Powered versus manual toothbrushing for oral health (Review)

Yaacob M, Worthington HV, Deacon SA, Deery C, Walmsley AD, Robinson PG, Glenny AM

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[Intervention Review]

Powered versus manual toothbrushing for oral health

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ABSTRACT

Background

Removing dental plaque may play a key role maintaining oral health. There is conflicting evidence for the relative merits of manual and powered toothbrushing in achieving this. This is an update of a Cochrane review first published in 2003, and previously updated in 2005.

Objectives

To compare manual and powered toothbrushes in everyday use, by people of any age, in relation to the removal of plaque, the health of the gingivae, staining and calculus, dependability, adverse effects and cost.

Search methods

We searched the following electronic databases: the Cochrane Oral Health Group's Trials Register (to 23 January 2014), the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2014, Issue 1), MEDLINE via OVID (1946 to 23 January 2014), EMBASE via OVID (1980 to 23 January 2014) and CINAHL via EBSCO (1980 to 23 January 2014). We searched the US National Institutes of Health Trials Register and the WHO Clinical Trials Registry Platform for ongoing trials. No restrictions were placed on the language or date of publication when searching the electronic databases.

Selection criteria

Randomised controlled trials of at least four weeks of unsupervised powered toothbrushing versus manual toothbrushing for oral health in children and adults.

Data collection and analysis

We used standard methodological procedures expected by The Cochrane Collaboration. Random-effects models were used provided there were four or more studies included in the meta-analysis, otherwise fixed-effect models were used. Data were classed as short term (one to three months) and long term (greater than three months).

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Main results

Fifty-six trials met the inclusion criteria; 51 trials involving 4624 participants provided data for meta-analysis. Five trials were at low risk of bias, five at high and 46 at unclear risk of bias.

There is moderate quality evidence that powered toothbrushes provide a statistically significant benefit compared with manual toothbrushes with regard to the reduction of plaque in both the short term (standardised mean difference (SMD) -0.50 (95% confidence interval (CI) -0.70 to -0.31); 40 trials, n = 2871) and long term (SMD -0.47 (95% CI -0.82 to -0.11; 14 trials, n = 978). These results correspond to an 11% reduction in plaque for the Quigley Hein index (Turesky) in the short term and 21% reduction long term. Both meta-analyses showed high levels of heterogeneity (I^2 = 83% and 86% respectively) that was not explained by the different powered toothbrush type subgroups.

With regard to gingivitis, there is moderate quality evidence that powered toothbrushes again provide a statistically significant benefit when compared with manual toothbrushes both in the short term (SMD -0.43 (95% CI -0.60 to -0.25); 44 trials, n = 3345) and long term (SMD -0.21 (95% CI -0.31 to -0.12); 16 trials, n = 1645). This corresponds to a 6% and 11% reduction in gingivitis for the Löe and Silness index respectively. Both meta-analyses showed high levels of heterogeneity (I^2 = 82% and 51% respectively) that was not explained by the different powered toothbrush type subgroups.

The number of trials for each type of powered toothbrush varied: side to side (10 trials), counter oscillation (five trials), rotation oscillation (27 trials), circular (two trials), ultrasonic (seven trials), ionic (four trials) and unknown (five trials). The greatest body of evidence was for rotation oscillation brushes which demonstrated a statistically significant reduction in plaque and gingivitis at both time points.

Authors' conclusions

Powered toothbrushes reduce plaque and gingivitis more than manual toothbrushing in the short and long term. The clinical importance of these findings remains unclear. Observation of methodological guidelines and greater standardisation of design would benefit both future trials and meta-analyses.

Cost, reliability and side effects were inconsistently reported. Any reported side effects were localised and only temporary.

PLAIN LANGUAGE SUMMARY

Powered/electric toothbrushes compared to manual toothbrushes for maintaining oral health

Review question

This review has been conducted to assess the effects of using a powered (or 'electric') toothbrush compared with using a manual toothbrush for maintaining oral health.

Background

Good oral hygiene, through the removal of plaque (a sticky film containing bacteria) by effective toothbrushing has an important role in the prevention of gum disease and tooth decay. Dental plaque is the primary cause of gingivitis (gum inflammation) and is implicated in the progression to periodontitis, a more serious form of gum disease that affects the tissues that support the teeth. The build up of plaque can also lead to tooth decay. Both gum disease and tooth decay are the primary reasons for tooth loss.

There are numerous different types of powered toothbrushes available to the public, ranging in price and mode of action. Different powered toothbrushes work in different ways (such as moving from side to side or in a circular motion). Powered toothbrushes also vary drastically in price. It is important to know whether powered toothbrushes are more effective at removing plaque than manual toothbrushes, and whether their use reduces the inflammation of the gums (gingivitis) and prevents or slows the progression of periodontitis.

Study characteristics

Authors from the Cochrane Oral Health Group carried out this review of existing studies and the evidence is current up to 23 January 2014. It includes 56 studies published from 1964 to 2011 in which 5068 participants were randomised to receive either a powered toothbrush or a manual toothbrush. Majority of the studies included adults, and over 50% of the studies used a type of powered toothbrush that had a rotation oscillation mode of action (where the brush head rotates in one direction and then the other).

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Key results

The evidence produced shows benefits in using a powered toothbrush when compared with a manual toothbrush. There was an 11% reduction in plaque at one to three months of use, and a 21% reduction in plaque when assessed after three months of use. For gingivitis, there was a 6% reduction at one to three months of use and an 11% reduction when assessed after three months of use. The benefits of this for long-term dental health are unclear.

Few studies reported on side effects; any reported side effects were localised and only temporary.

Quality of the evidence

The evidence relating to plaque and gingivitis was considered to be of moderate quality.

