Different powered toothbrushes for plaque control and gingival health (Review)

Deacon SA, Glenny AM, Deery C, Robinson PG, Heanue M, Walmsley AD, Shaw WC

This is a reprint of a Cochrane review, prepared and maintained by The Cochrane Collaboration and published in *The Cochrane Library* 2011, Issue 6

http://www.thecochranelibrary.com

TABLE OF CONTENTS

[Intervention Review]

Different powered toothbrushes for plaque control and gingival health

Scott A Deacon[1], Anne-Marie Glenny[2], Chris Deery[3], Peter G Robinson[4], Mike Heanue[5], A Damien Walmsley[6], William C Shaw[7]

[1]South West Cleft Unit, Frenchay Hospital, Bristol, UK. [2]Cochrane Oral Health Group, School of Dentistry, The University of Manchester, Manchester, UK. [3]Department of Oral Health and Development, University of Sheffield, Sheffield, UK. [4]Department of Dental Public Health, School of Clinical Dentistry, University of Sheffield, Sheffield, UK. [5]Sheffield, UK. [6]Department of Prosthetic Dentistry, School of Dentistry, Birmingham, UK. [7]Department of Orthodontics, School of Dentistry, The University of Manchester, Manchester, UK

Contact address: Scott A Deacon, South West Cleft Unit, Frenchay Hospital, Frenchay Park Road, Bristol, BS16 1LE, UK. scott.deacon@nbt.nhs.uk.

Editorial group: Cochrane Oral Health Group.
Publication status and date: Edited (no change to conclusions), published in Issue 6, 2011.
Review content assessed as up-to-date: 24 March 2011.

Citation: Deacon SA, Glenny AM, Deery C, Robinson PG, Heanue M, Walmsley AD, Shaw WC. Different powered toothbrushes for plaque control and gingival health. *Cochrane Database of Systematic Reviews* 2010, Issue 12. Art. No.: CD004971. DOI: 10.1002/14651858.CD004971.pub2.

ABSTRACT

Background

Powered brushes were first introduced commercially in the 1960s. A recent systematic review suggested the superiority of certain modes of powered over manual toothbrushing for plaque and gingivitis reduction. That review did not allow for direct comparison between different modes of powered toothbrush.

Objectives

To compare different modes of powered toothbrushing against each other for plaque reduction and the health of the gingivae. Other factors to be assessed were calculus and stain removal, cost, dependability and adverse effects.

Search strategy

The following databases were searched: Cochrane Oral Health Group's Trials Register (to 26 July 2010); Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2010, Issue 3); MEDLINE via OVID (1950 to 26 July 2010); EMBASE via OVID (1980 to 26 July 2010); CINAHL via EBSCO (1982 to 26 July 2010). There were no language restrictions.

Selection criteria

Trials were considered for inclusion with the following criteria: random allocation of participants; no compromised manual dexterity; unsupervised powered toothbrushing for at least 4 weeks. The primary outcomes were the plaque and gingivitis scores after powered toothbrush use during trial period.

Data collection and analysis

Data extraction was performed independently and in duplicate. The authors of trials were contacted to provide missing data where possible. The effect measure for each meta-analysis was the standardised mean difference (SMD) with 95% confidence intervals (CI) using the random-effects model. Potential sources of heterogeneity were assessed.

Main results

The review included data from 17 trials with 1369 participants. There is evidence from seven trials of up to three months and at unclear/high risk of bias that rotation oscillation brushes reduce plaque (SMD 0.24; 95% CI 95% 0.02, 0.46) and gingivitis (SMD 0.35; 95% CI -0.04, 0.74) more than side to side brushes. Due to the dearth of trials, no other definitive conclusions can be stated regarding the superiority of one mode of powered toothbrush over any other. Only minor and transient side effects were reported. Cost, dependability were not reported.

Authors' conclusions

There is some evidence that rotation oscillation brushes reduce plaque and gingivitis more than side to side brushes in the short term. This difference is small and it's clinical importance is unclear. Further trials of good quality are required to assess the superiority of other modes of action for powered toothbrushes.

PLAIN LANGUAGE SUMMARY

Different types of powered toothbrushes for plaque control and healthy gums

Powered brushes were first introduced commercially in the 1960s. A previously published Cochrane systematic review suggested one type of powered brush was superior to manual toothbrushing for the removal of plaque and reduction of gum inflammation.That review did not allow direct comparison between the different types of powered toothbrushes.

This review included data from 17 trials with 1369 participants. Brushes with a rotation oscillation action reduced plaque and gingivitis more than those with a side to side action in the short term. However, the difference was small and it's clinical importance unclear. Due to the low numbers of trials using other types of powered brushes, no other definitive conclusions can be drawn regarding the superiority of one type of powered toothbrush over another. Only minor and transient side effects were reported. Cost and reliability of the brushes were not reported in the trials.

Further trials of good quality are required to establish if other types of powered brush are better at reducing plaque and gingivitis.

BACKGROUND

Dental plaque

Dental plaque is the primary causal factor both in gingivitis (gum inflammation) and periodontitis (loss of bone around the teeth) although the link between the two is complex and not well understood (Loe 1965). Periodontitis can lead to tooth loss (Lorentz 2010).

Thus, good oral hygiene (the removal of plaque) by effective toothbrushing has a key role in oral health with the prevention of periodontal disease and caries (Axelsson 1978; Axelsson 1981). Effective toothbrushing depends on a number of factors including motivation, knowledge and manual dexterity.

The relationship between oral cleanliness and caries is not clear-cut (Addy 1986; Richardson 1977) unless a fluoride toothpaste is used. This is due more to the effect of fluoride than brushing per se (Marinho 2003).

In clinical trials assessing the levels of plaque, indices are commonly used to quantify the amount of plaque present on the surfaces of teeth. Among the most commonly used of these is the Quigley & Hein Index (Quigley 1962) with/out the Turesky modification (Turesky 1970). Such indices have become popular due to their ease of use, both in terms of time and lack of specialised equipment required. However, they have ordinal scales which creates problems when interpreting the clinical relevance of the data.

Toothbrushing

Powered toothbrushes were first introduced commercially in the early 1960s (Chilton 1962; Cross 1962; Elliot 1963; Hoover 1962) and have become established as an alternative to manual methods of toothbrushing. They simulate the manual motion of toothbrushes. A recent review (Robinson 2005) compared powered toothbrushes with manual toothbrushes and concluded that only

powered toothbrushes with a rotation oscillation action were more effective at removing plaque and reducing gingivitis than manual brushing. This review did not allow direct comparison between the different modes of powered toothbrushes. Therefore the question remains: Which powered toothbrushes may perform better, at reducing plaque and gingivitis?

Powered toothbrushes have been designed with different movements of the bristles. It is therefore important to assess whether they cause damage to the gingival tissues during use (Addy 2003).

OBJECTIVES

To compare powered toothbrushes with different modes of action, in everyday use, by people of any age, in relation to:

(1) removal of plaque;

(2) health of the gingivae;

(3) adverse effects.

METHODS

Criteria for considering studies for this review

Types of studies

The review is confined to studies comparing two or more powered brushes with different modes of action. Trials comparing powered toothbrushes with the same mode of action were not included. Only randomised controlled trials (RCTs) that clearly implied randomisation were included. Where the method of randomisation was unclear, the authors were contacted to request clarification. Cross-over trials were eligible to be included. This study design has been shown to be a valid method of assessing the efficacy of toothbrushes in clinical trials (McCracken 2005). Split-mouth trials were excluded as these are not considered representative of 'everyday use'.

Types of participants

Included individuals were of any age with no reported disability that may affect their ability to practice normal self toothbrushing. Individuals wearing orthodontic appliances were included.

Types of interventions

Toothbrushes reviewed were all forms of powered brush with mechanical movement of the brush head (i.e. electric, electronic, sonic, ultrasound etc.) or with power delivered to the brush head (i.e. ionic). The brushes were grouped according to their mode of action. This included.

- 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).
- Ionic, indicates a brush which applies a low electric current to the bristles during toothbrushing. The aim of the brush is to change the charge polarity of the tooth with the purpose of attracting dental plaque away from the tooth towards the bristles. Such brushes have no powered mechanical action.
- Multidimensional, indicates a brush with more than one action. Such brushes usually include two of the above action types. This additional mode of action was added during the review process to reflect the advances in toothbrush design that have occurred in recent years.
- Unknown, indicates a brush action that the review authors have been unable to establish based on the trial report or confirm with the manufacturers.

Combined interventions, e.g. brushing combined with the use of mouthrinses or irrigation were excluded. However, trials where subjects were permitted to continue with their usual personal adjuncts to oral hygiene, such as flossing, in both groups, were considered for inclusion. Trials where professional or supervised brushing was used were excluded. Trials of 28 days and over were eligible. We also aimed to undertake a subgroup analysis on the duration of trials for the different outcome measurements.

As with the previous reviews comparing powered and manual toothbrushes (Heanue 2003; Robinson 2005) it was considered that the 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. These factors have therefore not been assessed in this current review.

Types of outcome measures

Primary outcomes

The outcome measures used were quantified levels of plaque or gingivitis or both.

Values recorded on arrival at the assessment were used, not those after subjects have been instructed to brush their teeth. It was assumed that plaque scores achieved during toothbrushing under these circumstances would not reflect scores achieved in normal home use. Gingival scores were included as these were assumed not to be altered by supervised brushing immediately before assessment. Where several outcome measures for plaque or gingivitis were reported, the data entered for analysis were selected according to an index hierarchy developed on a previous review (Heanue 2003). This was developed to handle the many different indices of plaque and gingivitis which are used across trials, with some trials reporting multiple indices. A frequencies table was prepared of the indices used and they were ranked based on common usage and simplicity. Therefore for plaque when multiple indices were reported the data extracted, where possible, were reported using the Turesky modification of the Quigley-Hein plaque index (Turesky 1970). For gingival inflammation when multiple indices were reported the data extracted, where possible, were reported as the gingival index of Loe and Silness (Loe 1963) or, if unavailable, bleeding on probing (Ainamo 1975). When available, data were extracted for whole mouth rather than part mouth scores. Where only part mouth scores were reported, they were extracted with the intention of performing a sensitivity analysis to consider their impact on the results of the review. Part mouth scoring was assumed if plaque and/or gingivitis were not recorded around all erupted teeth, except third molars.

Secondary outcomes

Cost; reliability; calculus; staining; adverse events.

Search methods for identification of studies

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 via OVID (*see* Appendix 1) but revised appropriately for each database to take account of differences in controlled vocabulary and syntax rules. The MEDLINE searches were conducted with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials: sensitivity maximising version (2009 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of the *Cochrane Handbook for Systematic Reviews of Interventions* version 5.0.2 (updated September 2009) (Higgins 2009). There were no language restrictions. The following databases were searched:

- The Cochrane Oral Health Group's Trials Register (whole database to 26 July 2010) (Appendix 2)
- The Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2010, Issue 3) (Appendix 3)
- MEDLINE via OVID (1950 to 26 July 2010) (Appendix 1)
- EMBASE via OVID (1980 to 26 July 2010) (Appendix 4)
- CINAHL via EBSCO (1982 to 26 July 2010) (Appendix 5).

Handsearching of key journals, which have not already been searched by the Cochrane Oral Health Group, was carried out, including the *Journal of Dental Research* and *Journal of Dentistry*. Additionally all references in the identified trials were checked and the authors contacted to identify any additional published or unpublished data. All identified manufacturers were contacted and additional published or unpublished trial reports requested. Publications in all languages were considered.

Data collection and analysis

Study selection

Titles and abstracts identified through the searches were checked by two review authors. The full texts of all studies of possible relevance were obtained for independent assessment by two review authors. The review authors decided which trials fitted the inclusion criteria. Any disagreement was resolved by discussion between the review authors. Authors were contacted for clarification where necessary.

