 1999 | Not RCT |
| Killoy 1989 | Contacted authors for more information, no reply after 3 months |
| Killoy 1993 | Contacted authors for more information, no reply after 3 months |
| Lamendola-Site 1998 | No mechanical action of brush head |
| Lange 1978 | Less than 28 days |
| Leftkowitz 1962 | Less than 28 days |
| Lim 1995 | Contacted authors for more information, no reply after 3 months |
| Long 1985 | Split mouth |
| Love 1988 | Contacted authors for more information, no reply after 3 months |
| Love 1993 | Combined intervention |
| Lundergan 1988 | Less than 28 days |
| Manhold 1965 | Outcomes not under consideration |
| Mantokoudis 2001 | Less than 28 days |
| Mayer 1978 | Less than 28 days |
| Mayer 1988 | Split mouth |
| McCracken 2000 | Not powered versus manual toothbrushing |
| McInnes 1994 | Outcomes not under consideration |
| McKendrick 1968 | Not RCT |
| Moran 1995 | Less than 28 days |
| Moran 1995b | Less than 28 days |
| Morris 1997 | Contacted authors for more information, no reply after 3 months |
| Moschen 1999 | Less than 28 days |
| Murray 1989 | Outcomes not under consideration |
| Niemi 1986 | Less than 28 days |
| Niemi 1987 | Less than 28 days |
| Niemi 1988 | Less than 28 days |
| Owen 1972 | Cross-over study, contacted authors for more information, no reply after 3 months |
| Park 1997 | Not teeth (e.g. implants, enamel sections on dentures) |
| Plagmann 1978 | Not human |

Characteristics of excluded studies

| | |
|--------------------|---|
| Powers 1967 | Less than 28 days |
| Preber 1991 | Less than 28 days |
| Priestland 1993 | Not powered versus manual toothbrushing |
| Quigley 1962 | Less than 28 days |
| Quirynen 1994 | Split mouth |
| Rapley 1994 | Laboratory study |
| Rashid 1998 | Less than 28 days |
| Renton-Harper 2001 | Less than 28 days |
| Reynolds 1998 | Not powered versus manual toothbrushing |
| Ruhlman 2001 | Less than 28 days |
| Sato 1995 | Less than 28 days |
| Schifter 1983 | Less than 28 days |
| Schmage 1999 | Supervised or professional cleaning |
| Schuler 1996 | Abstract only |
| Schwarz 1990 | Not powered versus manual toothbrushing |
| Sgan-Cohen 1995 | Not powered versus manual toothbrushing |
| Shaw 1983 | Potential high for compromised self toothbrushing efficacy |
| Silverstone 1992 | Contacted authors for more information, no reply after 3 months |
| Sjogren 1998 | Less than 28 days |
| Smith 1964 | Cross-over study, contacted authors for more information, no reply after 3 months |
| Stadtler 1984 | Less than 28 days |
| Swenson 1967 | No mechanical action of brushhead |
| Taylor 1995 | Less than 28 days |
| Tenenbaum 1984 | Less than 28 days |
| Terezhalmly 1994 | Not RCT |
| Thienpont 2001 | Cross-over study, contacted authors for more information, no reply after 3 months |
| Timmerman 1995 | Less than 28 days |
| Toto 1961 | Not RCT |
| Toto 1967 | Outcomes not under consideration |
| Trimpeeneers 1996 | Duplicate abstract of included study |
| Trimpeeneers 1997 | Cross-over study, contacted authors for more information, no reply after 3 months |
| Trombeli 1995 | Less than 28 days |
| Twetman 1997 | Not powered versus manual toothbrushing |
| Vervliet 1989 | Split mouth |

Characteristics of excluded studies

| | |
|----------------------|---|
| Walsh 1984 | Less than 28 days |
| Warren 2000 | Not powered versus manual toothbrushing |
| White 1996 | Not RCT |
| Whitmyer 1998 | Potential high for compromised self toothbrushing efficacy |
| Wiedemann 2001 | Split mouth |
| Wilcoxon 1991 | Cross-over study, contacted authors for more information, no reply after 3 months |
| Willershausen 2001 | Not RCT |
| Wilson 1991 | Contacted authors for more information, no reply after 3 months |
| Womack 1968 | Not RCT |
| Ximenez-Fyvie 2000 | Supervised or professional cleaning |
| Yankell 1985 | Not RCT |
| Yankell 1994 | Less than 28 days |
| Youngblood 1985 | Laboratory study |
| Yukna 1993a | Combined intervention |
| Zimmer 1999 | Less than 28 days |
| van Venrooy 1985 | Less than 28 days |
| van der Weij 1993b | Not powered versus manual toothbrushing |
| van der Weijden 1993 | Supervised brushing |
| van der Weijden 1995 | Not powered versus manual toothbrushing |
| van der Weijden 1996 | Less than 28 days |
| van der Weijden 1998 | Split mouth study |
| van der Weijden 2001 | Not powered versus manual toothbrushing |

ADDITIONAL TABLES

Table 01 Summary of characteristics of excluded studies

| Reason for exclusion | Number (n=159) |
|--|----------------|
| Less than 28 days | 60 |
| Not powered versus manual | 18 |
| Not RCT | 17 |
| Author contacted for more information, no reply after 3 months | 12 |
| Split mouth | 9 |
| Duplicate abstract or study | 8 |
| Potential high for compromised tooth brushing efficacy | 6 |

Table 01 Summary of characteristics of excluded studies

| | |
|---|---|
| Cross-over trial, authors contacted for more information, no reply after 3 months | 5 |
| Outcomes not under consideration | 5 |
| Combined intervention | 4 |
| No movement of brush head | 4 |
| Laboratory study | 4 |
| Supervised brushing | 4 |
| Not teeth | 1 |
| Not human | 1 |
| Abstract only | 1 |

Table 02 Summary of inclusion criteria categories within included studies

| Inclusion criteria | Number (n=29) |
|--|---------------|
| No relevant medical history | 21 |
| Adults | 19 |
| Minimum number of teeth | 17 |
| Minimum periodontal baseline measures | 16 |
| Participants recruited from dental clinics | 5 |
| Concurrent fixed orthodontic treatment | 2 |
| Aged less than 16 years | 2 |
| Volunteer university students | 2 |
| Dental students | 1 |