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SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

Powered toothbrushes compared with manual toothbrushes for oral health

Patient or population: Individuals of any age with no reported disability that might affect toothbrushing
Intervention: Powered toothbrushes with any mode of action
Comparison: Manual toothbrushes

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Manual toothbrush	Powered toothbrush				
Plaque scores at 1 to 3 months Scale from: 0 to 5	The mean plaque score in the control group was 2.16 points[1]	The mean plaque score in the intervention groups was 0.23 **lower** (0.32 lower to 0.14 lower)		2871 (40 studies)	⊕⊕⊕○ **moderate**[3,4]	This effect represents an 11% reduction in plaque at 1 to 3 months Long-term data (>3 months) also showed a statistically significant reduction in plaque for powered toothbrushes compared to manual toothbrushes
Gingival scores at 1 to 3 months Scale from: 0 to 3	The mean gingivitis score in the control group was 1.1 points[2]	The mean gingivitis score in the intervention groups was 0.07 **lower** (0.10 lower to 0.04 lower)		3345 (44 studies)	⊕⊕⊕○ **moderate**[3,4]	This effect represents a 6% reduction in gingivitis at 1 to 3 months Long-term data (>3 months) also showed a statistically significant reduction in gingivitis for powered toothbrushes compared to manual toothbrushes

Adverse events	There was no apparent relationship between the use of powered toothbrushes and soft tissue trauma. In part this finding was due to the very small number of adverse events reported in the trials

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI)
CI: confidence interval

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate
Very low quality: We are very uncertain about the estimate

[1.] Based on median of control means for all trials presenting data using Quigley Hein index at 1 to 3 months
[2.] Based on median of control means for all trials presenting data using Löe and Silness index at 1 to 3 months
[3.] Downgraded due to statistically significant heterogeneity (I^2 = 83% for plaque; I^2 = 82% for gingivitis)
[4.] No downgrading was undertaken for risk of bias although 46/56 included trials were assessed as being at unclear risk of bias. Given that many of the studies were conducted over 10 years ago, it was felt much of the uncertainty may be due to poor reporting

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BACKGROUND

Description of the condition

Periodontal diseases

Periodontal diseases are a diverse family of oral health conditions affecting the periodontium. As the most prevalent periodontal diseases, gingivitis and periodontitis are of major public health importance. Dental plaque is the primary cause of gingivitis (gum inflammation), which is recognised by redness of the gums at the junction with the teeth, together with slight swelling and bleeding from the gingival margin (Farina 2013). Globally, 80% to 90% of adolescents between 15 and 19 years of age have mild to moderate gingivitis, rising to 92% to 97% in adults between 35 and 44 (Petersen 2012).

Gingivitis can progress to involve the periodontal membrane (periodontitis). A pocket between the gingiva and the tooth forms, and with further destruction bone supporting the tooth is eroded. Eventually the tooth becomes mobile and can be lost. This is a slow process and is related to the amount of plaque and calculus present on the tooth surface, mediated by genetic factors, age, and lifestyle choices such as smoking (British Society of Periodontology 2012). Severe periodontitis is the sixth most prevalent condition, affecting 11% of the global population (Marcenes 2013) and tooth loss as a result is found in 5% to 20% of most adult populations worldwide (Petersen 2005).

Dental caries

Caries (decay) in permanent teeth is the most prevalent disease worldwide, with a global prevalence of 35% for all ages combined (Marcenes 2013). Whilst in high-income countries the prevalence of caries has decreased over the past decade, in lower- and middle-income countries (LMICs) the incidence is increasing due to population growth, an aging population, changing diets and inadequate exposure to fluorides (Marcenes 2013). In the United Kingdom (UK), 85% of adults have at least one filling (Steele 2011) and 31% have obvious untreated caries (White 2011).

The presence of plaque (biofilm) on the tooth is necessary for the development of caries. Like periodontal disease, caries has a complex aetiology, being an interaction between lifestyle, particularly diet and fluoride use, together with host factors. Although the relationship between the presence of plaque and caries is not as clear as with gingivitis, there is clear evidence that the presence of plaque makes teeth more at risk of caries. Zenkner 2013 demonstrated that on erupting teeth with visible plaque accumulation were 14.5 times more likely to have caries than teeth without the presence of visible plaque.

Over twice as many adults who reported not brushing their teeth have caries compared to those who report brushing their teeth twice a day (White 2011). Almost all people in industrialised countries use fluoride toothpaste. When teeth are brushed with a fluoride toothpaste there is clear evidence that this is effective at preventing caries (White 2011) and that this is overall more important than brushing per se (Chesters 1992).

Description of the intervention

Powered versus manual toothbrushing for oral health

Good oral hygiene (the removal of plaque or biofilm from the tooth and gums) by effective toothbrushing has a key role in oral health. In general, populations of high-income countries have adopted regular toothbrushing (Albertsson 2010). There is, however, substantial within-country variation correlating strongly with educational level (Chen 1997). Toothbrushing is much less frequent in LMICs but is again associated with social status indicators (McKittrick 2014).

Effective toothbrushing depends on a number of factors including motivation, knowledge and manual dexterity. Powered brushes simulate the manual motion of toothbrushes with lateral and rotary movements of the brush head. Brushes which operate at a higher frequency of vibration have also been introduced (Johnson 1994; Terezhalmy 1995b). Powered toothbrushes were first introduced commercially in the early 1960s (Chilton 1962a; Cross 1962; Elliot 1963; Hoover 1962) and have become established as an alternative to manual methods of toothbrushing. In the UK a quarter of adults report using a powered toothbrush (Chadwick 2011) and use by children may be even higher (White 2004).