Data extraction

Data extraction was performed independently by two review authors and the authors of trials contacted to provide missing data where possible. The data extraction form used was modified from the data extraction form piloted and used in a previous review by the same team of investigators (Heanue 2003).

Numerical data were assessed for accuracy by a third review author and entered into Review Manager (RevMan) software (RevMan2008) by one review author.

The data extraction protocol included:

- Patient characteristics (age, number, gender, special group such as dental students, orthodontic treatment);
- Intervention characteristics (type of brush, duration of use, delivery of instructions etc.);
- Outcome characteristics (plaque, gingivitis indices etc.); sponsors of trial; publication status.

Risk of bias in included studies

The risk of bias in included studies was assessed independently and in duplicate by two review authors as part of the data extraction process in accordance with the *Cochrane Handbook for Systematic Reviews of Interventions* 5.0.2 (Higgins 2009). Included trials were assessed on the following key criteria:

- generation of random sequence
- concealed allocation of treatment
- blind outcome assessment
- handling of withdrawals/drop outs.

Details on the following criteria were also recorded:

- comparability of groups at baseline/adjustment for confounding factors
- clear inclusion/exclusion criteria
- method of assessment (valid assessment criteria)
- duration of follow-up
- power of study/a priori calculation of sample size.

Where there was uncertainty authors were contacted for clarification. The agreement on methodological assessment is reported using Kappa statistics in the Risk of bias in included studies section below.

A description of the key quality items was tabulated for each included trial, and a judgement of low, high or unclear risk of bias made. Criteria for risk of bias judgements regarding allocation concealment are given below as described in the *Cochrane Handbook for Systematic Reviews of Interventions* 5.0.2 (Higgins 2009).

- Low risk of bias - adequate concealment of the allocation (e.g. sequentially numbered, sealed, opaque envelopes or centralised or pharmacy-controlled randomisation).
- Unclear risk of bias - uncertainty about whether the allocation was adequately concealed (e.g. where the method of concealment is not described or not described in sufficient detail to allow a definite judgement).
- High risk of bias - inadequate allocation concealment (e.g. open random number lists or quasi-randomisation such as alternate days, date of birth, or case record number).

A summary assessment of the risk of bias for the primary outcomes (across domains) was undertaken (Higgins 2009). Within a study, a summary assessment of low risk of bias was given when there was a low risk of bias for all key domains, unclear risk of bias when there was an unclear risk of bias for one or more key domains, and high risk of bias when there was a high risk of bias for one or more key domains. Across studies, a summary assessment was rated as low risk of bias when most information was from studies at low risk of bias, unclear risk of bias when most information was from studies at low or unclear risk of bias, and high risk of bias when the proportion of information was from studies at high risk of bias sufficient to affect the interpretation of the results.

Data synthesis

Summary statistics and overall effect size

Primary analyses compared the relative effectiveness of the toothbrush modes of action. Studies are grouped according to time of outcome measurements. Short term is defined as an outcome measured between 4 weeks and 3 months. Long term is defined as an outcome measured after 3 months or more. For trials presenting more than one outcome measurement within a time period, the last outcome in that time period was entered.

Different indices for plaque measurement exist, using the same concept on different scales. Although the different scales measure very similar constructs, it is not possible to combine the results from different indices. Therefore, 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 (Deeks 2001). Statistical values such as SMD have no inherent clinical meaning. We therefore back-translated them to clinical indices using a study with similar SMDs. Such examples are given in the discussion. Random-effects models were performed unless fewer than four trials in an analysis, when a fixed-effect model was used.

Assessment of heterogeneity and investigation of reasons for heterogeneity

Heterogeneity was assessed by inspection of trial characteristics, a graphical display of the estimated treatment effects from the trials along with their 95% CI, and by Cochran's test for heterogeneity and the I^2 statistic. Subgroup analyses were to be 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

Data from cross-over trials were combined with that of similar parallel group trials, using the techniques described by Elbourne and colleagues (Elbourne 2002).

Investigation of publication and other biases

We intended to use funnel plots (plots of effect estimates versus the inverse of their standard errors) to assess reporting biases. 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 to be 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 to be carried out (Begg 1994). Both methods were to be carried out using Stata version 7.0 (Stata Corporation, USA) using the program Metabias. Due to the low number of included trials neither of these tests was carried out.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

The search identified 396 studies of which 332 were considered to be ineligible from the information provided in the abstract or title. From the full articles 48 were excluded or outstanding information is still required for these trials to be considered further for inclusion. This left 17 trials which have been included within the review.

A primary 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. Eleven trials required further details/data from the authors and information was still outstanding at the time of publication. Should these required data be supplied the trials will be considered in the next review update. A summary of the reasons for exclusion is given in Additional Table 1 - 'Reasons for exclusion of excluded trials'.

Table 1. Reason for exclusion of excluded trials

Reason for exclusion	Number of trials
Too short in length	8
Split-mouth design	11
Outcome measures not plaque and gingivitis levels	7
Same mode of action of brushes	7
Not RCT design	2
Data published in other source	2
Awaiting further information	11

RCT = randomised controlled trial

Of the trials included eleven were conducted in the USA, two in Belgium and one trial conducted in Canada, Germany, Brazil and the UK each. The combined number of participants in the trials was 1369; the number lost to follow-up during the trials was 71 (5%).

Characteristics of participants

The characteristics of participants in each study are noted in the Characteristics of included studies table. Exclusion criteria for included trials were noted and summarised in Additional Table 2.

Table 2. Exclusion criteria of participants in included trials

Exclusion criteria	Number of trials
Medical history	7
History of powered toothbrush use	3

Table 2. Exclusion criteria of participants in included trials (*Continued*)

Recent drug history	7
Orthodontic appliance	6
Prosthetic appliance	4
Plaque level	4
Gingivitis level	5
Not adult age	6
Dental disease	7
Dental staff	0
Number of teeth	9

Characteristics of interventions

The powered toothbrushes, included:
Braun Oral B Plaque Remover, Braun Oral-B 3D Plaque Remover, Braun Oral B Ultra Plaque Remover D9545, Braun Oral B D7, Braun Oral B Professional Care 7000, Oral B Triumph, Braun Oral B Ultra Plaque Remover D9, Crest Spin Brush, Crest Spin Brush Pro, Cybersonic, Epident, Haprika Powerbrush, Interplak, Philips, Philips Jordan HP 510, Rotadent, Rowenta Plaque Control Plus, Sonicare Ultrasonic, Sonicare Plus, Ultrasonex Ultima.
The toothbrushes were subdivided into seven groups according to their mode of action. These brushes are summarised in Additional Table 3 - 'Interventions used in included trials'.
The seven groups according to their mode of action were:

Table 3. Interventions used in included trials

Mode of action	Toothbrushes
Side to side	Sonicare brushes (Sonicare c/o Philips Oral Healthcare, 35301 SE Center Street, Snoqualmie, WA 98065; www.sonicare.com/), Epident (EPI Products, Santa Monica CA), Cybersonic (Amden Corporation, Attn: Cybersonic Customer Service, 27285 Las Ramblas Suite 100, Mission Viejo, CA 92691-8552; www.amdencorp.com/), Haprika Powerbrush (Minimum Corporation, Tokyo, Japan)
Counter oscillation	Interplak brush (Bausch and Lomb Oral Care, GA; www.bausch.com/en˙US/default.aspx)
Rotation oscillation	Braun Oral B Plaque Remover, Braun Oral B D7, Braun Oral B Plaque Remover D9 (Braun Oral B Consumer Services, 1 Gillette Park, South Boston, MA; www.oralb.com/), Crest Spin Brush (Procter and Gamble, One Procter & Gamble Plaza, Cincinnati, Ohio, USA 45202; www.pg.com/en˙US/index.jhtml), Philips Jordan,

Table 3. Interventions used in included trials (*Continued*)

	Philips Jordan HP 510 (c/o Philips Oral Healthcare, 35301 SE Center Street, Snoqualmie, WA 98065; www.sonicare.com/), Philips (c/o Philips Oral Healthcare, 35301 SE Center Street, Snoqualmie, WA 98065; www.sonicare.com/)
Circular	Plaque Dentacontrol Plus (Rowenta Werke GmbH, Franz Alban, Stützer, Germany; www.products.rowenta.de/row/index.html), Rotadent (c/o Professional Dental Technologies, Inc PO Box 4160, Batesville AR 72501; www.prodentec.com/company.asp)
Ultrasonic	Ultrasonex Ultima Toothbrush (Sonex International Corp, Brewster, New York)
Ionic	No included trials investigated this brush type
Multidimensional	Braun Oral B 3D Plaque Remover, Braun Oral B Professional Care 7000, Braun Oral B 3D Excel D17525 (Braun Oral B Consumer Services, 1 Gillette Park, South Boston, MA; www.oralb.com/), Crest Spin Brush Pro (Procter and Gamble, One Procter & Gamble Plaza, Cincinnati, Ohio, USA 45202; www.pg.com/en˙US/index.jhtml)

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

1. Side to side action
2. Counter oscillation
3. Rotation oscillation
4. Circular
5. Ultrasonic
6. Ionic
7. Multidimensional.

Summary of trials by toothbrush mode of action

- Side to side versus counter oscillation: Khocht 1992; Shibly 1997.
- Side to side versus rotation oscillation: Goyal 2009; Grossman 1995; Hefti 2000; Isaacs 1998; Robinson 1997; Williams 2009; Yankell 1997.
- Side to side versus circular: Yankell 1997.
- Counter oscillation versus rotation oscillation: Trimpeneers 1997.
- Counter oscillation versus circular: Trimpeneers 1997.
- Rotation oscillation versus circular: Trimpeneers 1997; Yankell 1997.
- Multidimensional versus side to side: Goyal 2005; Patters 2005; Zimmer 2005.
- Multidimensional versus rotation oscillation: Heasman 1999; Thienpont 2001; Williams 2002.
- Ultrasonic versus multidimensional: Costa 2007.

See Additional Table 4 - 'Summary of toothbrush modes of action and number of trials'.

Table 4. Summary of toothbrush modes of action and number of trials

Mode of action	Trial	Number of trials
Side to side	Goyal 2005, Grossman 1995, Hefti 2000, Isaacs 1998, Kocht 1992, Patters 2005, Robinson 1997, Shibly 1997, Yankell 1997, Zimmer 2005	10
Counter oscillation	Kocht 1992, Shibly 1997, Trimpaneers 1997	3

Table 4. Summary of toothbrush modes of action and number of trials (*Continued*)

Rotation oscillation	Grossman 1995, Heasman 1999, Hefti 2000, Isaacs 1998, Robinson 1997, Thienpoint 2001, Trimpaneers 1997, Williams 2002, Yankell 1997	9
Circular	Trimpaneers 1997, Yankell 1997	2
Ultrasonic	Costa 2007	1
Ionic		
Multidimensional	Goyal 2005, Heasman 1999, Patters 2005, Thienpoint 2001, Williams 2002, Zimmer 2005	6
Unknown		

Characteristics of outcome measures

Fourteen trials reported plaque at 1 to 3 months and one trial reported plaque at longer than 3 months. Fifteen trials reported gingivitis at 1 to 3 months and one trial reported gingivitis at greater than 3 months.