Table 03 Summary of exclusion criteria categories within included studies

| Exclusion criteria | Number (n=29) |
|---|---------------|
| Pregnancy or lactation | 3 |
| Previous use of powered toothbrushes | 4 |
| Patients undergoing orthodontic treatment | 4 |
| Previous periodontal treatment | 2 |
| Dental students | 2 |
| Cervical restorations | 1 |
| Smoking | 0 |
| Maximum periodontal measure | 1 |

Table 04 Summary of toothbrush modes of action, number of trials and participants

| Mode of action | Trial ID | Number of trials | n - attrition |
|----------------------|--|------------------|---------------|
| Side to side | Glass 1965, Ho 1997, Johnson 1994, Lobene 1964, O'Beirne 1996, Tritten 1996, Walsh 1989, Yankell 1997 | 8 | 627 |
| Counter oscillation | Baab 1989, Khocht 1992, Stabholz 1996, Wilson 1993, Yukna 1993 | 5 | 228 |
| Rotation oscillation | Ainamo 1997, Barnes 1993, Clerehugh 1998, Cronin 1998, Dentino unpublished, Heasman 1999, Lazarescu unpublished, Stoltze 1994, Warren 2001, Yankell 1997, van der Weijden 1994 | 11 | 954 |
| Circular | Khocht 1992, McAllan 1976, Yankell 1996 | 3 | 168 |
| Ultrasonic | Forgas Brockman 1998, Terezhalmly 1995 | 2 | 108 |
| Unknown | Emling 1991, Soparkar 1964 | 2 | 296 |

Table 05 Sensitivity analyses of trials of rotation oscillation versus manual (1-3mths)

| group selected | index | number of studies | SMD(95%CI) | effect p-value | Het. chi-square | Het. p-value |
|-----------------------------------|--------|-------------------|-------------------------|----------------|-----------------|--------------|
| all studies | plaque | 10 | -0.44 (-0.66 to -0.21) | <0.001 | 22.9 | 0.007 |
| full mouth recording | plaque | 8 | -0.53 (-0.76 to -0.30) | <0.001 | 15.8 | 0.03 |
| adequate concealed allocation | plaque | 3 | -0.33 (-0.63 to -0.028) | 0.032 | 3.8 | 0.15 |
| adequate random number generation | plaque | 2 | -0.24 (-0.68 to 0.20) | 0.29 | 2.4 | 0.12 |
| outcome assessor blinded | plaque | 9 | -0.37 (-0.51 to -0.23) | <0.001 | 6.5 | 0.60 |
| adequate reporting of attrition | plaque | 7 | -0.44 (-0.77 to -0.11) | 0.009 | 21.0 | 0.002 |

Table 05 Sensitivity analyses of trials of rotation oscillation versus manual (1-3mths)

| | | | | | | |
|---|------------|----|-------------------------|--------|------|--------|
| comparable toothbrush instruction | plaque | 6 | -0.53 (-0.89 to -0.16) | 0.005 | 20.1 | 0.001 |
| trials not limited to patients wearing fixed orthodontic appliances | plaque | 9 | -0.48 (-0.71 to -0.25) | <0.001 | 19.2 | 0.01 |
| all studies | gingivitis | 10 | -0.44 (-0.72 to -0.15) | 0.003 | 38.0 | <0.001 |
| full mouth recording | gingivitis | 9 | -0.47 (-0.79 to -0.15) | 0.004 | 37.1 | <0.001 |
| adequate concealed allocation | gingivitis | 3 | -0.34 (-0.55 to -0.13) | 0.002 | 0.79 | 0.68 |
| adequate random number generation | gingivitis | 2 | -0.37 (-0.73 to -0.004) | 0.047 | 1.5 | 0.21 |
| outcome assessor blinded | gingivitis | 9 | -0.30 (-0.46 to -0.140) | <0.001 | 10.5 | 0.23 |
| adequate reporting of attrition | gingivitis | 7 | -0.51 (-0.92 to 0.11) | 0.012 | 32.0 | <0.001 |
| comparable toothbrush instruction | gingivitis | 6 | -0.56 (-1.04 to -0.08) | 0.02 | 34.4 | <0.001 |
| trials not limited to patients wearing fixed orthodontic appliances | gingivitis | 9 | -0.47 (-0.79 to -0.15) | 0.004 | 37.4 | <0.001 |

COVER SHEET

| | |
|-----------------------------|--|
| Title | Manual versus powered toothbrushing for oral health |
| Reviewer(s) | Heanue M, Deacon SA, Deery C, Robinson PG, Walmsley AD, Worthington HV, Shaw WC |
| Contribution of reviewer(s) | Bill Shaw and Helen Worthington wrote the protocol. Bill Shaw, Mike Heanue, Peter Robinson and Damien Walmsley co-ordinated the review. Bill Shaw wrote the letters to the authors. Bill Shaw, Scott Deacon, Chris Deery, Mike Heanue, |

Peter Robinson and Damien Walmsley independently and in duplicate assessed the eligibility of trials, extracted data and assessed the quality of the trials. Damien Walmsley and Peter Robinson provided the background and sourced information on brush action and plaque and gingival indices. Helen Worthington conducted the statistical analysis. Scott Deacon and Mike Heanue checked and entered data. Peter Robinson and Mike Heanue wrote the review. Proof reading and numerical consistency checked by Chris Deery.

| | |
|---|--|
| Issue protocol first published | 2000/2 |
| Issue review first published | 2003/1 |
| Date of most recent amendment | 21 November 2001 |
| Date of most recent SUBSTANTIVE amendment | 13 November 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 |
| Contact address | Professor Bill Shaw Co-ordinating Editor Cochrane Oral Health Group MANDEC, University Dental Hospital of Manchester Higher Cambridge Street Manchester M15 6FH UK Telephone: +44 161 275 6620 E-mail: Bill.Shaw@man.ac.uk Facsimile: +44 161 275 7815 |
| Cochrane Library number | CD002281 |
| Editorial group | Cochrane Oral Health Group |
| Editorial group code | HM-ORAL |

SUMMARY TABLES

01 Side to side powered toothbrushes versus manual toothbrushes

| Outcome title | No. of studies | No. of participants | Statistical method | Effect size |
|--|----------------|---------------------|--|---------------------|
| 01 Plaque scores at 1 to 3 month at all sites | 6 | 402 | Standardised Mean Difference (Random) 95% CI | -0.42 [-0.91, 0.07] |
| 02 Gingival scores at 1 to 3 months at all sites | 8 | 627 | Standardised Mean Difference (Random) 95% CI | -0.44 [-0.91, 0.02] |
| 03 Plaque scores at > 3 months | 2 | 220 | Standardised Mean Difference (Random) 95% CI | 0.03 [-0.23, 0.29] |
| 04 Gingival Scores at > 3 months | 2 | 220 | Standardised Mean Difference (Random) 95% CI | 0.12 [-0.14, 0.39] |