How the intervention might work

Dental plaque is the primary cause of gingivitis and is implicated in the progression of periodontitis. Therefore more effective removal of plaque by a powered toothbrush compared to a manual brush will reduce the inflammation of the gums (gingivitis), a benefit in itself, and in the long term may prevent or slow the progression of periodontitis and therefore maintain a functioning dentition for longer (Aspiras 2013).

There is a potential to reduce caries incidence by the effective removal of plaque (Zenkner 2013) but previous reviews on the effectiveness of powered toothbrushes have not identified any studies reporting this outcome (Deacon 2010; Robinson 2005).

Why it is important to do this review

Powered toothbrushes are popular and expensive compared to manual toothbrushes. However, the question remains, which is better, powered or manual? This is an update of the Cochrane review first published in 2003 and previously updated in 2005

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comparing powered and manual toothbrushes (Heanue 2003; Robinson 2005). There is also a related review comparing the effectiveness of different designs of powered toothbrushes (Deacon 2010). However, the previous review comparing powered and manual toothbrushes was published in 2005, and there is a requirement to update that review to identify new evidence, and to include any evaluations of new designs of powered toothbrush introduced to the market.

OBJECTIVES

To compare manual and powered toothbrushes in everyday use, by people of any age, in relation to the removal of plaque, the health of the gingivae, staining and calculus, dependability, adverse effects and cost.

METHODS

Criteria for considering studies for this review

Types of studies

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

In the current update an agreement was made that cross-over trials were eligible for inclusion if the wash-out period length was more than two weeks. This was particularly important to diminish any carry-over effects of the different toothbrushes on clinical gingivitis. Split-mouth trials were excluded, as these were not considered representative of 'everyday use'.

Studies were included irrespective of publication status or language.

Types of participants

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

Types of interventions

The toothbrushes included in the review were all forms of manual brushes and all forms of powered brushes. Trials instituting combined interventions, e.g. brushing combined with the use of mouthrinse or irrigation, were excluded. However, trials where participants were permitted to continue with their usual adjuncts to oral hygiene, such as flossing, were included.

Trials were excluded where the brushing intervention was carried out or was supervised by a professional less than 28 days before a follow-up assessment.

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

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

1. Side to side action, indicates a brush head action that moves laterally from side to side.
2. Counter oscillation, indicates a brush action in which adjacent tufts of bristles (usually six 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.
3. Rotation oscillation, indicates a brush action in which the brush head rotates in one direction and then the other.
4. Circular, indicates a brush action in which the brush head rotates in one direction.
5. Ultrasonic, indicates a brush action where the bristles vibrate at ultrasonic frequencies (> 20 kHz).
6. Ionic, indicates a brush that aims to impart an electrical charge to the tooth surface with the intent of disrupting the attachment of dental plaque.
7. Unknown, indicates a brush action that the review authors have been unable to establish based on the trial report or confirm with the manufacturers.

An additional group was added in a parallel review of the effectiveness of different powered brushes (Deacon 2010). This 'multi-dimensional group' included brushes with two of the above action types. Due to the limited number of trials conducted using this brush type, they were considered as part of the rotation oscillation group in this update.

It was agreed from the earlier reviews that analysis of filament arrangement, orientation, size, shape and flexibility, brush head size and shape along with presence or absence and characteristics of a timer would prove difficult to define across time and brush types.

Types of outcome measures

Primary outcomes

The primary outcome measures employed were quantified levels of plaque or gingivitis or both. Where possible, values recorded on arrival at the assessment were used. If necessary, measures of gingivitis taken after participants had been instructed or permitted to brush their teeth at the assessment visit were used as it was assumed that toothbrushing would not affect gingivitis within such a short period. However, measures of plaque taken after participants had been instructed or permitted to brush their teeth at the assessment visit were not used. It was assumed that plaque scores

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achieved during toothbrushing under these circumstances would not reflect scores achieved in normal home use.

Secondary outcomes

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

Search methods for identification of studies

For the identification of studies included or considered for this review, we developed a detailed search strategy for each database, based on the strategy developed for MEDLINE (OVID) but revised accordingly. The search strategy used a combination of controlled vocabulary and free text terms and was linked with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials (RCTs) in MEDLINE: sensitivity maximising version (2008 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 5.1.0 (updated March 2011) (Higgins 2011). Details of the MEDLINE search are provided in Appendix 3. The searches of EMBASE and CINAHL were linked to the Cochrane Oral Health Group filters for identifying RCTs.

Electronic searches

We searched the following electronic databases:

- the Cochrane Oral Health Group's Trials Register (to 23 January 2014) (Appendix 1);
- the Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2014, Issue 1) (Appendix 2);
- MEDLINE via OVID (1946 to 23 January 2014) (Appendix 3);
- EMBASE via OVID (1980 to 23 January 2014) (Appendix 4);
- CINAHL via EBSCO (1980 to 23 January 2014) (Appendix 5).

No restrictions were placed on the language or date of publication when searching the electronic databases.

Searching other resources

We searched the following databases for ongoing trials, *see* Appendix 6 for details of the search strategy:

- US National Institutes of Health Trials Register (http://clinicaltrials.gov) (to 23 January 2014);
- the WHO Clinical Trials Registry Platform (http://apps.who.int/trialsearch/default.aspx) (to 23 January 2014).

Only handsearching done as part of the Cochrane Worldwide Handsearching Programme and uploaded to CENTRAL was included (*see* the Cochrane Masterlist for details of journal issues searched to date).

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

Data collection and analysis

Selection of studies

Two review authors independently reviewed the titles and abstracts identified in the search. If in the opinion of both authors an article clearly did not fulfil the defined inclusion criteria it was considered ineligible. We obtained full reports of all trials of possible relevance for assessment. On receipt of the full article, two review authors assessed each study independently using specifically designed data extraction forms. Disagreements were resolved by discussion with the review team.