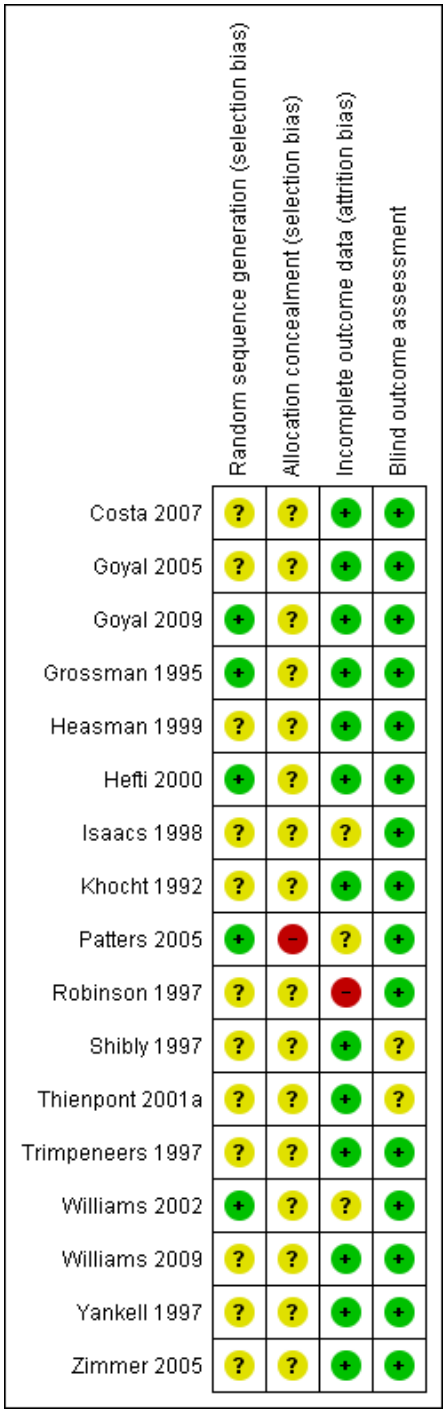
Fourteen trials recorded whole mouth scores for plaque and/or gingivitis; three trials recorded part mouth scores for plaque and two trials for gingivitis.

Risk of bias in included studies

The agreement between the review authors with regard to key quality criteria varied, with Kappa values for adequacy of allocation concealment 0.233 (fair), adequate outcome assessor blinding 0.615 (good) and adequacy or reporting and handling of attrition 0.492 (moderate).

Thirteen of the included studies have been classified as being at unclear risk of bias. Two studies are classified as being at high risk of bias (Patters 2005; Robinson 1997) (Figure 1). No trial was assessed as being at low risk of bias.

Figure 1. Risk of bias summary: review authors' judgements about each domain for each included study



Sponsorship

Funding by the manufacturer of one of the toothbrushes investigated was stated in ten trials and was unclear in the remaining seven trials.

Allocation

In only one trial was it clear that there was not adequate allocation concealment (1/17, 6%) (Patters 2005). For the remainder of the studies there was insufficient detail to determine whether allocation concealment was adequate or not.

Blinding

Fifteen of the 17 included trials reported blind outcome assessment (88%). In two studies it was unclear as to whether blind outcome assessment had been undertaken (Shibly 1997; Thienpont 2001a).

Incomplete outcome data

Eight trials reported no loss to follow-up (64%) (Costa 2007; Goyal 2005; Grossman 1995; Heasman 1999; Khocht 1992; Shibly 1997; Yankell 1997; Zimmer 2005). In the remaining trials loss to follow-up ranged from 3% to 18%. In three of these trials it was felt that missing data were unlikely to be related to outcomes (Hefti 2000; Thienpont 2001a; Trimpeneers 1997).

Effects of interventions

The differences in plaque and gingivitis reduction between the different modes of action of powered brushes were expressed as standardised mean differences (SMDs) for both short term and long term studies and are reported below.

Side to side versus counter oscillation

(Analysis 1.1; Analysis 1.2)
Two trials (Khocht 1992; Shibly 1997), with data from 130 participants, showed no significant difference between these modes of powered brushing in the short term (1-3 months) for plaque (SMD -0.02 (95% confidence interval (CI) -0.37 to 0.32)) and gingivitis (SMD -0.02 (95% CI -0.37 to 0.32)). No long term data were reported.

Side to side versus rotation oscillation

(Analysis 2.1; Analysis 2.2; Analysis 2.3, Analysis 2.4)
Seven trials compared side to side and rotation oscillation brushes (Goyal 2009; Grossman 1995; Hefti 2000; Isaacs 1998; Robinson 1997; Williams 2009; Yankell 1997). Rotation oscillation toothbrushes were statistically significantly better for plaque reduction in the short term (1-3 months) (SMD 0.24 (95% CI 0.02 to 0.46)). The confidence interval for the meta-analysis for effects on gingivitis only just included zero (SMD 0.35 [-0.04, 0.74]), suggesting that rotation oscillation brushes may also be better at reducing gingivitis than side to side brushes. No significant heterogeneity was found. There were no differences between the modes action for either plaque or gingivitis reduction in the long term (> 3 months).

Side to side versus circular

(Analysis 3.1; Analysis 3.2)
One trial, with data from 64 participants (Yankell 1997) showed no significant difference between these modes of action in the short term (1-3 months) for plaque. The circular mode of action toothbrushes showed a significant reduction in gingivitis in the short term (SMD 0.89 (95% CI 0.38 to 1.41)). No long term data were reported.

Counter oscillation versus rotation oscillation

One cross-over trial of 36 adolescents (Trimpeneers 1997) compared brushes with counter oscillation and a rotation oscillation mode of action (as well as a brush with a circular action and a manual toothbrush). Between brush differences were assessed in terms of the gingival index, bleeding index, plaque index and plaque index brackets at 1 and 2 months. Data were not presented in a suitable format for meta-analysis. However, no significant differences were found between the counter oscillation and rotation oscillation brushes (P values ranged from 0.06 to 0.75) for any of the reported outcomes.

Counter oscillation versus circular

The trial by Trimpeneers 1997 reported a significant difference in favour of the counter oscillation brush for both gingival index and plaque index at 2 months over a circular mode of action brush. Data were unsuitable for meta-analysis.

Rotation oscillation versus circular

(Analysis 4.1; Analysis 4.2)
Two trials (Trimpeneers 1997; Yankell 1997) compared a rotation oscillation brush with a brush with a circular mode of action. Yankell 1997 analysed data from 64 participants. No significant difference between these modes of powered brushing in the short term (1-3 months) for plaque was shown (SMD -0.02 (95% CI

-0.51 to 0.47)). A significant reduction in gingivitis was shown in favour, in the short term, of the circular mode of action brush (SMD 0.87 (95% CI 0.36 to 1.39)).

Multidimensional versus side to side

(Analysis 5.1; Analysis 5.2)

Three trials, with data from 236 participants (Goyal 2005; Patters 2005; Zimmer 2005) presented data with regard to short term plaque reduction. However, there was significant heterogeneity across the studies ($P < 0.1$; $I^2 = 96\%$), so no statistical pooling was undertaken. Similarly, there was considerable heterogeneity for the two trials presenting data on gingivitis (< 3 months) (Patters 2005; Zimmer 2005). No long term data were reported.

Multidimensional versus rotation oscillation

(Analysis 6.1; Analysis 6.2)

The two trials making this comparison (Heasman 1999; Williams 2002) show no significant difference between these modes of powered brushing in the short term (1-3 months) for plaque or gingivitis. No long term data were reported.

Ultrasonic versus multidimensional

One cross-over trial made this comparison (Costa 2007). Data were not available in a useable form.

Sensitivity analysis

Insufficient data were available.

Publication bias

Insufficient data were available.

Secondary outcomes

Cost

None of the trials reported on the relative costs of using the individual powered toothbrushes.

Reliability

No mechanical failures were reported in the trials.

Calculus

One trial included reported a significant reduction with lower lingual incisor calculus with the use of a rotation oscillation versus a side to side mode of action powered toothbrush in the short term (1-3 months) (Isaacs 1998).

Staining

One trial reported reduced staining in the short term (1-3 months) with a multidimensional versus side to side mode of action powered brushes (Patters 2005).

Adverse events

One trial reported "transient abrasions" in both powered toothbrush groups (Khocht 1992). One trial reported some discomfort with use with one mode of action brush (Grossman 1995). No difference in dentine hypersensitivity was reported in one trial (Hefti 2000). Costa 2007 also reported no adverse events identified by either participants or examiner.

DISCUSSION

There is a substantial market in powered toothbrushes and the public need substantiated advice about whether specific products are worthy of their investment. From a professional perspective, dentists want to assist their patients with the long term maintenance of their oral health. The findings of this review do not support the use of any particular mode of action for powered brushes. No mode of action was consistently superior across all outcomes/time periods studied.

When pooling was achievable without significant heterogeneity, data supported the superiority of rotation oscillation over side to side modes of action in the short term for plaque reduction and a similar effect was a likely on gingivitis. Clinically the relative superiority of the rotation oscillation mode of action to the side to side mode of action would equate to a 7% reduction in Turesky plaque scores at the significance level demonstrated in the meta-analysis using the data from one of the trials with a similar standard deviation (Grossman 1995).

Few other definitive conclusions could be drawn due to the small number of studies included in the review. No mode of action consistently proved to be superior to other modes of action when assessed over short and longer time periods and by plaque and gingival scores. Analysis of the longer term effects (> 3 months) is particularly hampered by the lack of trials, with only one trial reporting any outcome after 3 months. As is often the case, it must be stressed, that absence of evidence is not evidence of absence, and it may be that future trials may show superiority of specific toothbrush designs.

Previous reviews (Heanue 2003; Robinson 2005) indicated that powered brushes with a rotation oscillation mode of action were more effective at reducing plaque and gingivitis when compared to manual brushes. No other powered brushes showed consistent reductions in plaque and gingivitis when compared to manual brushes. The findings of these earlier reviews have sometimes been

interpreted to suggest that rotation oscillation brushes are more effective than powered brushes with other modes of action. The results in this current review may be compatible with such indirect comparisons. Indirect and direct comparisons have yielded conflicting findings in other systematic reviews, in part because indirect comparisons are susceptible to bias (Glenny 2005).

There may be other clinical outcomes from oral hygiene with powered toothbrushes, including changed incidence and progression of periodontitis or dental caries, and further research may be required using these outcomes. In addition, there are other reasons people chose to use a particular type of toothbrush, which may or may not be related to clinical outcomes, including avoiding bad breath, improving the appearance of the teeth and because they like to use technological solutions. The ease and comfort of use are also factors which decide the purchase of these products. These factors fall outside the scope of this review, but may also warrant further research.

No data were reported on the costs or reliability of the brushes. The problems reported were injuries to the gingivae, which were minor and transient, and some discomfort with use. 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).

A possible weakness of this review was the grouping of toothbrushes by their modes of action. This was attempted to allow more powerful meta-analysis. Subtle differences between powered brushes could therefore not be analysed. This grouping also reduced the number of trials entered, as some trials compared different brushes with the same mode of action, therefore these were not included. Similarly, many other 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, so that not all of them could be isolated and analysed. Whether the brush has a battery or rechargeable power source may also be important.

AUTHORS' CONCLUSIONS

Implications for practice

Powered brushing offers a method of controlling both plaque and gingivitis. There is some evidence that rotation oscillation brushes reduce plaque and gingivitis reduction more than side to side brushes in the short term. This difference is small and it's clinical importance is unclear. Rotation oscillation brushes were also more effective at reducing plaque and gingivitis when compared to manual brushing (Robinson 2005). At present the superiority of any other mode of powered brushing has not been established. Further research is required before evidence based advice concerning the relative performance of the different powered toothbrushes can be given by healthcare professionals to the public.

Implications for research

Further trials of good quality as suggested previously (Robinson 2006) will help to assess whether any other modes of action are superior. These recommendations include: following CONSORT guidelines, greater standardisation of the indices used to measure plaque and gingivitis and trials which utilise longer follow-up periods to establish the long term effects of the different modes of powered toothbrushing.

ACKNOWLEDGEMENTS

Thanks are due to Sylvia Bickley and Anne Littlewood, Trials Search Co-ordinators for the Cochrane Oral Health Group, for carrying out the searches for the review.

REFERENCES

References to studies included in this review

Costa 2007 ***{published data only}***
Costa MR, Silva VC, Miqui MN, Sakima T, Spolidorio DMP, Cirelli JA. Efficacy of ultrasonic, electric and manual toothbrushes in patients with fixed orthodontic appliances. *Angle Orthodontist* 2007;**77**(2):361–6.