02 Counter oscillation

| Outcome title | No. of studies | No. of participants | Statistical method | Effect size |
|--|----------------|---------------------|--|----------------------|
| 01 Plaque scores at 1 to 3 month at all sites | 4 | 184 | Standardised Mean Difference (Random) 95% CI | -0.07 [-0.36, 0.22] |
| 02 Gingivitis scores at 1 to 3 months at all sites | 4 | 172 | Standardised Mean Difference (Random) 95% CI | -0.04 [-0.52, 0.45] |
| 03 Plaque scores at > 3 months | 2 | 69 | Standardised Mean Difference (Random) 95% CI | -0.63 [-1.11, -0.14] |
| 04 Gingival scores at > 3 months | 2 | 69 | Standardised Mean Difference (Random) 95% CI | -0.19 [-0.66, 0.29] |

03 Rotation oscillation

| Outcome title | No. of studies | No. of participants | Statistical method | Effect size |
|--|----------------|---------------------|--|----------------------|
| 01 Plaque scores at 1 to 3 month at all sites | 10 | 867 | Standardised Mean Difference (Random) 95% CI | -0.44 [-0.66, -0.21] |
| 02 Gingival scores at 1 to 3 months at all sites | 10 | 866 | Standardised Mean Difference (Random) 95% CI | -0.45 [-0.76, -0.15] |
| 03 Plaque scores at > 3 months | 4 | 423 | Standardised Mean Difference (Random) 95% CI | -1.15 [-2.02, -0.29] |

| 03 Rotation oscillation | | | | |
|----------------------------------|---|-----|--|----------------------|
| 04 Gingival scores at > 3 months | 4 | 423 | Standardised Mean Difference (Random) 95% CI | -0.51 [-0.76, -0.25] |

| 04 Circular | | | | |
|---|----------------|---------------------|--|---------------------|
| Outcome title | No. of studies | No. of participants | Statistical method | Effect size |
| 01 Plaque scores at 1 to 3 month at all sites | 3 | 168 | Standardised Mean Difference (Random) 95% CI | -0.06 [-0.36, 0.25] |
| 02 Gingival scores at 1-3 months at all sites | 3 | 168 | Standardised Mean Difference (Random) 95% CI | -0.39 [-0.95, 0.18] |
| 03 Plaque scores at > 3 months | 1 | 40 | Standardised Mean Difference (Random) 95% CI | 0.04 [-0.58, 0.66] |
| 04 Gingival scores at > 3 months | 1 | 40 | Standardised Mean Difference (Random) 95% CI | -0.30 [-0.92, 0.33] |

| 05 Ultrasonic | | | | |
|--|----------------|---------------------|--|---------------------|
| Outcome title | No. of studies | No. of participants | Statistical method | Effect size |
| 01 Plaque scores at 1 to 3 month at all sites | 2 | 108 | Standardised Mean Difference (Random) 95% CI | -0.45 [-0.90, 0.00] |
| 02 Gingival scores at 1 to 3 months at all sites | 2 | 108 | Standardised Mean Difference (Random) 95% CI | -0.55 [-1.17, 0.07] |
| 03 Plaque scores at > 3 months at all sites | 1 | 46 | Standardised Mean Difference (Random) 95% CI | 0.20 [-0.38, 0.78] |
| 04 Gingival scores at > 3 months | 1 | 46 | Standardised Mean Difference (Random) 95% CI | 0.00 [-0.58, 0.58] |

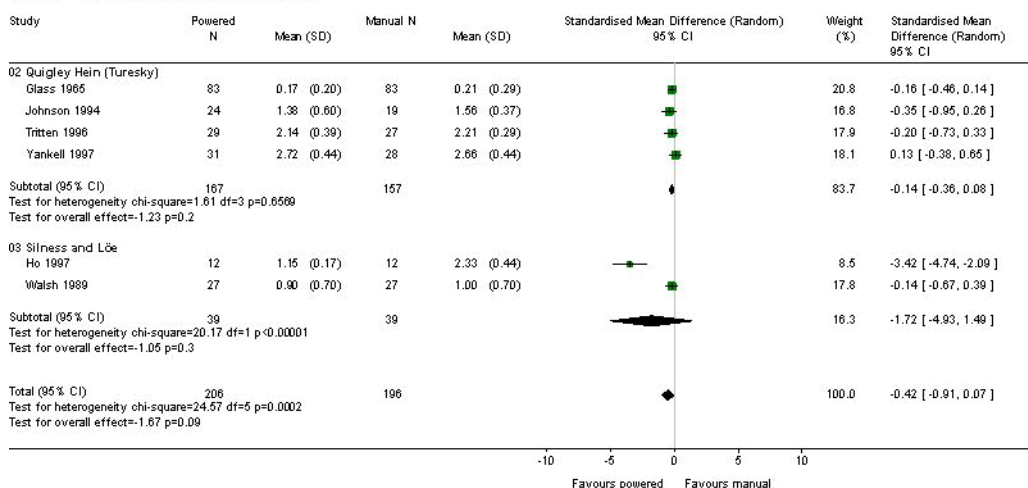
| 06 Unknown or other action | | | | |
|--|----------------|---------------------|--|---------------------|
| Outcome title | No. of studies | No. of participants | Statistical method | Effect size |
| 01 Plaque scores at 1 to 3 months at all sites | 1 | 57 | Standardised Mean Difference (Random) 95% CI | -0.32 [-0.84, 0.20] |
| 02 Gingival scores at 1 to 3 months at all sites | 2 | 295 | Standardised Mean Difference (Random) 95% CI | -0.32 [-0.69, 0.05] |