Data extraction and management

For this update, piloting of data extraction was performed independently by two authors on eight pilot articles. However, all authors reported back on the design of the data extraction forms and their interpretation of the inclusion and exclusion criteria along with their understanding of the outcome measures and new risk of bias (ROB) assessment. On the basis of this feedback the data extraction forms were altered and the inclusion, exclusion, outcome measures and ROB assessment were redefined to avoid misinterpretation. All data extraction for the included studies was then undertaken independently and in duplicate.

The final data extraction protocol considered the following information.

1. Bibliographic details of the study.
2. Funding source for the trial. A trial was considered to have been funded by a brush manufacturer if it was reported that any material sponsorship from the manufacturer occurred, including the donation of brushes. It was considered unclear, if there was no statement on funding. A trial was only considered to be unsponsored by a manufacturer if it clearly stated so.
3. Inclusion eligibility.
4. Baseline characteristics of the participants in the study, including age, number of participants in the study and gender. Also, specific groups, such as dental students or orthodontic patients were noted, where mentioned.
5. Intervention characteristics including type of brush and its mode of action, duration of use and delivery of instructions.
6. Outcomes including plaque and gingivitis indices.

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7. Additional information on a priori calculation of sample size, duration of study, reliability and validity of outcomes measures and monitoring of compliance.

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

Data from trials that reported follow-up before and after three months were included in the short- and long-term meta-analyses. Likewise, data from trials that reported both plaque and gingivitis would be included in meta-analyses for both outcomes. These were the only circumstances when data from the same trial were considered more than once.

Many different indices of plaque and gingivitis were used across trials and some trials reported multiple indices. A frequencies table was prepared of the indices used and they were ranked based on common usage and simplicity. For plaque we extracted, where possible, data reported as the Turesky modification of the Quigley-Hein plaque index (Quigley 1962; Turesky 1970). For gingival inflammation we extracted where possible data reported as the gingival index of Löe and Silness (Löe 1963) or, if unavailable, bleeding on probing (Ainamo 1975). Data for Russell's periodontal index were excluded because this index fails to distinguish between gingivitis and periodontitis (Russell 1967).

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

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

Assessment of risk of bias in included studies

We conducted this assessment using the recommended approach for assessing risk of bias in included studies for Cochrane reviews (Higgins 2011). All included studies were assessed independently and in duplicate by two review authors as part of the data extraction process. The risk of bias tool evaluates six specific domains.

- Sequence generation (selection bias).
- Allocation concealment (selection bias).
- Blinding of outcome assessment (detection bias).
- Incomplete outcome data (attrition bias).
- Selective outcome reporting (reporting bias).
- Other sources of bias; comparability of groups at baseline.

Risk of bias assessment.

- A trial was considered to have adequately generated a random sequence of allocation, if it fully reported the type of allocation generation and it satisfied the CONSORT guidelines as true randomisation (http://www.consort-statement.org/).
- A trial was considered to have adequate blinding, if the report indicated that the method of outcome assessment did not allow the recording clinician to know to which group the participants had been allocated, with no other contradicting statement.
- Attrition was considered to have been adequately reported if there was a clear indication of how many withdrawals occurred in each group during the trial and an attempt made to give reasons why the withdrawals occurred.

The first part of the entry involved authors' describing what was reported in the study. The second part involved the authors' judgements of the adequacy of the study, that is, whether they are at low, high or unclear risk of bias. Numerical data extracted from the included trials were checked by a third author for accuracy and entered into Review Manager (RevMan) software (RevMan 2012).

Two risk of bias figures were generated to illustrate the findings of the assessment. A 'Risk of bias graph' illustrated the proportion of studies across the domain with each of the judgements ('low risk', 'high risk', 'unclear risk'). A 'Risk of bias summary' summarised all of the judgements for a study entry. We assumed that the risk of bias of outcomes was equally important both within and across studies. They were assessed as follows.

Low risk of bias	Interpretation	Within a study	Across studies
Low risk of bias	Plausible bias unlikely to seriously alter the results	Low risk of bias for all key domains	Most information is from studies at low risk of bias
Unclear risk of bias	Plausible bias that raises some doubt about the results	Unclear risk of bias for one or more key domains	Most information is from studies at low or unclear risk of bias

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(*Continued*)

High risk of bias	Plausible bias that seriously weakens confidence in the results	High risk of bias for one or more key domains	The proportion of information from studies at high risk of bias is sufficient to affect the interpretation of results

Measures of treatment effect

The estimate of effect used was the mean difference (MD) and corresponding 95% confidence intervals (CI). However, different indices for plaque measure the same concept on different scales, with high correlation between the different indices. The same is true for gingivitis. As it is not possible to combine the results from different indices, the effects were expressed as standardised values, which have no units, before combining. The standardised mean difference (SMD) was therefore calculated along with the appropriate 95% CI and was used as the effect measure for each meta-analysis where results were available for more than one index (Deeks 2001). Where only one index was presented in a comparison, the treatment effect was measured as the MD with 95% CI.

Unit of analysis issues

No units of analysis issues were anticipated other than cross-over studies which were included using the generic inverse variance (GIV) approach (Elbourne 2002; Higgins 2011).

Dealing with missing data

Trial authors were contacted to retrieve missing data where necessary. Data remain excluded until further clarification becomes available. Standard deviations were imputed as in section 7.7.3 of the *Cochrane Handbook for Systematic Reviews of interventions* (Higgins 2011).