Goyal 2005 ***{published data only}***
Goyal CR, Sharma NC, Qaqish JG, Cugini MA, Thompson MC, Warren PR. Efficacy of a novel brush head in the comparison of two power toothbrushes on removal of plaque and naturally occurring extrinsic stain. *Journal of Dentistry* 2005;**33 Suppl 1**:37–43.

Goyal 2009 ***{published data only}***
Goyal CR, Qaqish J, He T, Grender J, Walters P, Biesbrock AR. A randomized 12-week study to compare the gingivitis and plaque reduction benefits of a rotation-oscillation power toothbrush and a sonic power toothbrush. *The Journal of clinical dentistry* 2009;**20**(3):93–8.

Grossman 1995 ***{published data only}***
Grossman E, Dembling W, Proskin HM. A comparative clinical investigation of the safety and efficacy of an oscillating/rotating electric toothbrush and a sonic toothbrush. *Journal of Clinical Dentistry* 1995;**6**(1):108–12.

Heasman 1999 ***{published data only}***
Heasman PA, Stacey F, Heasman L, Sellers P, Macgregor ID,

Kelly PJ. A comparative study of the Philips HP 735, Braun/ Oral B D7 and the Oral B 35 Advantage toothbrushes. *Journal of Clinical Periodontology* 1999;**26**(2):85–90.

Hefti 2000 ***{published data only}***
Hefti AF, Stone C. Power toothbrushes, gender, and dentin hypersensitivity. *Clinical Oral Investigations* 2000;**4**(2): 91–7.

Isaacs 1998 ***{published data only}***
Isaacs RL, Beiswanger BB, Rosenfield ST, Crawford JL, Mau MS, Eckert GJ, et al.A crossover clinical investigation of the safety and efficacy of a new oscillating/rotating electric toothbrush and a high frequency electric toothbrush. *American Journal of Dentistry* 1998;**11**(1):7–12.

Khocht 1992 ***{published data only}***
Khocht A, Spindel L, Person P. A comparative clinical study of the safety and efficacy of three toothbrushes. *Journal of Periodontology* 1992;**63**(7):603–10.

Patters 2005 ***{published data only}***
Patters MR, Bland PS, Shiloah J, Blankenship JA, Scarbecz M. Comparison of the Hydrabrush powered toothbrush with two commercially-available powered toothbrushes. *Journal of the International Academy of Periodontology* 2005; **7**(3):80–9.

Robinson 1997 ***{published data only}***
Robinson PJ, Maddalozzo D, Breslin S. A six-month clinical comparison of the efficacy of the Sonicare and the Braun Oral-B electric toothbrushes on improving periodontal health in adult periodontitis patients. *Journal of Clinical Dentistry* 1997;**8**(1 Spec No):4–9.

Shibly 1997 ***{published data only}***
Shibly O, Schifferle RE, Ciancio SG, Tarakji M, Mather ML. A clinical comparison of 2 electric toothbrush designs. *Journal of Clinical Periodontology* 1997;**24**(4):260–3.

Thienpont 2001a ***{published data only}***
Thienpont V, Dermaut LR, Van Maele G. Comparative study of 2 electric and 2 manual toothbrushes in patients with fixed orthodontic appliances. *American Journal of Orthodontics & Dentofacial Orthopedics* 2001;**120**(4): 353–60.

Trimpeneers 1997 ***{published data only}***
Trimpeneers LM, Wijgaerts IA, Grognard NA, Dermaut LR, Adriaens PA. Effect of electric toothbrushes versus manual toothbrushes on removal of plaque and periodontal status during orthodontic treatment. *American Journal of Orthodontics & Dentofacial Orthopedics* 1997;**111**(5):492–7.

Williams 2002 ***{published data only}***
Williams K, Walters PA, Bartizek RD, Biesbrock AR. The reduction of gingivitis using battery-powered toothbrushes over a one-month period. *Journal of Clinical Dentistry* 2002; **13**(5):207–10.

Williams 2009 ***{published data only}***
Williams K, Rapley K, Haun J, Walters P, He T, Grender J, et al.Comparison of rotation/oscillation and sonic power toothbrushes on plaque and gingivitis for 10 weeks. *American Journal of Dentistry* 2009;**22**(6):345–9.

Yankell 1997 ***{published data only}***
Yankell SL, Emling RC. A thirty-day safety and efficacy evaluation of the Rowenta, Braun and Sonicare powered toothbrushes and a manual toothbrush. *Journal of Clinical Dentistry* 1997;**8**(4):120.

Zimmer 2005 ***{published data only}***
Zimmer S, Strauss J, Bizhang M, Krage T, Raab WH, Barthel C. Efficacy of the Cybersonic in comparison with the Braun 3D Excel and a manual toothbrush. *Journal of Clinical Periodontology* 2005;**32**(4):360–3.

References to studies excluded from this review

Aass 2000 ***{published data only}***
Aass AM, Gjermo P. Comparison of oral hygiene efficacy of one manual and two electric toothbrushes. *Acta Odontologica Scandinavica* 2000;**58**(4):166–70.

Ainamo 1991 ***{published data only}***
Ainamo J, Hormia M, Kaunisaho K, Sorsa T, Suomalainen K. Effect of manual versus powered toothbrushes. *Journal of Dental Research* 1991;**70**(Special Issue):557 (Abs No 2329).

Bader 1997 ***{published data only}***
Bader H, Williams R. Clinical and laboratory evaluation of powered electric toothbrushes: comparative efficacy of two powered brushing instruments in furcations and interproximal areas. *Journal of Clinical Dentistry* 1997;**8**(3 Spec No):91–4.

Bader 1999 ***{published data only}***
Bader HI, Boyd RL. Comparative efficacy of a rotary and a sonic powered toothbrush on improving gingival health in treated adult periodontitis patients. *American Journal of Dentistry* 1999;**12**(3):143–7.

Bader 2001 ***{published data only}***
Bader HI, Zahradnik RT. Comparative clinical efficacy of a rotary and a counter-rotating powered toothbrush. *Journal of Dental Research* 2001;**80**(Special Issue):119 (Abs No 667).

Barnes 1999 ***{published data only}***
Barnes CM, Russell CM, Weatherford TW 3rd. A comparison of the efficacy of 2 powered toothbrushes in affecting plaque accumulation, gingivitis, and gingival bleeding. *Journal of Periodontology* 1999;**70**(8):840–7.

Berbig 2000 ***{published data only}***
Berbig B, Von Bethlenfalvy ER, Pioch T, Staehle HJ, Dorfer CE. Cleaning efficacy of two powered toothbrushes. *Journal of Dental Research* 2000;**79**(Special Issue):623 (Abs No 3838).

Blahut 1993 ***{published data only}***
Blahut P. A clinical trial of the INTERPLAK powered toothbrush in a geriatric population. *Compendium (Newtown, Pa). Supplement* 1993;**(16)**:S606–10.

Brambilla 1998 ***{published data only}***
Brambilla E, Felloni A, Cagetti MG, Canegallo LF, Strohmenger L. Effects of two powered toothbrushes on cariogenic microflora In vivo. *Journal of Dental Research* 1998;**77**(Special Issue A):287 (Abs No 1453).

Buchmann 1987 *{published data only}*
Buchmann R. Indications and use of electric toothbrushes in individual oral hygiene - a comparison. *Die Quintessenz* 1987;**38**(3):531–5.

Ciancio 1994 *{published data only}*
Ciancio SG, Kazmierczak M, Mather ML, Bessinger MA, Nisengard RJ. Microbiological effects of manual and three electric toothbrushes. *Journal of Dental Research* 1994;**73** (Special Issue):433 (Abst No 2652).

Ciancio 1994a *{published data only}*
Ciancio SG, Kazmierczak M, Mather ML, Bessinger MA, Ho AW. Clinical comparison of manual brushing and three electric toothbrushes. *Journal of Dental Research* 1994;**73** (Special Issue):433 (Abst No 2653).

Conforti 2001 *{published data only}*
Conforti NJ, Chaves ES, Liebman J, Bowman JP, Warren PR, Cugini M. A comparative 3-month clinical investigation of the safety and efficacy of a battery-operated and a rechargeable oscillating-rotating power toothbrush. *American Journal of Dentistry* 2001;**14**(2):59–62.

Cronin 1996 *{published data only}*
Cronin M, Gordon J, Fernandez P, Reardon R. Comparison of two electric toothbrushes in reducing plaque and gingivitis. *Journal of Dental Research* 1996;**75**(March Special Issue 1):86 (Abs No 550).

Cronin 2005 *{published data only}*
Cronin MJ, Dembling WZ, Cugini MA, Thompson MC, Warren PR. Three-month assessment of safety and efficacy of two electric toothbrushes. *Journal of Dentistry* 2005;**33 Suppl 1**:23–8.

Cross 1962a *{published data only}*
Cross WG, Forrest JO, Wade AB. A comparative study of tooth cleansing using conventional and electrically operated toothbrushes. *British Dental Journal* 1962;**113**(1):19–22.

He 2001 *{published data only}*
He T, Carpinello L, Baker R, Knippenberg S, Das A, Winston L, et al.Safety of three toothbrushes. *American Journal of Dentistry* 2001;**14**(3):123–6.

Heasman 1998 *{published data only}*
Heasman P, Wilson Z, Macgregor I, Kelly P. Comparative study of electric and manual toothbrushes in patients with fixed orthodontic appliances. *American Journal of Orthodontics & Dentofacial Orthopedics* 1998;**114**(1):45–9.

Hefti 2000a *{published data only}*
Hefti AF, Stone C. Power toothbrushes, gender, and dentin hypersensitivity. *Clinical Oral Investigations* 2000;**4**(2): 91–7.

Heintze 1996 *{published data only}*
Heintze SD, Jost-Brinkmann PG, Loundos J. Effectiveness of three different types of electric toothbrushes compared with a manual technique in orthodontic patients. *American Journal of Orthodontics & Dentofacial Orthopedics* 1996;**110** (6):630–8.

Karpinia 2002 *{published data only}*
Karpinia K, Magnusson I, Biesbrock AR, Walters PA, Bartizek RD. The effectiveness of two different battery-powered toothbrushes on whitening through removal of stain. *Journal of Clinical Dentistry* 2002;**13**(5):215–8.

Lobene 1971 *{published data only}*
Lobene RR, Soparkar PM, Hein JW. The effect of different powered toothbrush motions on gingival health. *Journal of Dental Research* 1971;**IADR Program & Abstracts**:121 (Abs No 276).

Mayer 1990 *{published data only}*
Mayer R. Electric toothbrushes--manual toothbrushes, a comparison. *ZWR* 1990;**99**(3):188–92.

McCracken 2000 *{published data only}*
McCracken GI, Heasman L, Stacey F, Kelly PJ, Heasman PA. Testing the efficacy of plaque removal of a prototype brush head for a powered toothbrush. *Journal of Clinical Periodontology* 2000;**27**(8):542–8.

McCracken 2001 *{published data only}*
McCracken GI, de Jager M, van Kemenade P, Milward M. A multi-centre study of 2 powered toothbrushes for plaque removal efficacy. *Journal of Dental Research* 2001;**80**(Special Issue March 2001):548 (Abs No 0173).

McCracken 2001a *{published data only}*
McCracken GI, Stacey F, Heasman L, Sellers P, Macgregor ID, Kelly PJ, et al.A comparative study of two powered toothbrushes and one manual toothbrush in young adults. *Journal of Clinical Dentistry* 2001;**12**(1):7–10.

McCracken 2006 *{published data only}*
McCracken GI, Preshaw PM, Steen IN, Swan M, deJager M, Heasman PA. Measuring plaque in clinical trials: index or weight?. *Journal of Clinical Periodontology* 2006;**33**(3): 172–6.