GRAPHS AND OTHER TABLES

Fig. 01 Side to side powered toothbrushes versus manual toothbrushes

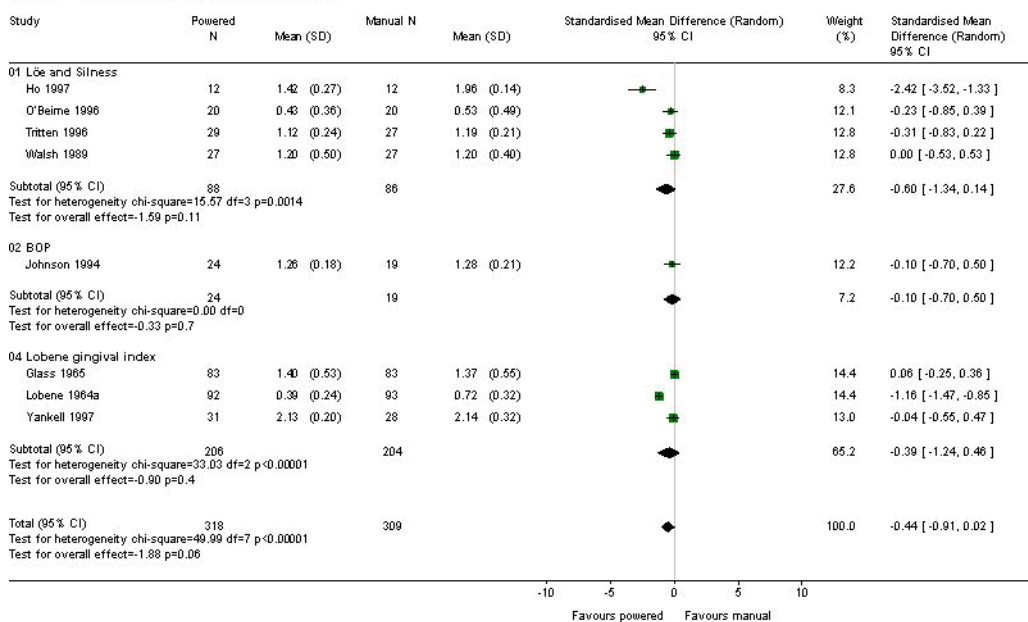
01.01 Plaque scores at 1 to 3 month at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 01 Side to side powered toothbrushes versus manual toothbrushes
 Outcome: 01 Plaque scores at 1 to 3 month at all sites



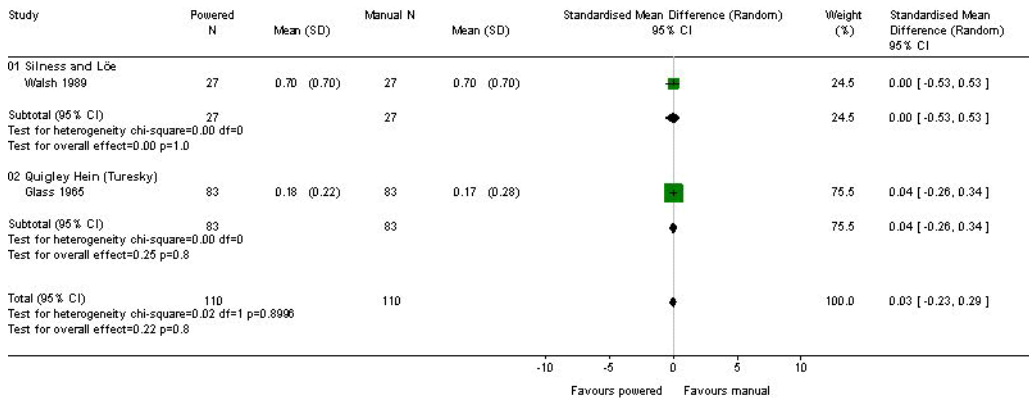
01.02 Gingival scores at 1 to 3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 01 Side to side powered toothbrushes versus manual toothbrushes
 Outcome: 02 Gingival scores at 1 to 3 months at all sites



01.03 Plaque scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 01 Side to side powered toothbrushes versus manual toothbrushes
 Outcome: 03 Plaque scores at > 3 months



01.04 Gingival Scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 01 Side to side powered toothbrushes versus manual toothbrushes
 Outcome: 04 Gingival Scores at > 3 months

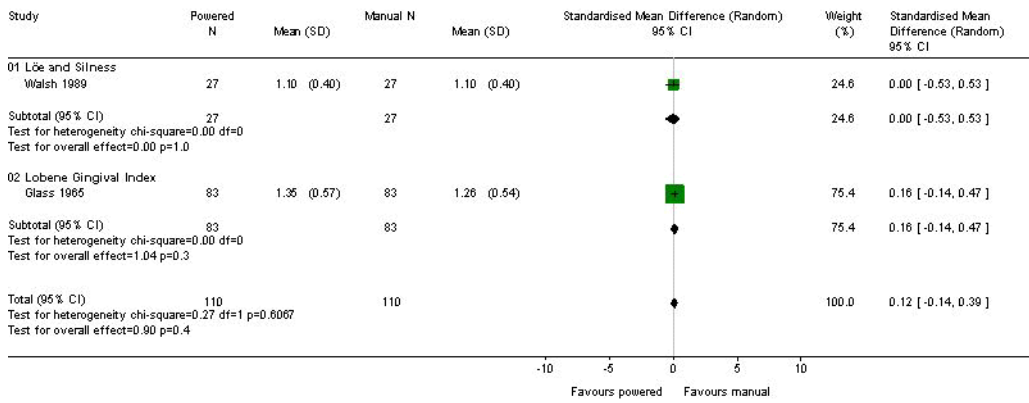
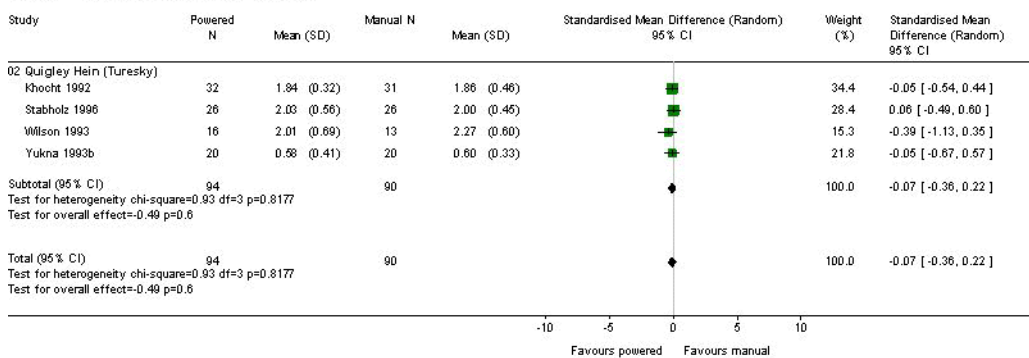