Assessment of heterogeneity

We assessed heterogeneity by inspection of a graphical display of the estimated treatment effects from the trials along with their 95% CI and by Cochran's test for heterogeneity undertaken before each meta-analysis as described in the *Cochrane Handbook for Systematic Reviews of interventions* (Higgins 2011). The heterogeneity was quantified using the I^2 statistic, where a guide for interpretation in the *Cochrane Handbook for Systematic Reviews of interventions* is (Higgins 2011):

- 0% to 40%: might not be important;
- 30% to 60%: may represent moderate heterogeneity;
- 50% to 90%: may represent substantial heterogeneity;
- 75% to 100%: considerable heterogeneity.

Assessment of reporting biases

A funnel plot (plots of effect estimates versus the inverse of their standard errors) was drawn. Asymmetry of the funnel plot may indicate publication bias and other biases related to sample size, though it may also represent a true relationship between trial size and effect size. A formal investigation of the degree of asymmetry was performed using the method proposed by Egger et al (Egger 1997). This was carried out using Stata version 12.0 (Stata Corporation, USA) using the program Metabias.

Data synthesis

Statistical values such as SMD have no inherent clinical meaning. Therefore we back-translated key effect scores using the clinical indices from a study where the difference was similar to the SMD. Such examples are given in the Discussion. Random-effects models were performed where four or more studies were to be combined, otherwise fixed-effect models were used.

Data from cross-over trials were included with that of similar parallel group trials, using the techniques described by Elbourne and colleagues (Elbourne 2002). This was done using the generic inverse variance method within RevMan (Higgins 2011).

Subgroup analysis and investigation of heterogeneity

Subgroup analyses were undertaken for assessments based on full mouth recording versus those based on a partial recording and to examine the effects of concealed allocation, randomisation generation and blinded outcome assessment on the overall estimates of effect for important outcomes.

Additional subgroup analyses were undertaken to explore heterogeneity. Evidence of variability in any subgroup was further explored by examining funnel plots.

Sensitivity analysis

Sensitivity analyses were conducted to test whether the assumptions involved in the design of this review affected the findings. These analyses were undertaken by repeating the meta-analyses

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in the following cases: where a full mouth index had been used, where adequate concealment of randomisation occurred, where there was adequate generation of randomisation sequence, where there was blinding of the outcome assessor, if the trial was funded by a manufacturer, with adequate information about attrition and for trials that were not restricted to participants only wearing fixed orthodontic appliances.

Presentation of main results

A GRADE approach was used to interpret findings. A 'Summary of findings' table was developed for the primary outcomes of this review using GRADE Profiler software (version 3.6). These tables provide information concerning the overall quality of the evidence from the trials, the magnitude of effect of the interventions examined, and the sum of available data on the primary outcomes and secondary outcomes. The outcomes selected for inclusion in these tables were plaque and gingivitis at two time points.

RESULTS

Description of studies

Results of the search

See Figure 1.

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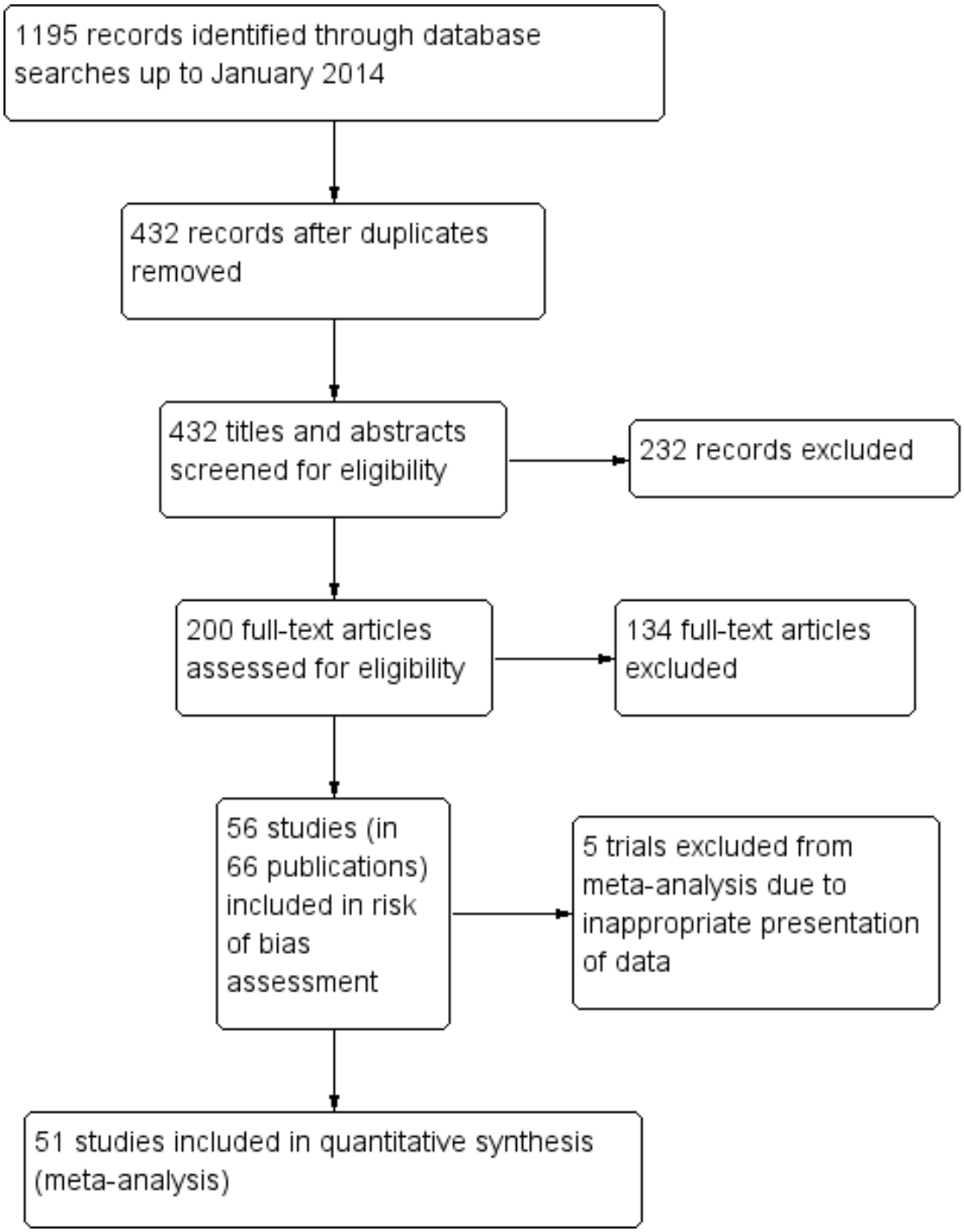
Figure 1. Flow chart of study selection in this update.