Moran 1995 *{published data only}*
Moran JM, Addy M, Newcombe RG. A comparative study of stain removal with two electric toothbrushes and a manual brush. *Journal of Clinical Dentistry* 1995;**6**(4): 188–93.

Moran 1995a *{published data only}*
Moran J, Addy M, Warren P, Newcombe R. Stain removal efficacy of two electric toothbrushes. *Journal of Dental Research* 1995;**74**(Special Issue):132 (Abs No 968).

Moschen 1999 *{published data only}*
Moschen I, Furtlehner H, Kulmer S, Horl R, Falk M, Kemmler G. Clinical comparative study of one manual and three electric toothbrushes with different mechanical movement patterns. *Deutsche Zahnarztliche Zeitschrift* 1999;**54**(6):372–9.

Putt 1999 *{published data only}*
Putt MS, Davidson KR, Milleman JL, Kleber CJ. Comparison of two electric toothbrushes in reducing plaque and gingivitis. *Journal of Dental Research* 1999;**78**(March Special Issue):413 (Abs No 2461).

Putt 2001 *{published data only}*
Putt MS, Milleman JL, Davidson KR, Kleber CJ, Cugini M. A split-mouth comparison of a three-dimensional-action electric toothbrush and a high-frequency electric toothbrush for reducing plaque and gingivitis. *Journal of the International Academy of Periodontology* 2001;**3**(4):95–103.

Putt 2001a *{published data only}*
Putt MS, Milleman JL, Davidson KR, Cugini M, Warren PR. A 3-month clinical comparison of the safety and efficacy of two battery-operated toothbrushes: the Braun Oral-B Battery toothbrush and the Colgate Actibrush. *American Journal of Dentistry* 2001;**14 Spec No**:13B–17B.

Rosema 2005 *{published data only}*
Rosema NA, Timmerman MF, Piscaer M, Strate J, Warren PR, Van der Velden U, et al.An oscillating/pulsating electric toothbrush versus a high-frequency electric toothbrush in the treatment of gingivitis. *Journal of Dentistry* 2005;**33 Suppl 1**:29–36.

Sharma 1998 *{published data only}*
Sharma NC, Galustians J, Qaqish J, Cugini M. A comparison of two electric toothbrushes with respect to plaque removal and subject preference. *American Journal of Dentistry* 1998;**11**(Spec No):S29–33.

Sharma 2000 *{published data only}*
Sharma NC, Galustians HJ, Qaqish J, Cugini M, Warren PR. A comparison of the Braun Oral-B 3D plaque remover and the Sonicare plus electric toothbrush in removing naturally occurring extrinsic staining. *American Journal of Dentistry* 2000;**13**(1):17–20.

Sharma 2001 *{published data only}*
Sharma NC, Galustians HJ, Qaqish J, Cugini M, Warren PR. The effect of two power toothbrushes on calculus and stain. *Journal of Dental Research* 2001;**80**(Special Issue March 2001):548 (Abs No 0171).

Sharma 2002 *{published data only}*
Sharma NC, Galustians HJ, Qaqish J, Cugini M, Warren PR. The effect of two power toothbrushes on calculus and stain formation. *American Journal of Dentistry* 2002;**15**(2): 71–6.

Siebert 2000 *{published data only}*
Siebert K, Glockmann I, Glockmann E, Sigusch B. Efficacy in plaque removal by the three dimensionally working electric toothbrush. *Journal of Dental Research* 2000;**79** (Special Issue 1):298 (Abs No 1235).

Silverman 2004 *{published data only}*
Silverman J, Rosivack RG, Matheson PB, Houpt MI. Comparison of powered and manual toothbrushes for plaque removal by 4- to 5-year-old children. *Pediatric Dentistry* 2004;**26**(3):225–30.

Thienpont 2001 *{published data only}*
Thienpont V, Dermaut LR, Van Maele G. Comparative study of 2 electric and 2 manual toothbrushes in patients with fixed orthodontic appliances. *American Journal of Orthodontics & Dentofacial Orthopedics* 2001;**120**(4): 353–60.

Trimpeners 1996 *{published data only}*
Trimpeners L, Dermaut L, Adriaens UZ. Effect of electric versus manual toothbrushes on plaque removal and periodontal status during orthodontic treatment. *European Journal of Orthodontics* 1996;**18**(4):426 (Abs No 66).

Tscharre 1989 *{published data only}*
Tscharre-Zachhuber C, Riedl MA, Kulmer S, Kemmler G. Effectiveness of power toothbrushes. *Zeitschrift fur Stomatologie* 1989;**86**(6):369–75.

van der Weijden 1999 *{published data only}*
van der Weijden GA, Timmerman MF, Piscaer M, Ijzerman Y, van deer Velden U. Efficacy and gingival abrasion after brushing with three electric toothbrushes. *Journal of Dental Research* 1999;**78**(Specia Issue):216 (Abs No 883).

Versteeg 2005 *{published data only}*
Versteeg PA, Timmerman MF, Rosema NA, Warren PR, Van der Velden U, Van der Weijden GA. Sonic-powered toothbrushes and reversal of experimental gingivitis. *Journal of Clinical Periodontology* 2005;**32**(12):1236–41.

Williams 2010 *{published data only}*
Williams K, Rapley K, Haun J, Walters P, Grender J, He T, et al.Benefit of the power component of sonic and rotation-oscillation modes of action for plaque removal using power toothbrushes. *American Journal of Dentistry* 2010;**23**:60–4.

Wilson 1991 *{published data only}*
Wilson S, Levine D, Porush J. A clinical study to compare the antiplaque and antigingivitis effectiveness of 2 electric toothbrushes and a manual toothbrush after 3 months of normal useage. *Journal of Periodontology* 1991;**62**(12):808.

Zimmer 1999 *{published data only}*
Zimmer S, Fosca M, Roulet JF. Clinical study of the effectiveness of two sonic toothbrushes. *Journal of Clinical Dentistry* 1999;**11**(1):24–7.

Additional references

Addy 1986
Addy M, Dummer PM, Griffiths G, Hicks R, Kingdon A, Shaw WC. Prevalence of plaque, gingivitis and caries in 11-12- year old children in South Wales. *Community Dentistry and Oral Epidemiology* 1986;**14**(2):115–8.

Addy 2003
Addy M, Hunter ML. Can tooth brushing damage your health? Effects on oral and dental tissues. *International Dental Journal* 2003;**53 Suppl 3**:177–86.

Ainamo 1975
Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. *International Dental Journal* 1975;**25** (4):229–35.

Axelsson 1978
Axelsson P, Lindhe J. Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. *Journal of Clinical Periodontology* 1978;**5**(2):133–51.

Axelsson 1981
Axelsson P, Lindhe J. Effect of controlled oral hygiene procedures on caries and periodontal disease in adults.

Results after 6 years. *Journal of Clinical Periodontology* 1981; **8**(3):239–48.

Begg 1994

Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics* 1994;**50**(4): 1088–101.

Chilton 1962

Chilton NW, Didio A, Rothner JT. Comparison of the clinical effectiveness of an electric and a standard toothbrush in normal individuals. *Journal of the American Dental Association* 1962;**64**:777–82.

Cross 1962

Cross WG, Forrest JO, Wade AB. A comparative study of tooth cleansing using conventional and electrically operated toothbrushes. *British Dental Journal* 1962;**113**:19–22.

Deeks 2001

Deeks JJ, Altman DG, Bradburn MJ. Statistical methods for examining heterogeneity and combining results from several studies in meta-analysis. In: Egger M, Davey Smith G, Altman DG editor(s). *Systematic Reviews in Health Care: Meta-analysis in Context*. 2nd Edition. London: BMJ Publication Group, 2001.

Egger 1997

Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;**315**(7109):629–34.

Elbourne 2002

Elbourne DR, Altman DG, Higgins JP, Curtin F, Worthington HV, Vail A. Meta-analyses involving cross-over trials: methodological issues. *International Journal of Epidemiology* 2002;**31**(1):140–9.

Elliot 1963

Elliot JR. A comparison of the effectiveness of a standard and electric toothbrush. *Journal of Periodontology* 1963;**34**: 375–9.

Glenny 2005

Glenny AM, Altman DG, Song F, Sakarovitch C, Deeks JJ, D'Amico R, et al.Indirect comparisons of competing interventions. *Health Technology Assessment* 2005;**9**(26):1-134, iii-iv.

Heanue 2003

Heanue M, Deacon SA, Deery C, Robinson PG, Walmsley AD, Worthington HV, et al.Manual versus powered toothbrushing for oral health. *Cochrane Database of Systematic Reviews* 2003, Issue 1. [DOI: 10.1002/14651858.CD002281]

Higgins 2008

Higgins JP, White IR, Anzures-Cabrera J. Meta-analysis of skewed data: combining results reported on log-transformed or raw scales. *Statistics in Medicine* 2008;**27**(29):6072–92.

Higgins 2009

Higgins JPT, Green S (editors). The Cochrane Handbook for Systematic Reviews of Interventions version 5.0.2 (updated September 2009). The Cochrane Collaboration 2009. Available from www.cochrane-handbook.org.

Hoover 1962

Hoover DR, Robinson HB. Effect of automatic and hand toothbrushing on gingivitis. *Journal of the American Dental Association* 1962;**65**:361–7.

Lang 1998

Lang NP, Hase JC, Grassi M, Hammerle CH, Weigel C, Kelty E, et al.Plaque formation and gingivitis after supervised mouthrinsing with 0.2% delmopinol hydrochloride, 0.2% chlorhexidine digluconate and placebo for 6 months. *Oral Diseases* 1998;**4**(2):105–13.

Loe 1963

Löe H, Silness J. Periodontal disease in pregnancy. I.Prevalence and severity. *Acta Odontologica Scandinavica* 1963;**21**:533–51.

Loe 1965

Löe H, Theilade E, Jensen SB. Experimental gingivitis in man. *Journal of Periodontology* 1965;**36**:177–87.

Lorentz 2010

Lorentz TC, Cota LO, Cortelli JR, Vargas AM, Costa FO. Tooth loss in individuals under periodontal maintenance therapy: prospective study. *Brazilian Oral Research* 2010;**24** (2):231–7.

Marinho 2003

Marinho VC, Higgins JP, Logan S, Sheiham A. Topical fluoride (toothpastes, mouthrinses, gels or varnishes) for preventing dental caries in children and adolescents. *Cochrane Database of Systematic Reviews* 2003, Issue 4. [DOI: 10.1002/14651858.CD002782]

McCracken 2005

McCracken GI, Steen N, Preshaw PM, Heasman L, Stacey F, Heasman PA. The crossover design to evaluate the efficacy of plaque removal in tooth-brushing studies.. *Journal of Clinical Periodontology* 2005;**32**(11):1157–62.

McCracken 2009

McCracken GI, Heasman L, Stacey F, Swan M, Steen N, de Jager M, et al.The impact of powered and manual toothbrushing on incipient gingival recession. *Journal of Clinical Periodontology* 2009;**36**(11):950–7.

Quigley 1962

Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *Journal of the American Dental Association* 1962;**65**:26–9.

RevMan2008

The Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager (RevMan). 5.0. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2008.

Richardson 1977

Richardson AS, Boyd MA, Conry RF. A correlation study of diet, oral hygiene and dental caries in 457 Canadian children. *Community Dentistry and Oral Epidemiology* 1977; **5**(5):227–30.

Robinson 2005

Robinson PG, Deacon SA, Deery C, Heanue M, Walmsley AD, Worthington HV, et al.Manual versus powered toothbrushing for oral health. *Cochrane Database of*

Systematic Reviews 2005, Issue 2. [DOI: 10.1002/14651858.CD002281.pub2]

Robinson 2006

Robinson PG, Walmsley AD, Heanue M, Deacon S, Deery C, Glenny AM, et al.Quality of trials in a systematic review of powered toothbrushes: suggestions for future clinical trials. *Journal of Periodontology* 2006;**77**(12):1944–53.