Fig. 02 Counter oscillation

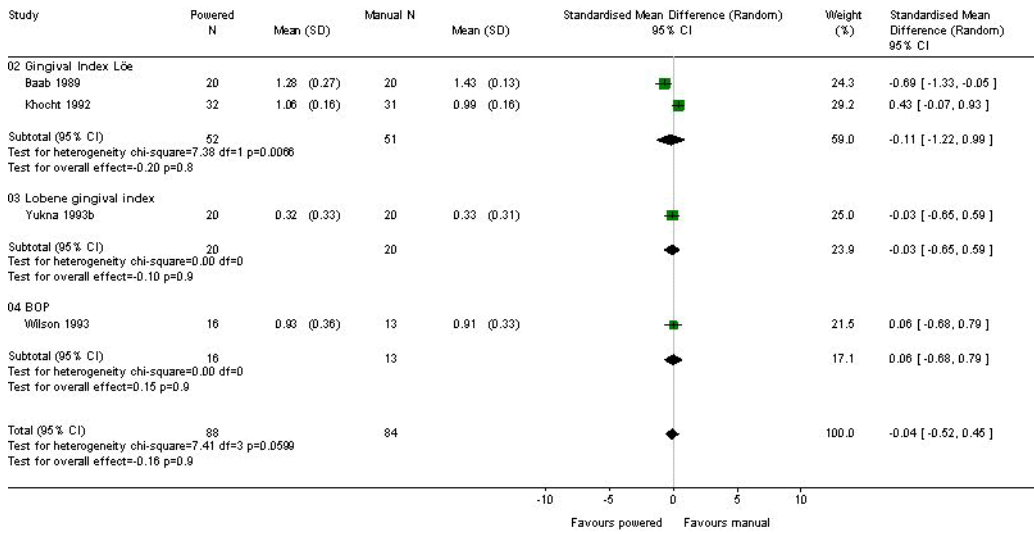
02.01 Plaque scores at 1 to 3 month at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 02 Counter oscillation
 Outcome: 01 Plaque scores at 1 to 3 month at all sites



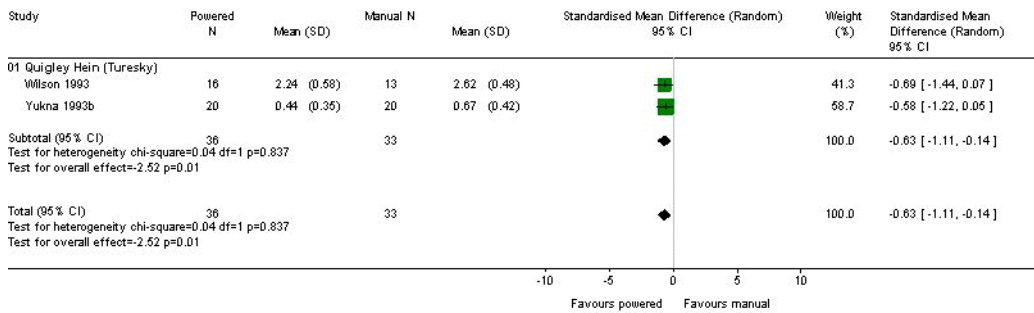
02.02 Gingivitis scores at 1 to 3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 02 Counter oscillation
 Outcome: 02 Gingivitis scores at 1 to 3 months at all sites



02.03 Plaque scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 02 Counter oscillation
 Outcome: 03 Plaque scores at > 3 months



02.04 Gingival scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 02 Counter oscillation
 Outcome: 04 Gingival scores at > 3 months

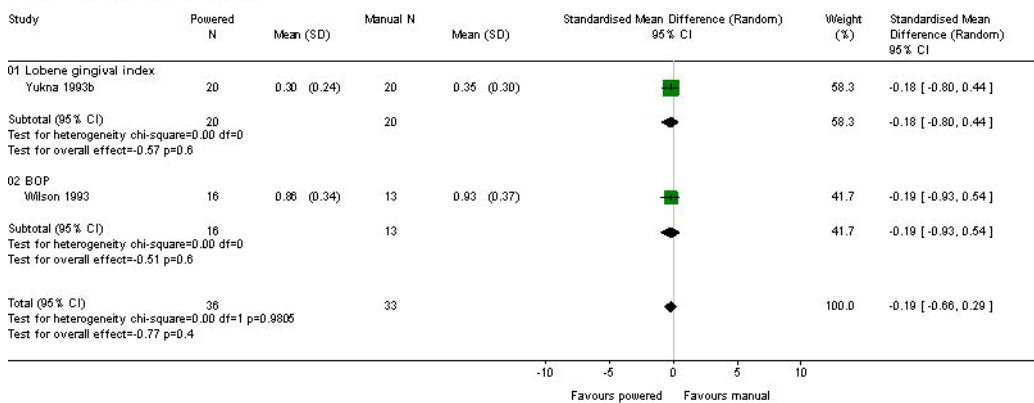
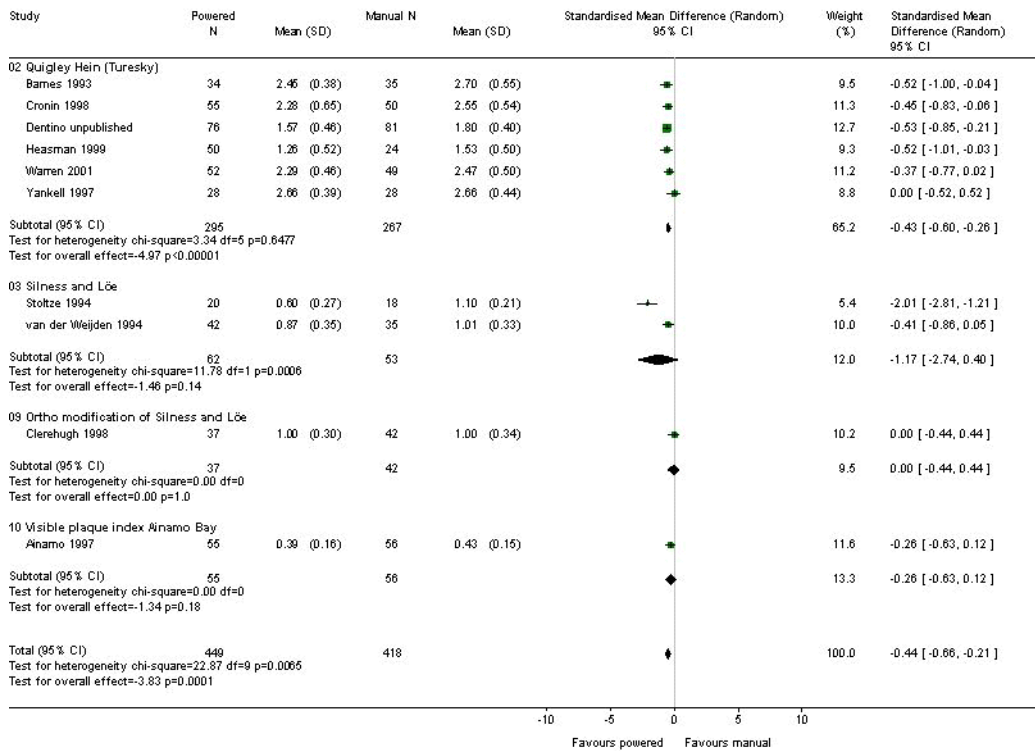