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This review was originally published in 2003, updated in 2005 and again for this version. Since its first publication to January 2014 a total of 1195 articles have been identified through the search strategy. After removing duplicates, this number falls to 432; titles and abstracts of these 432 articles were screened for eligibility. A total of 200 full-text articles were retrieved as potentially relevant trials. Of these, 134 were excluded (Characteristics of excluded studies table) leaving 56 trials, in 66 publications.

In the original review 29 trials, all providing data for meta-analysis, were included. In the 2005 update, an additional 10 trials were identified as meeting the inclusion criteria (Galgut 1996; Garcia-Godoy 2001; Hickman 2002; Pucher 1999; Sharma 2000; Soparkar 2000; Sowinski 2000; Toto 1966; Van Swol 1996; Zimmer 2002). Data for three trials identified in the original search was received from the authors allowing their inclusion (Haffajee 2001a; Lapiere unpublished; Singh unpublished). Thus 42 trials were included in the 2005 publication.

In the current update, an additional 15 trials were identified as being eligible (Biavati Silvestrini 2010; Biesbrock 2007; Costa 2007; Dorfer 2009; Goyal 2007; Gugerli 2007; Kallar 2011; McCracken 2004; McCracken 2009; Moreira 2007; Moritis 2008; Rosema 2008; Sharma 2010; Silverman 2004; Zimmer 2005). Fourteen were parallel group designs and there was one cross-over trial (Moreira 2007). One trial included in the original review was excluded as it was not truly a randomised controlled trial (McAllan 1976), leaving a total of 56 trials included in this 2014 update. Of these 56 trials, five did not present data in a way that allowed for meta-analysis (Costa 2007; Galgut 1996; Gugerli 2007; Moreira 2007; Zimmer 2005). The meta-analyses are based on 51 trials with a parallel group design.

Included studies

Of the 56 included trials, 36 were conducted in North America (Baab 1989; Barnes 1993; Biesbrock 2007; Costa 2007; Cronin 1998; Dentino 2002; Emling 1991; Forgas-B 1998; Garcia-Godoy 2001; Glass 1965; Goyal 2007; Haffajee 2001a; Ho 1997; Johnson 1994; Khocht 1992; Lobene 1964a; Moreira 2007; O'Beirne 1996; Pucher 1999; Sharma 2000; Sharma 2010; Silverman 2004; Singh unpublished; Soparkar 1964; Soparkar 2000; Sowinski 2000; Terezhalmy 1995a; Toto 1966; Tritten 1996; Van Swol 1996; Walsh 1989; Warren 2001; Wilson 1993; Yankell 1996; Yankell 1997; Yukna 1993b); 18 in Europe (Ainamo 1997; Biavati Silvestrini 2010; Clerehugh 1998; Dorfer 2009; Galgut 1996; Gugerli 2007; Heasman 1999; Hickman 2002; Lapiere unpublished; Lazarescu 2003; McCracken 2004; McCracken 2009; Moritis 2008; Rosema 2008; Stoltze 1994; van der Weijden 1994; Zimmer 2002; Zimmer 2005), one each in Israel (Stabholz 1996) and in India (Kallar 2011).

Three trials remain unpublished (Lapiere unpublished; Lazarescu 2003; Singh unpublished). The remainder were published between 1964 and October 2011; four in the 1960s; one in the 1970s; two in the 1980s; 23 in the 1990s and 19 in the 20th century. At least 37 were funded in some part by the manufacturer of one of the powered toothbrushes, one was funded by government scholarship and the remainder were unclear about sponsorship.

The combined total number of participants included in the trials was 5068. The number of patients reported lost to follow-up was 334 (6.6%).

Characteristics of participants

The characteristics of participants in each study are noted in the Characteristics of included studies table and in Additional Table 1. Out of the 56 included trials the four most frequently stated inclusion criteria were adults (77% of trials), no relevant medical history (55%), a stated minimum number of teeth (55%) and a criterion related to gingival or periodontal health or plaque at baseline (50%). Exclusion criteria used in the included trials were noted and are summarised in Additional Table 2. Only seven trials included orthodontic patients (Biavati Silvestrini 2010; Clerehugh 1998; Costa 2007; Hickman 2002; Ho 1997; Pucher 1999; Singh unpublished).