Russell 1967

Russell AL. The Periodontal Index. *Journal of Periodontology* 1967;**38**(6):586–91.

Turesky 1970

Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of vitamin C. *Journal of Periodontology* 1970;**41**(1):41–3.

White 2008

White IR, Higgins JP, Wood AM. Allowing for uncertainty due to missing data in meta-analysis--part 1: two-stage methods. *Statistics in Medicine* 2008;**27**(5):711–27.

* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Costa 2007

Methods	RCT, cross-over, single blind, n = 21 with no drop outs
Participants	Brazil, children (aged 12 years to 18 years), orthodontic treatment with fixed appliances for > 1 year, > 20 teeth
Interventions	Ultrasonic Ultima Toothbrush versus Braun Oral B 3D
Outcomes	Silness and Loe plaque Index, Loe and Silness gingival index. Assessment at 4 weeks. Examination 3-5 hours post-brushing
Notes	Funding unclear Trial had third intervention arm of manual toothbrush

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "participants were randomly divided"
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Blind outcome assessment	Low risk	Quote: "blinded trained examiner"

Goyal 2005

Methods	RCT, parallel, single blind, n = 90 with no drop outs
Participants	Canada, adults, no appliances, previous powered brush use, > 18 teeth
Interventions	Braun Oral B Professional Care 7000 plus standard FlexiSoft brush head versus Braun Oral B Professional Care 7000 plus Prop Polisher versus Sonicare Elite
Outcomes	Quigley and Hein modified Turesky plaque index. Assessment at 6 weeks. Full mouth assessment used. No brushing 12-18 hours prior to examination
Notes	Manufacturer funded For purpose of analysis, the 2 multidimensional brushes were combined (Braun Oral B Professional Care 7000 plus standard FlexiSoft brush head versus Braun Oral B Professional Care 7000 plus Prop Polisher) and compared to the Sonicare Elite

Goyal 2005 (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Blind outcome assessment	Low risk	Quote: "The same examiner performed all clinical assessments for all subjects at all time points, but was blinded to product assignment"

Goyal 2009

Methods	RCT, parallel, n = 170 with 4 drop outs
Participants	USA, adults, with good general health, brush twice daily, gingivitis level threshold 1.75-2.3 at entrance to trial
Interventions	Oral B Triumph versus Sonicare
Outcomes	Silness and Loe gingival index. Full mouth assessment. No brushing 12 hours before assessment
Notes	Manufacturer funded

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Stratified according to plaque, gingivitis, gender, smoking
Allocation concealment (selection bias)	Unclear risk	Not clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop outs reported
Blind outcome assessment	Low risk	Protected area for blind assessor described

Grossman 1995

Methods	RCT, parallel, single blind, n = 116 with no drop outs	
Participants	USA, adults, with no previous history with powered toothbrushing, no systemic disease	
Interventions	Braun Oral B Plaque Remover versus Sonicare	
Outcomes	Quigley and Hein modified Turesky plaque index and Silness and Loe gingival index. Assessment at 2 months. Full mouth assessment. No brushing overnight prior to examination	
Notes	Funding unclear	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Implied though details not explicit, quote "groups were matched according to age, gender, baseline plaque index and baseline gingival index"
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Blind outcome assessment	Low risk	Single blind assessment with different examiners for plaque and gingivitis

Heasman 1999

Methods	RCT, parallel, blind, n = 50 with no drop outs	
Participants	UK, adults, no previous powered brush use, no periodontal disease, no removable prosthesis	
Interventions	Braun Oral B D7 versus Philips Jordan HP 735	
Outcomes	Quigley and Hein modified Turesky plaque index and Loe and Silness gingival index. Assessment at 6 weeks. Full mouth assessment. Supervised brushing instruction, brushing 3-4 hours prior to examination	
Notes	Funding unclear	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

Heasman 1999 (*Continued*)

Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Blind outcome assessment	Low risk	Quote: "Subjects were instructed carefully and repeatedly, not to reveal the identity of their allocated toothbrush to the clinician who recorded the clinical indices"

Hefti 2000

Methods	RCT, parallel, unclear blind, n = 62 with 3 drop outs
Participants	USA, adults, dentine hypersensitivity, no systemic or oral disease
Interventions	Braun Oral B Plaque Remover versus Sonicare
Outcomes	Quigley and Hein modified Turesky plaque index. Assessment at 8 weeks. Full mouth assessment. Supervised brushing instruction, refrain from brushing 1 hour prior to examination Mean and SD data were taken from the graphical format in the paper. Authors were contacted for the original data, no response to date
Notes	Funding unclear

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Probably done due to details of stratification, although not explicit
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	3/62 excluded. Reasons unlikely to be related to outcomes
Blind outcome assessment	Low risk	Quote: "examiner-blind clinical trial"

Isaacs 1998

Methods	RCT, cross-over, single blind, n = 72 with 10 drop outs	
Participants	USA, adults, no oral disease, no use of mouthwash	
Interventions	Braun Oral B D9 versus Sonicare	
Outcomes	Quigley and Hein modified Turesky plaque index and Silness and Loe gingival index. Assessment at 6 weeks. Full mouth assessment. No brushing from midnight prior to examination	
Notes	Manufacturer funded	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	14% drop outs. Non-device related, although unclear as to original treatment group
Blind outcome assessment	Low risk	Quote: "examiner-blind"

Khocht 1992

Methods	RCT, parallel, single blind, n = 64 with no drop outs	
Participants	USA, adults, 15 teeth with no crown or cervical restorations, no oral disease, plaque and gingivitis level	
Interventions	Epident versus Interplak	
Outcomes	Turesky plaque index and Silness and Loe gingival index. Assessment at 4 weeks. Full mouth assessment, no brushing morning of examination	
Notes	Manufacturer funded	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information

Khocht 1992 (*Continued*)

Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop outs for included brushes
Blind outcome assessment	Low risk	Examiner blind

Patters 2005

Methods	RCT, parallel, single blind, n = 95 with 15 drop outs
Participants	USA, adults with periodontal disease, no appliances, no medical conditions, no antibiotics or steroid medication
Interventions	Sonicare versus Braun Oral B 3D Excel D17525
Outcomes	Quigley and Hein modified Turesky plaque index and modified Lobene gingival index. Assessment at 12 weeks. Ramjford teeth assessed. Refrain from oral hygiene 2 hours prior to assessment
Notes	Manufacturer funded

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "random number assignment sheet generated by a computer"
Allocation concealment (selection bias)	High risk	Study co-ordinator could foresee assignment
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	14% drop outs. Reasons not given. Unbalanced drop outs across groups
Blind outcome assessment	Low risk	Quote: "examiner-blinded"

Robinson 1997

Methods	RCT, parallel, single blind, n = 66 with 12 drop outs
Participants	USA, adults, active periodontal disease, no systemic disease
Interventions	Braun Oral B D7 versus Sonicare
Outcomes	Quigley and Hein modified Turesky plaque index and bleeding on probing. Assessment at 2 months and 6 months. Full mouth assessment. Video on oral hygiene, refrain 8-12 hours brushing pre-examination

Robinson 1997 (*Continued*)

Notes	Manufacturer funded	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	High risk	18% drop outs. Uneven drop outs across groups
Blind outcome assessment	Low risk	Examiner blind

Shibly 1997

Methods	RCT, parallel, blinding unclear, n = 66	
Participants	USA, adults, plaque index ≧ 2.0, gingival index ≧ 1.5, bleeding on probing at 1/3 of sites	
Interventions	Hapika power brush versus Interplak Ultra 10	
Outcomes	Quigley and Hein modified Turesky plaque index and Lobene modified gingival index. Assessment at 1 month. Full mouth assessment. No brushing 12-14 hours prior to assessment	
Notes	Funding unclear	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Blind outcome assessment	Unclear risk	"Single blind" but not explicit

Thienpont 2001a

Methods	RCT, cross-over, single blind, n = 36 with 3 drop outs
Participants	Belgium, adolescents with fixed appliances
Interventions	Braun Oral B 3D versus Philips Jordan HP510
Outcomes	Quigley and Hein plaque index and Lobene modified gingival index. Assessment at 4 weeks. Full mouth assessment
Notes	Funding unclear

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	3/36 excluded due to lack of co-operation. Reasons unlikely to be related to outcomes
Blind outcome assessment	Unclear risk	Insufficient information

Trimpeneers 1997

Methods	RCT, cross-over, single blind, n = 36 with 1 drop out
Participants	Belgium, adolescents with fixed appliances
Interventions	Interplak versus Philips versus Rotadent
Outcomes	Quigley and Hein plaque index and Lobene modified gingival index. Assessment at 2 months. Full mouth assessment
Notes	Manufacturer funded

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information

Trimpeneers 1997 (*Continued*)

Incomplete outcome data (attrition bias) All outcomes	Low risk	1/36 excluded due to lack of compliance with orthodontic treatment. Reasons unlikely to be related to outcomes
Blind outcome assessment	Low risk	Examiner blind

Williams 2002

Methods	RCT, parallel, single blind, n = 95 with 8 drop outs	
Participants	USA, adults, > 15 teeth and 20 sites of gingival bleeding, no appliances or prosthesis, no periodontal disease	
Interventions	Crest Spinbrush versus Crest Spinbrush Pro	
Outcomes	Loe and Silness gingival index. Assessment at 4 weeks. Full mouth assessment	
Notes	Manufacturer funded	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Computer generated
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	8% drop outs. Unclear as to original treatment group
Blind outcome assessment	Low risk	Examiner blind

Williams 2009

Methods	RCT, parallel, n = 179 with 14 drop outs
Participants	USA, adults, general good health, > 16 teeth, > 20 sites BOP, entrance level plaque score required
Interventions	Oral B Triumph versus Philips Sonicare
Outcomes	Loe and Silness Ginigval Index. Full mouth scores
Notes	Manufacturer funded
Risk of bias	

Williams 2009 (*Continued*)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not clear
Allocation concealment (selection bias)	Unclear risk	Not clear
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop outs reported. Not due brush allocation.
Blind outcome assessment	Low risk	Examiner blind

Yankell 1997

Methods	RCT, parallel, single blind, n = 96 with no drop outs
Participants	USA, adults, no antibiotics, steroidal or non-steroidal anti-inflammatory agents in previous 2 weeks. No major hard of soft tissue lesions
Interventions	Braun Oral B Ultra versus Sonicare versus Rowenta Plaque Dentacontrol Plus
Outcomes	Turesky plaque index for Ramjford teeth, Lobene gingival index and Eastman bleeding index. Assessment at 1 month. Full mouth assessment. No brushing for 10-16 hours prior to assessment
Notes	Funding unclear

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Blind outcome assessment	Low risk	Examiner blind

Zimmer 2005

Methods	RCT, parallel, single blind, n = 80 with no drop outs
Participants	Germany, adults, > 20 teeth, no history of powered brush use, no non-steroidal drug recent history, no appliances or partial dentures
Interventions	Braun Oral B Excel 3D versus Cybersonic
Outcomes	Turesky plaque index, Papillary bleeding index. Assessment at 8 weeks. Full mouth assessment
Notes	Manufacturer funded Trial had third treatment arm of manual toothbrush (n = 40)

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "randomly assigned", stratified by sex and bleeding
Allocation concealment (selection bias)	Unclear risk	Insufficient information
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing data
Blind outcome assessment	Low risk	Examiner blind

RCT = randomised controlled trial; SD = standard deviation

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

Study	Reason for exclusion
Aass 2000	Too short
Ainamo 1991	Awaiting further information
Bader 1997	Split-mouth
Bader 1999	Split-mouth
Bader 2001	Split-mouth
Barnes 1999	Same brush type

(*Continued*)