Fig. 03 Rotation oscillation

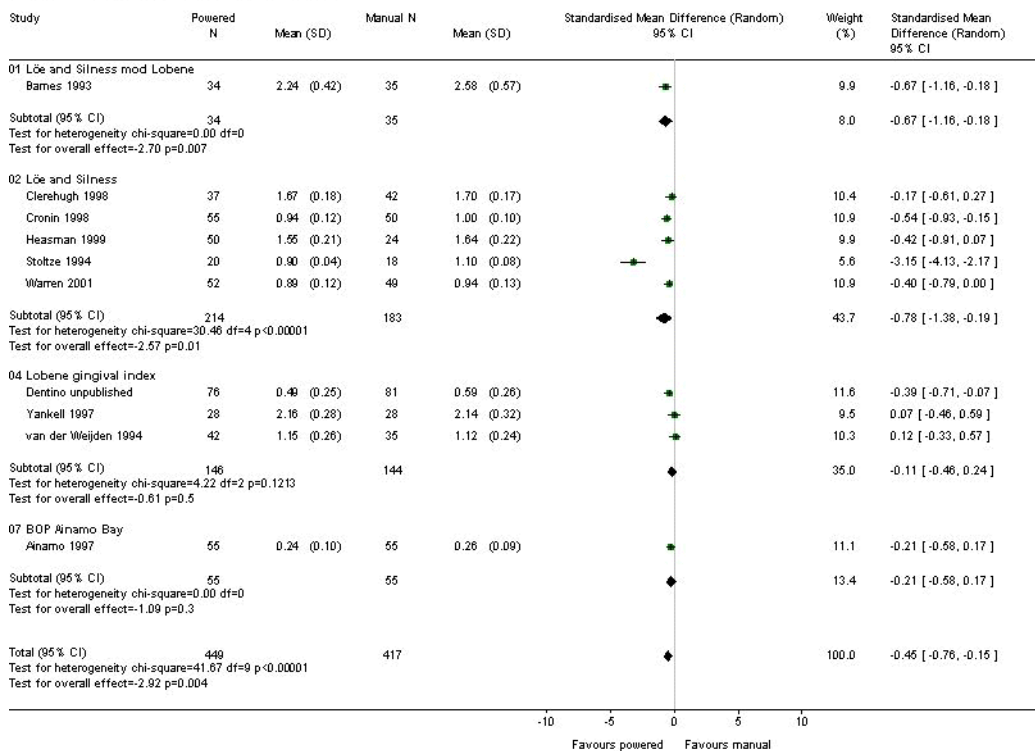
03.01 Plaque scores at 1 to 3 month at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 03 Rotation oscillation
 Outcome: 01 Plaque scores at 1 to 3 month at all sites



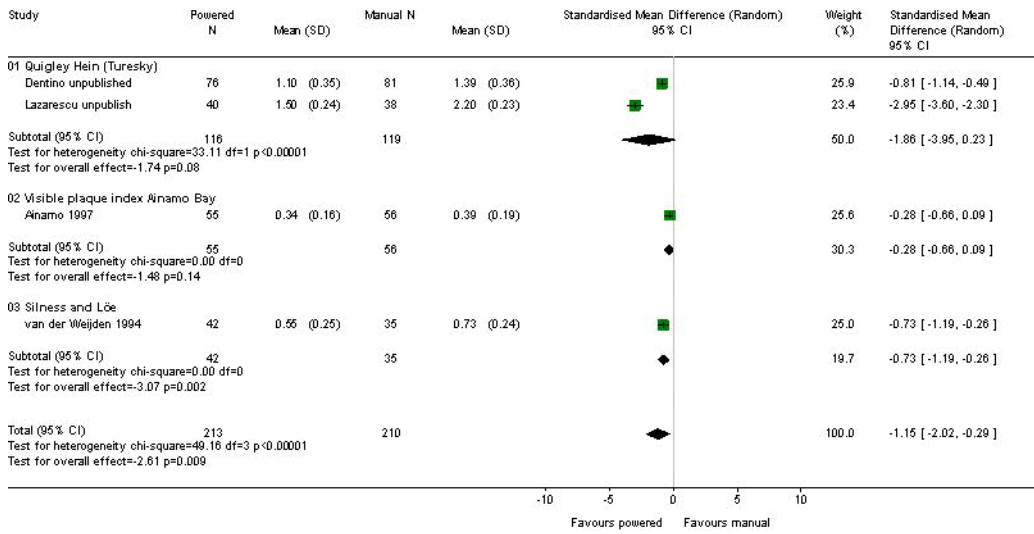
03.02 Gingival scores at 1 to 3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 03 Rotation oscillation
 Outcome: 02 Gingival scores at 1 to 3 months at all sites



03.03 Plaque scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 03 Rotation oscillation
 Outcome: 03 Plaque scores at > 3 months



03.04 Gingival scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 03 Rotation oscillation
 Outcome: 04 Gingival scores at > 3 months