Characteristics of interventions

The powered toothbrushes, included:

Braun, Interplak, Braun Plaque Remover with OD5 head, Braun Oral B Pro Care series, Oral B CrossAction, Braun Oral B Pro Care 8500, Braun Oral B D25, Braun Oral B 3D, Braun Oral B D9, PlaK Trac, Ultrasonex, GEC, Braun Oral B D7, Philips Jordan HP 735, Philips HP 550, Sonicare Ultrasonic, Philips Sonicare, Philips Sensiflex 2000, Philips Sonicare Elite, Epident, Braun Oral B D5, Philips 550, Touchtronic Teledyne Aqua Tec, Ronson, Dominion, Pulse Plaque Remover, Broxodent, Plaq and White, LPA/Broxo, Braun D17, Rowenta Dentiphant, Rowenta, Plaque Dentacontrol Plus, Sangi Co Electronic, Braun Oral B D10, Braun Oral B D15 Plaque Remover, Braun Plaque Remover 3D with orthodontic head, Oral B Mickey Mouse, Hukuba Ionic, Colgate Actibrush, HyG Ionic, unspecified ionic, Ultra Sonex Ultima, Ultreo, Sunbeam cordless. These are summarised in Additional Table 3.

Powered toothbrush, mode of action

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

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Side to side action

Philips Sonicare, Philips Sonicare Elite and Sonicare brushes (Sonicare c/o Philips Oral Healthcare, 35301 SE Center Street, Snoqualmie, WA 98065; http://www.sonicare.com/); Philips 550 (Philips Jordan, PO Box 324, 5500 AH Veldhoven, The Netherlands; http://www.philips-jordan.com/) and Philips Sensiflex 2000 (http://www.philips.co.uk/c/electric-toothbrushes/sensiflex-hx1610˙05/prd/).

Counter oscillation

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

Rotation oscillation

Oral B CrossAction, Braun Oral B 3D, D17, Plaque Remover with OD5 head, Oral B D9, Oral B D7, Oral B D5, Oral B D10, Oral B D25, Oral B Pro Care 8500, Oral B Mickey Mouse, Braun Plaque Remover 3D with orthodontic head, Braun Oral B D15 Plaque Remover (Braun Oral B Consumer Services, 1 Gillette Park, South Boston, MA; http://www.oralb.com/); Philips Jordan HP 735, Philips HP 550 (Philips Jordan PO Box 324, 5500 AH Veldhoven, The Netherlands; http://www.philips-jordan.com/); Colgate Actibrush (Consumer Affairs, Colgate-Palmolive (UK) Limited, Guildford Business Park, Middleton Road, Guildford, Surrey GU2 8JZ UK; http://www.colgate.co.uk/contact/index.shtml).

Circular

Rowenta Dentiphant, Rowenta, Plaque Dentacontrol Plus (Rowenta Werke GmbH, Franz Alban, Stützer, Germany; http://www.products.rowenta.de/row/index.html); Epident (EPI Products, Santa Monica, CA).

Ultrasonic

Ultrasonex brush, Ultra Sonex Ultima (Salton-Maxim 1801 N Stadium Boulevard, Columbia, MO 65202; http://www.salton-maxim.com/salton/ultrasonex/ultrasonex.asp) and Ultreo (http://www.ultreo.com/meet-ultreo), Oral B Pulsonic.

Ionic

Sangi Co Electronic (Tokyo), Hukuba Ionic and the HyG Ionic (Hukuba Dental Corporation, 914-1 Nazukari, Nagareyama, Chiba, 270-01 Japan).

Unknown

Some companies are no longer trading or complete details of the relevant toothbrushes are not easily found. The following toothbrushes fall into this latter category: PlaK Trac, GEC, Epident, Touchtronic, Ronson, Dominion, Broxodent, Plaq and White, LPA/Broxo, Sunbeam cordless.

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.

Ten trials recruiting 988 participants compared manual brushing versus side to side powered toothbrushing. Five trials recruited 267 participants and compared manual brushing versus counter oscillating toothbrushing. Twenty-seven trials recruiting 2159 participants compared manual brushing versus rotation oscillation powered brushing. Two trials recruiting 162 participants compared manual brushing versus circular powered brushing and seven trials recruiting 506 participants compared manual brushing versus ultrasonic powered brushing. Four trials recruiting 221 participants compared manual brushing versus ionic brushing. Five trials recruiting 1130 participants compared manual brushing and a powered toothbrush with an unknown action. It should be noted that four trials evaluated two powered brushes (Costa 2007; Khocht 1992; Yankell 1997; Zimmer 2005).

Summary of trials by toothbrush action

See Additional Table 3 for list of trials by mode of action.

Characteristics of outcome measures

Forty trials (2871 participants at the end of the trials) provided data for analysis on plaque at one to three months and 14 trials (978 participants at the end of the trials) provided data at longer than three months. Forty-four trials (3345 participants at the end of the trials) provided data for analysis on gingivitis at one to three months and 16 trials (1645 participants at the end of the trials) provided data at longer than three months.

If it was not stated that a full or partial mouth index was used, we assumed it was full mouth. Fifty-four trials reported plaque data, and of these eight trials reported that a partial mouth assessment was used. Fifty-two trials reported gingivitis data and 10 of these reported using a partial mouth index.

The following plaque indices were reported.

- Quigley Hein (Turesky) (Barnes 1993; Cronin 1998; Dentino 2002; Dorfer 2009; Emling 1991; Forgas-B 1998; Garcia-Godoy 2001; Glass 1965; Haffajee 2001a; Heasman 1999; Johnson 1994; Kallar 2011; Khocht 1992; Lapiere unpublished; Lazarescu 2003; McCracken 2004; McCracken 2009; Pucher 1999; Rosema 2008; Silverman 2004; Sowinski 2000; Terezhalmy 1995a; Tritten 1996; Van Swol 1996; Warren 2001; Wilson 1993; Yankell 1996; Yankell 1997; Yukna 1993b; Zimmer 2002.