Berbig 2000	Split-mouth
Blahut 1993	Awaiting further information
Brambilla 1998	Plaque and gingivitis levels not considered
Buchmann 1987	Awaiting further information
Ciancio 1994	Plaque and gingivitis not considered
Ciancio 1994a	Awaiting further information
Conforti 2001	Same brush type
Cronin 1996	Too short
Cronin 2005	Same brush type
Cross 1962a	Split-mouth
He 2001	Plaque and gingivitis levels not considered
Heasman 1998	Same brush type
Hefti 2000a	Awaiting further information
Heintze 1996	Awaiting further information
Karpinia 2002	Plaque and gingivitis not considered
Lobene 1971	Awaiting further information
Mayer 1990	Not RCT
McCracken 2000	Same brush type
McCracken 2001	Too short
McCracken 2001a	Previously reported data
McCracken 2006	Not RCT
Moran 1995	Too short
Moran 1995a	Too short
Moschen 1999	Too short

(*Continued*)

Putt 1999	Split-mouth
Putt 2001	Split-mouth
Putt 2001a	Same brush type
Rosema 2005	Split-mouth
Sharma 1998	Split-mouth
Sharma 2000	Plaque and gingivitis levels not considered
Sharma 2001	Plaque and gingivitis levels not considered
Sharma 2002	Plaque and gingivitis levels not considered
Siebert 2000	Awaiting further information
Silverman 2004	Same brush type
Thienpont 2001	Awaiting further information
Trimpeners 1996	Data published in other source
Tscharre 1989	Awaiting further information
van der Weijden 1999	Split-mouth
Versteeg 2005	Split-mouth
Williams 2010	Too short
Wilson 1991	Awaiting further information
Zimmer 1999	Too short

RCT = randomised controlled trial

DATA AND ANALYSES

Comparison 1. Side to side versus counter oscillation

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque < 3 months	2	130	Std. Mean Difference (IV, Fixed, 95% CI)	-0.02 [-0.37, 0.32]
1.1 Turesky	2	130	Std. Mean Difference (IV, Fixed, 95% CI)	-0.02 [-0.37, 0.32]
2 Gingivitis < 3 months	2	130	Std. Mean Difference (IV, Fixed, 95% CI)	-0.02 [-0.37, 0.32]
2.1 Loe & Silness	1	64	Std. Mean Difference (IV, Fixed, 95% CI)	-0.33 [-0.82, 0.16]
2.2 Lobene	1	66	Std. Mean Difference (IV, Fixed, 95% CI)	0.28 [-0.21, 0.76]

Comparison 2. Side to side versus rotation oscillation

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque < 3 months	5		SMD (Random, 95% CI)	0.24 [0.02, 0.46]
1.1 Turesky	5		SMD (Random, 95% CI)	0.24 [0.02, 0.46]
2 Gingivitis < 3 months	6		SMD (Random, 95% CI)	0.35 [-0.04, 0.74]
2.1 Loe & Silness	4		SMD (Random, 95% CI)	0.51 [0.06, 0.97]
2.2 Papillary Bleeding Index	1		SMD (Random, 95% CI)	0.02 [-0.51, 0.55]
2.3 Lobene	1		SMD (Random, 95% CI)	-0.12 [-0.61, 0.37]
3 Plaque > 3 months	1		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3.1 Turesky	1		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 Gingivitis > 3 months	1	54	Std. Mean Difference (IV, Fixed, 95% CI)	-0.44 [-0.98, 0.11]
4.1 Papillary Bleeding Index	1	54	Std. Mean Difference (IV, Fixed, 95% CI)	-0.44 [-0.98, 0.11]

Comparison 3. Side to side versus circular

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque < 3 months	1		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 Turesky	1		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 Gingivitis < 3 months	1		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Lobene	1		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Comparison 4. Rotation oscillation versus circular

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque < 3 months	1		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 Turesky	1		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 Gingivitis < 3 months	1		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Lobene	1		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Comparison 5. Multidimensional versus side to side

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque < 3 months	3		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 Turesky	3		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 Gingivitis < 3 months	2		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Papillary Bleeding Index	1		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2.2 Lobene	1		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

Comparison 6. Multidimensional versus rotation oscillation

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque < 3 months	1		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Gingivitis < 3 months	2	137	Std. Mean Difference (IV, Fixed, 95% CI)	0.24 [-0.10, 0.58]

Analysis 1.1. Comparison 1 Side to side versus counter oscillation, Outcome 1 Plaque < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 1 Side to side versus counter oscillation

Outcome: 1 Plaque < 3 months

Study or subgroup	Side to side N	Mean(SD)	Counter oscillation N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
1 Turesky							
Khocht 1992	32	1.83 (0.42)	32	1.84 (0.32)		49.2 %	-0.03 [-0.52, 0.46]
Shibly 1997	33	2.11 (0.35)	33	2.12 (0.52)		50.8 %	-0.02 [-0.50, 0.46]
Total (95% CI)	**65**		**65**			**100.0 %**	**-0.02 [-0.37, 0.32]**

Heterogeneity: $Chi^2 = 0.00$, df = 1 (P = 0.99); $I^2 = 0.0\%$

Test for overall effect: Z = 0.14 (P = 0.89)

Analysis 1.2. Comparison 1 Side to side versus counter oscillation, Outcome 2 Gingivitis < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 1 Side to side versus counter oscillation

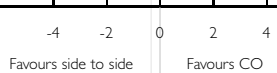
Outcome: 2 Gingivitis < 3 months

Study or subgroup	Side to side N	Mean(SD)	Counter oscillation N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
1 Loe % Silness							
Khocht 1992	32	1.01 (0.14)	32	1.06 (0.16)		49.1 %	-0.33 [-0.82, 0.16]
Subtotal (95% CI)	**32**		**32**			**49.1 %**	**-0.33 [-0.82, 0.16]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.30 (P = 0.19)							
2 Lobene							
Shibly 1997	33	1.33 (0.22)	33	1.27 (0.21)		50.9 %	0.28 [-0.21, 0.76]
Subtotal (95% CI)	**33**		**33**			**50.9 %**	**0.28 [-0.21, 0.76]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.11 (P = 0.27)							
Total (95% CI)	**65**		**65**			**100.0 %**	**-0.02 [-0.37, 0.32]**

Heterogeneity: $Chi^2 = 2.93$, df = 1 (P = 0.09); $I^2 = 66\%$

Test for overall effect: Z = 0.12 (P = 0.90)

Test for subgroup differences: $Chi^2 = 2.93$, df = 1 (P = 0.09), $I^2 = 66\%$



Analysis 2.1. Comparison 2 Side to side versus rotation oscillation, Outcome 1 Plaque < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 2 Side to side versus rotation oscillation

Outcome: 1 Plaque < 3 months

Study or subgroup	SMD (SE)	SMD IV,Random,95% CI	Weight	SMD IV,Random,95% CI
1 Turesky				
Hefti 2000	0.12 (0.3)		14.0 %	0.12 [-0.47, 0.71]
Yankell 1997	0.14 (0.25)		20.1 %	0.14 [-0.35, 0.63]
Grossman 1995	0.27 (0.19)		34.8 %	0.27 [-0.10, 0.64]
Isaacs 1998	0.3 (0.3)		14.0 %	0.30 [-0.29, 0.89]
Robinson 1997	0.34 (0.27)		17.2 %	0.34 [-0.19, 0.87]
Total (95% CI)			**100.0 %**	**0.24 [0.02, 0.46]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.52$, df = 4 (P = 0.97); $I^2 = 0.0\%$

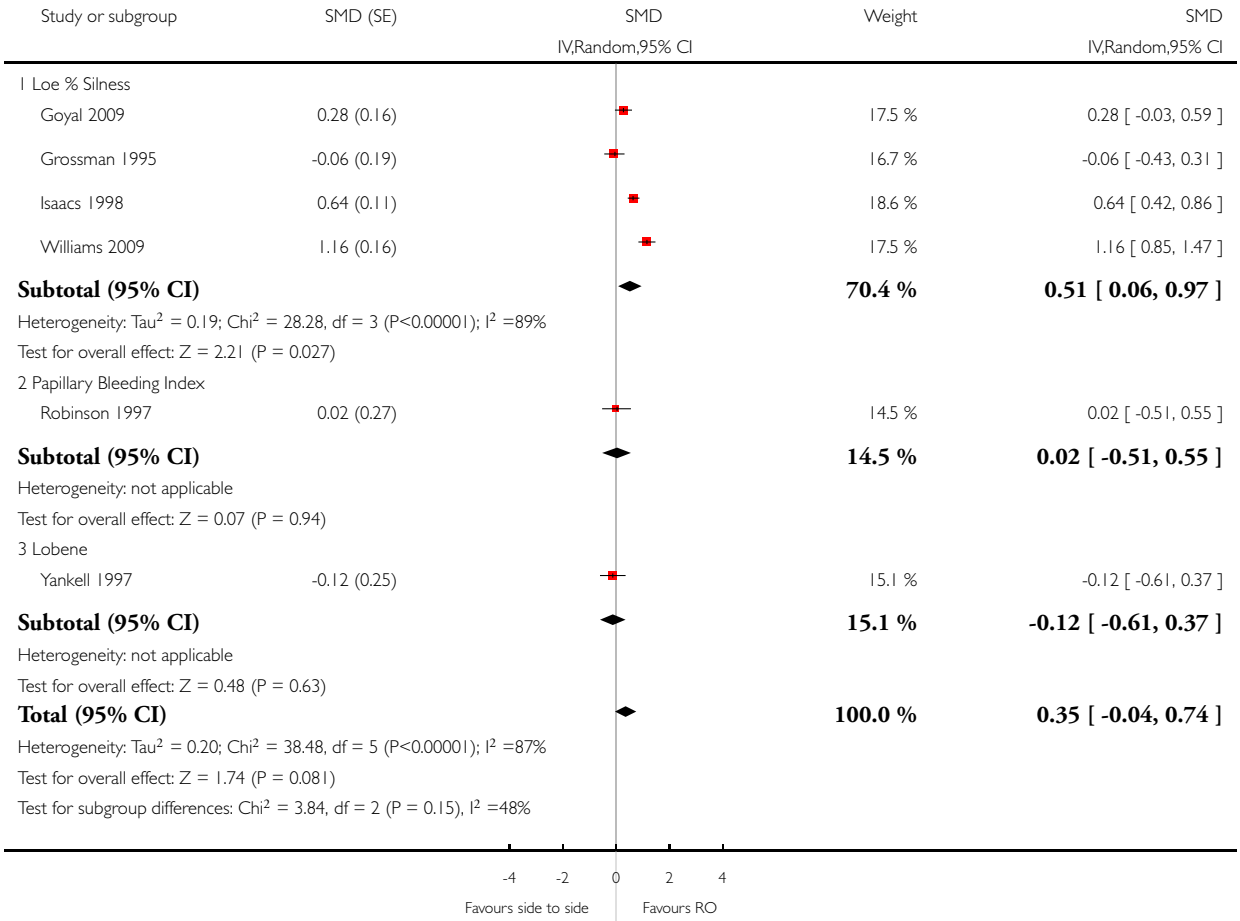
Test for overall effect: Z = 2.13 (P = 0.033)

Analysis 2.2. Comparison 2 Side to side versus rotation oscillation, Outcome 2 Gingivitis < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 2 Side to side versus rotation oscillation

Outcome: 2 Gingivitis < 3 months



Analysis 2.3. Comparison 2 Side to side versus rotation oscillation, Outcome 3 Plaque > 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 2 Side to side versus rotation oscillation

Outcome: 3 Plaque > 3 months

Study or subgroup	Side to side N	Mean(SD)	Rotation oscillation N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
1 Turesky						
Robinson 1997	29	1.69 (0.53)	25	1.65 (0.43)		0.08 [-0.45, 0.62]

Analysis 2.4. Comparison 2 Side to side versus rotation oscillation, Outcome 4 Gingivitis > 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 2 Side to side versus rotation oscillation