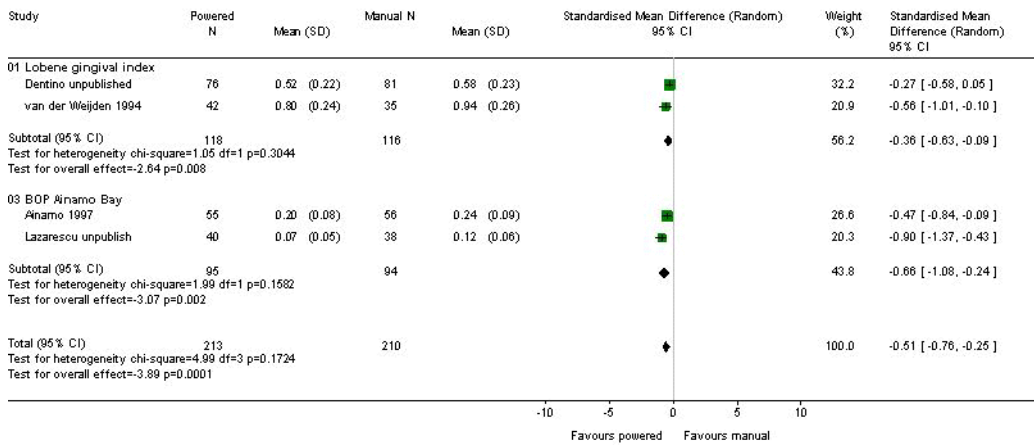
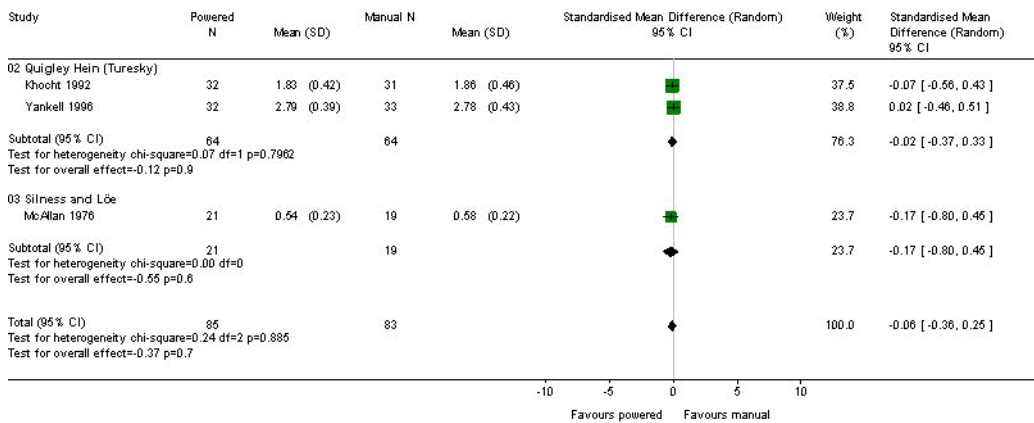


Fig. 04 Circular

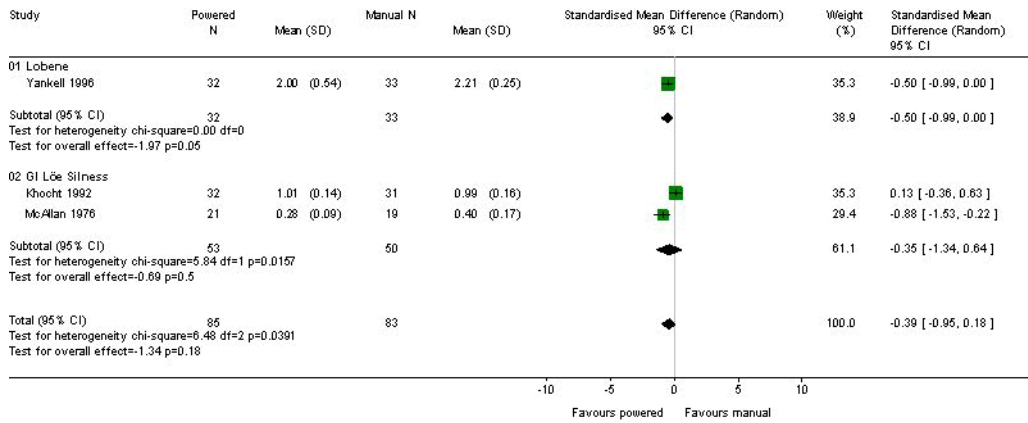
04.01 Plaque scores at 1 to 3 month at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 04 Circular
 Outcome: 01 Plaque scores at 1 to 3 month at all sites



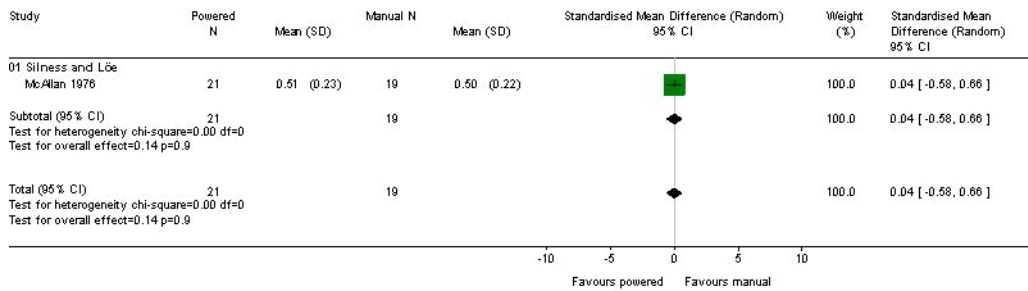
04.02 Gingival scores at 1-3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 04 Circular
 Outcome: 02 Gingival scores at 1-3 months at all sites



04.03 Plaque scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 04 Circular
 Outcome: 03 Plaque scores at > 3 months



04.04 Gingival scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 04 Circular
 Outcome: 04 Gingival scores at > 3 months

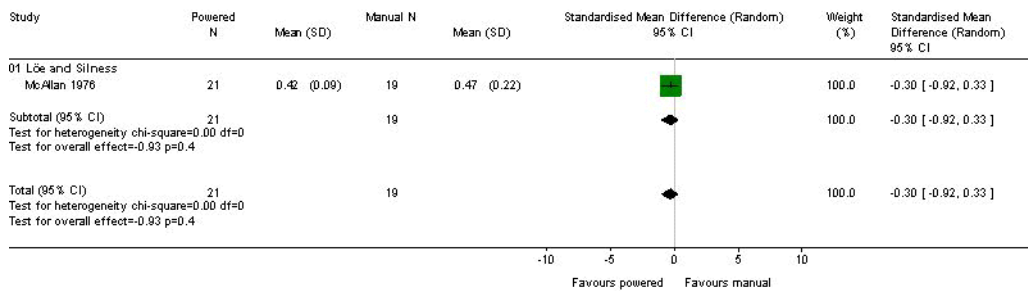
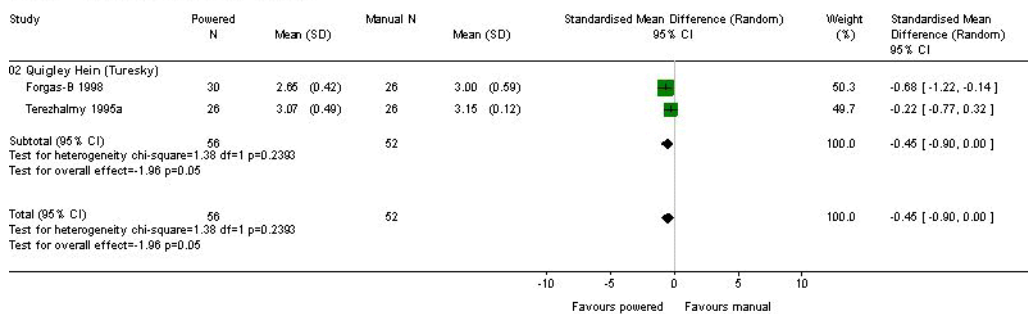


Fig. 05 Ultrasonic

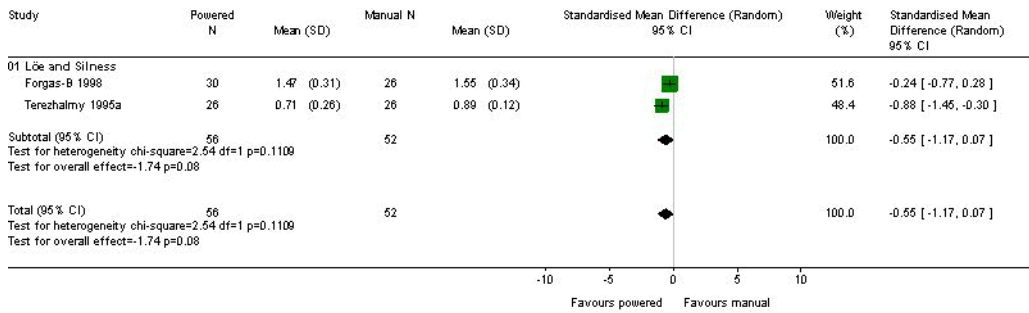
05.01 Plaque scores at 1 to 3 month at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 05 Ultrasonic
 Outcome: 01 Plaque scores at 1 to 3 month at all sites



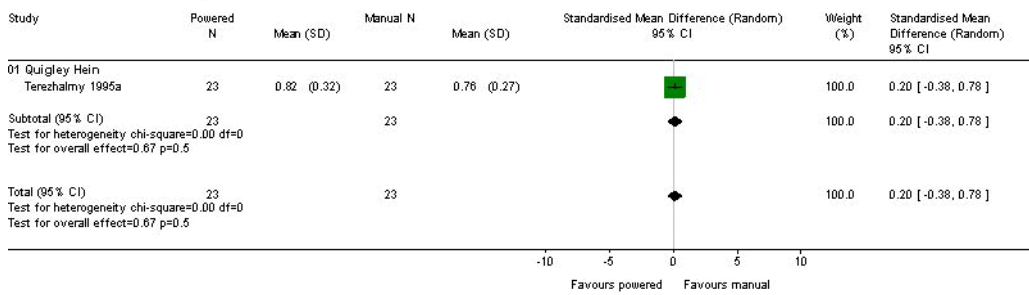
05.02 Gingival scores at 1 to 3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 05 Ultrasonic
 Outcome: 02 Gingival scores at 1 to 3 months at all sites



05.03 Plaque scores at > 3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 05 Ultrasonic
 Outcome: 03 Plaque scores at > 3 months at all sites



05.04 Gingival scores at > 3 months

Review: Manual versus powered toothbrushing for oral health
 Comparison: 05 Ultrasonic
 Outcome: 04 Gingival scores at > 3 months

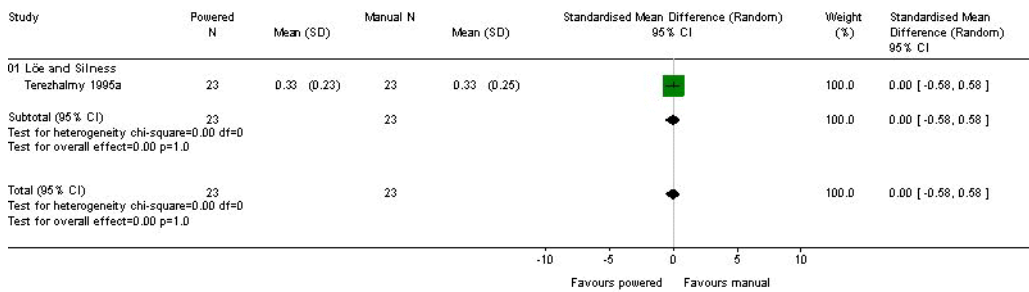
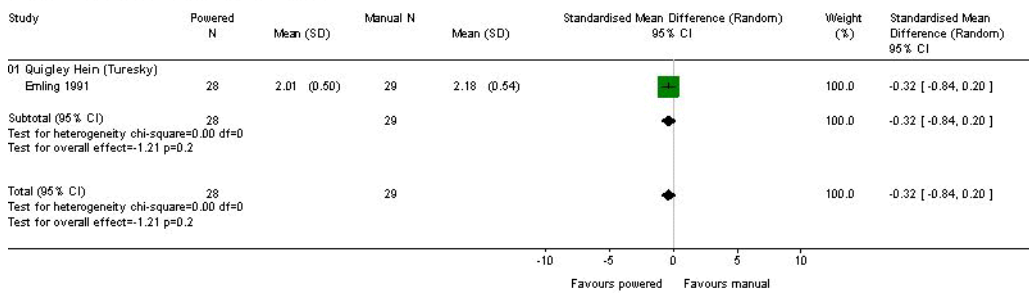


Fig. 06 Unknown or other action

06.01 Plaque scores at 1 to 3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 06 Unknown or other action
 Outcome: 01 Plaque scores at 1 to 3 months at all sites



06.02 Gingival scores at 1 to 3 months at all sites

Review: Manual versus powered toothbrushing for oral health
 Comparison: 06 Unknown or other action
 Outcome: 02 Gingival scores at 1 to 3 months at all sites