Outcome: 4 Gingivitis > 3 months

Study or subgroup	Side to side N	Mean(SD)	Rotation oscillation N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
1 Papillary Bleeding Index							
Robinson 1997	29	1.45 (0.29)	25	1.63 (0.51)		100.0 %	-0.44 [-0.98, 0.11]
Total (95% CI)	**29**		**25**			**100.0 %**	**-0.44 [-0.98, 0.11]**
Heterogeneity: not applicable							
Test for overall effect: Z = 1.58 (P = 0.11)							

Analysis 3.1. Comparison 3 Side to side versus circular, Outcome 1 Plaque < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 3 Side to side versus circular

Outcome: 1 Plaque < 3 months

Study or subgroup	Side to side N	Mean(SD)	Circular N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
1 Turesky						
Yankell 1997	32	2.72 (0.44)	32	2.67 (0.43)		0.11 [-0.38, 0.60]

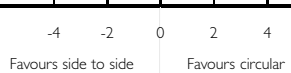
Analysis 3.2. Comparison 3 Side to side versus circular, Outcome 2 Gingivitis < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 3 Side to side versus circular

Outcome: 2 Gingivitis < 3 months

Study or subgroup	Side to side N	Mean(SD)	Circular N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
1 Lobene						
Yankell 1997	32	2.13 (0.2)	32	1.93 (0.24)		0.89 [0.38, 1.41]



Analysis 4.1. Comparison 4 Rotation oscillation versus circular, Outcome 1 Plaque < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 4 Rotation oscillation versus circular

Outcome: 1 Plaque < 3 months

Study or subgroup	Rotation oscillation N	Mean(SD)	Circular N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
1 Turesky						
Yankell 1997	32	2.66 (0.39)	32	2.67 (0.43)		-0.02 [-0.51, 0.47]

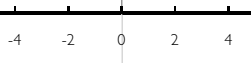
Analysis 4.2. Comparison 4 Rotation oscillation versus circular, Outcome 2 Gingivitis < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 4 Rotation oscillation versus circular

Outcome: 2 Gingivitis < 3 months

Study or subgroup	Rotation oscillation N	Mean(SD)	Circular N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
1 Lobene						
Yankell 1997	32	2.16 (0.28)	32	1.93 (0.24)		0.87 [0.36, 1.39]



Analysis 5.1. Comparison 5 Multidimensional versus side to side, Outcome 1 Plaque < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 5 Multidimensional versus side to side

Outcome: 1 Plaque < 3 months

Study or subgroup	Mulitdimensional N	Mean(SD)	Side to side N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
1 Turesky						
Goyal 2005	60	1.95 (0.55)	30	2.3 (0.27)		-0.73 [-1.18, -0.28]
Patters 2005	33	2.95 (0.1)	33	3.26 (0.09)		-3.22 [-3.96, -2.48]
Zimmer 2005	40	1.89 (0.28)	40	1.96 (0.26)		-0.26 [-0.70, 0.18]

Analysis 5.2. Comparison 5 Multidimensional versus side to side, Outcome 2 Gingivitis < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 5 Multidimensional versus side to side

Outcome: 2 Gingivitis < 3 months

Study or subgroup	Multidimensional N	Mean(SD)	Side to side N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
1 Papillary Bleeding Index						
Zimmer 2005	40	0.78 (0.35)	40	1.07 (0.37)		-0.80 [-1.25, -0.34]
2 Lobene						
Patters 2005	33	1.57 (0.29)	33	1.48 (0.44)		0.24 [-0.25, 0.72]

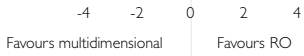
Analysis 6.1. Comparison 6 Multidimensional versus rotation oscillation, Outcome 1 Plaque < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 6 Multidimensional versus rotation oscillation

Outcome: 1 Plaque < 3 months

Study or subgroup	Multidimensional N	Mean(SD)	Rotation oscillation N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Std. Mean Difference IV,Fixed,95% CI
Heasman 1999	25	1.26 (0.5)	25	1.25 (0.53)		0.02 [-0.54, 0.57]



Analysis 6.2. Comparison 6 Multidimensional versus rotation oscillation, Outcome 2 Gingivitis < 3 months.

Review: Different powered toothbrushes for plaque control and gingival health

Comparison: 6 Multidimensional versus rotation oscillation

Outcome: 2 Gingivitis < 3 months

Study or subgroup	Multidimensional N	Mean(SD)	Rotation oscillation N	Mean(SD)	Std. Mean Difference IV,Fixed,95% CI	Weight	Std. Mean Difference IV,Fixed,95% CI
Heasman 1999	25	1.61 (0.21)	25	1.49 (0.21)		35.5 %	0.56 [0.00, 1.13]
Williams 2002	43	0.19 (0.17)	44	0.18 (0.13)		64.5 %	0.07 [-0.35, 0.49]
Total (95% CI)	**68**		**69**			**100.0 %**	**0.24 [-0.10, 0.58]**

Heterogeneity: Chi^2 = 1.91, df = 1 (P = 0.17); I^2 =48%

Test for overall effect: Z = 1.41 (P = 0.16)

APPENDICES

Appendix 1. MEDLINE via OVID search strategy

1. Toothbrushing/
2. toothbrush$ or (tooth adj brush$)).mp. [mp=ti, ot, ab, rw, sh]or/1-2
3. electr$ or power$ or mechanical$ or automatic$ or motor-driven or rota$ or
4. battery operat$ or counter-rota$ or ultraso$ or sonic$ or oscillat$ or ionic$).mp. [mp=ti, ot, ab, rw, sh]
5. 3 and 4

The above subject search was linked with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials in MEDLINE: sensitivity maximising version (2009 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of the *Cochrane Handbook for Systematic Reviews of Interventions v*ersion 5.0.2 (updated September 2009):

1. randomised controlled trial.pt.
2. controlled clinical trial.pt.
3. randomized.ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab.
9. or/1-8
10. exp animals/ not humans.sh.
11. 9 not 10

Appendix 2. The Cochrane Oral Health Group's Trials Register search strategy

((toothbrush* or "tooth brush*") AND (electr* or power* or mechanical* or rota* or counter-rota* or ultraso* or sonic* or automatic* or "motor driven" or "battery operat*" or oscillat* or ionic*))

Appendix 3. CENTRAL search strategy

#1 TOOTHBRUSHING (single term MeSH)
#2 toothbrush* or tooth brush*
#3 (#1 or #2)
#4 (electr* or electronic* or power* or mechanical* or rota* or counter rota* or ultraso* or sonic* or automatic* or motor driven or battery operat* or oscillat* or ionic*)
#5 (#3 and #4)

Appendix 4. EMBASE via OVID search strategy

1. tooth brushing/
2. (toothbrush$ or (tooth adj brush$)).mp. [mp=ti, ot, ab, rw, sh]
3. or/1-2
4. (electr$ or power$ or mechanical$ or automatic$ or motor-driven or rota$ or battery operat$ or counter-rota$ or ultraso$ or sonic$ or oscillat$ or ionic$).mp. [mp=ti, ot, ab, rw, sh]
5. 3 and 4

The above subject search was conducted with the Cochrane Oral Health Group search strategy for identifying randomised controlled trials in EMBASE:

1. random$.ti,ab.
2. factorial$.ti,ab.
3. (crossover$ or cross over$ or cross-over$).ti,ab.
4. placebo$.ti,ab.

5. (doubl$ adj blind$).ti,ab.
6. (singl$ adj blind$).ti,ab.
7. assign$.ti,ab.
8. allocat$.ti,ab.
9. volunteer$.ti,ab.
10. CROSSOVER PROCEDURE.sh.
11. DOUBLE-BLIND PROCEDURE.sh.
12. RANDOMIZED CONTROLLED TRIAL.sh.
13. SINGLE BLIND PROCEDURE.sh.
14. or/1-13
15. ANIMAL/ or NONHUMAN/ or ANIMAL EXPERIMENT/
16. HUMAN/
17. 16 and 15
18. 15 not 17
19. 14 not 18

Appendix 5. CINAHL via EBSCO search strategy

S1 MH Toothbrushes or TI toothbrush* or AB toothbrush* or SU toothbrush* or TI "tooth brush*" or AB "tooth brush*" or SU "tooth brush*"
S2 SU (electr* or power* or mechanical* or automatic* or motor-driven or rota* or "battery operat*" or counter-rota* or ultraso* or sonic* or oscillat* or ionic*) or TI (electr* or power* or mechanical* or automatic* or motor-driven or rota* or "battery operat*" or counter-rota* or ultraso* or sonic* or oscillat* or ionic*) or AB (electr* or power* or mechanical* or automatic* or motor-driven or rota* or "battery operat*" or counter-rota* or ultraso* or sonic* or oscillat* or ionic*)
S3 S1 and S2
The above subject search was conducted with the Cochrane Oral Health Group search strategy for identifying randomised controlled trials in CINAHL:
S1 MH Random Assignment or MH Single-blind Studies or MH Double-blind Studies or MH Triple-blind Studies or MH Crossover design or MH Factorial Design
S2 TI ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study") or AB ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study") or SU ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study")
S3 TI random* or AB random*
S4 AB "latin square" or TI "latin square"
S5 TI (crossover or cross-over) or AB (crossover or cross-over) or SU (crossover or cross-over)
S6 MH Placebos
S7 AB (singl* or doubl* or trebl* or tripl*) or TI (singl* or doubl* or trebl* or tripl*)
S8 TI blind* or AB mask* or AB blind* or TI mask*
S9 S7 and S8
S10 TI Placebo* or AB Placebo* or SU Placebo*
S11 MH Clinical Trials
S12 TI (Clinical AND Trial) or AB (Clinical AND Trial) or SU (Clinical AND Trial)
S13 S1 or S2 or S3 or S4 or S5 or S6 or S9 or S10 or S11 or S12

WHAT'S NEW

Last assessed as up-to-date: 24 March 2011.

Date	Event	Description
11 May 2011	Amended	Addition of two trials from July 2010 search, which were not added to initial review when published.

HISTORY

Protocol first published: Issue 4, 2004

Review first published: Issue 12, 2010

CONTRIBUTIONS OF AUTHORS

Scott Deacon and Anne-Marie Glenny wrote the manuscript and entered data. This was reviewed by Chris Deery and Peter Robinson. Data extraction was performed by Scott Deacon, Chris Deery, Mike Heanue, Peter Robinson, and Damien Walmsley. Technical advice regarding the brushes was provided by Chris Deery, Peter Robinson, and Damien Walmsley.

DECLARATIONS OF INTEREST

William C Shaw was a co-researcher 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 and has also been involved with laboratory trials for Sonicare. Peter Robinson has been the principle investigator on a study of potential health economic effects of using a powered toothbrush, which was sponsored by Procter and Gamble through a gift to the University of Sheffield.

SOURCES OF SUPPORT

Internal sources

- School of Dentistry, The University of Manchester, UK.
- School of Dentistry, The University of Birmingham, UK.
- Edinburgh Dental Institute, UK.
- School of Dentistry, University of Sheffield, UK.
- University of Bristol Dental School, UK.
- North Bristol NHS Trust, UK.
- Manchester Academic Health Sciences Centre (MAHSC) and NIHR Manchester Biomedical Research Centre, UK.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

Since the protocol was published it has become obvious that manufacturers are increasing the complexity of the mode of action with newer brush technologies. Therefore to include these types of brushes we added a further mode of action category 'multidimensional' which included brush types with more than one predominant movement.

Title has also been changed from 'Powered toothbrushes for oral health' to 'Different powered toothbrushes for plaque control and gingival health'.

INDEX TERMS

Medical Subject Headings (MeSH)

*Dental Devices, Home Care [adverse effects]; Dental Plaque [*prevention & control]; Gingivitis [*prevention & control]; Randomized Controlled Trials as Topic; Toothbrushing [adverse effects; *instrumentation]

MeSH check words

Humans