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- Silness and Löe (Galgut 1996; Ho 1997; Moritis 2008; Stoltze 1994; van der Weijden 1994; Walsh 1989).
- Visible plaque index Ainamo Bay (Ainamo 1997).
- Ortho modification of Silness and Löe (Hickman 2002).
- Navy plaque index mod Rustogi (Biesbrock 2007; Sharma 2000; Sharma 2010).
- O'Leary index (Biavati Silvestrini 2010).

The following gingivitis indices were reported.

- Löe Silness (Baab 1989; Barnes 1993; Biesbrock 2007; Clerehugh 1998; Cronin 1998; Dorfer 2009; Emling 1991; Forgas-B 1998; Goyal 2007; Haffajee 2001a; Heasman 1999; Hickman 2002; Ho 1997; Johnson 1994; Khocht 1992; Lapiere unpublished; Moritis 2008; O'Beirne 1996; Pucher 1999; Sharma 2000; Silverman 2004; Singh unpublished; Soparkar 1964; Soparkar 2000; Stoltze 1994; Terezhalmy 1995a; Tritten 1996; Van Swol 1996; Walsh 1989; Warren 2001).
- Lobene gingival index (Dentino 2002; Glass 1965; Lobene 1964a; Sharma 2010; van der Weijden 1994; Yankell 1996; Yankell 1997; Yukna 1993b).
- Bleeding on probing (BOP) (0 to 1 scale) (Ainamo 1997; Biavati Silvestrini 2010; Lazarescu 2003; McCracken 2009; Wilson 1993).
- Papillary bleeding index (0 to 4 scale) (McCracken 2004; Zimmer 2002).
- Bleeding on marginal probing (BOMP) (0 to 2 scale) (Rosema 2008).
- Papillary marginal attachment (PMA) (Toto 1966).

Excluded studies

The 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, however the primary reason for exclusion was study duration of less than 28 days. Other reasons included a high potential for compromised self toothbrushing efficacy; combined interventions that did not allow for assessment of the effect of powered toothbrushing; split-mouth design; or insufficient information to determine whether inclusion criteria were met (in these situations authors have been contacted and if further information is supplied to confirm criteria for inclusion are met, the studies will be included in subsequent updates).

Risk of bias in included studies

See Figure 2; Figure 3. Fifty-six studies were assessed for risk of bias, including five that were not meta-analysed (Costa 2007; Galgut 1996; Gugerli 2007; Moreira 2007; Zimmer 2005). Overall, only five were assessed as being at low risk of bias (Clerehugh 1998; Haffajee 2001a; McCracken 2009; Sharma 2010; Silverman 2004). Five trials were assessed as being at high risk of bias (Glass 1965; Kallar 2011; Lazarescu 2003; Walsh 1989; Wilson 1993).

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

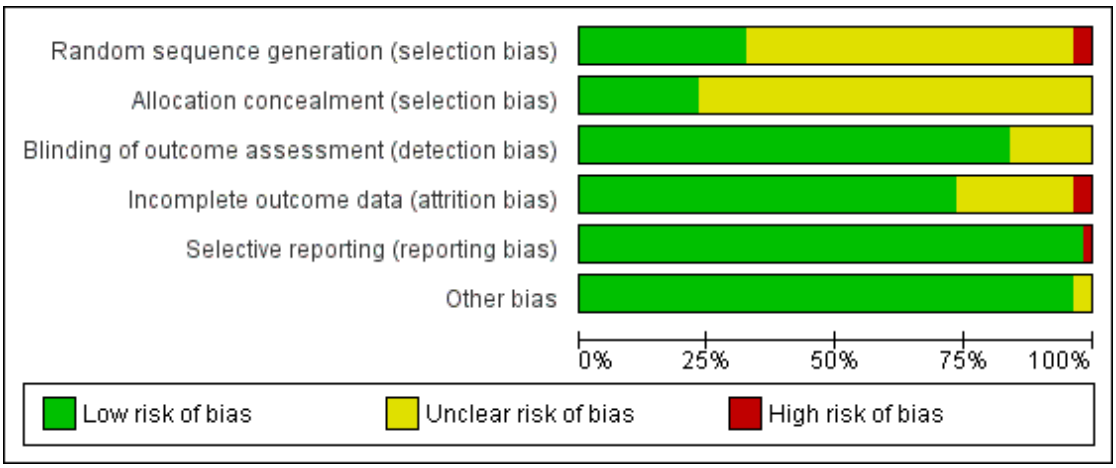

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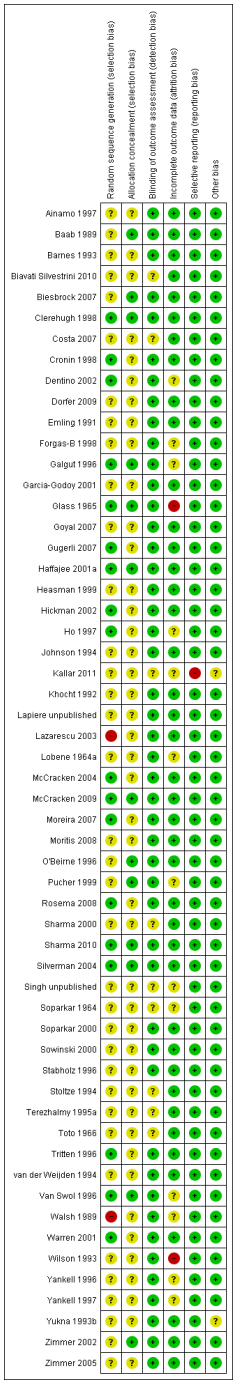
Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



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Allocation

The generation of randomisation sequence was at low risk of bias for 18 trials (32.1%), unclear risk for 36 (64.3%) and at high risk of bias for two trials (3.6%) (Lazarescu 2003; Walsh 1989). The concealment of allocation was at low risk of bias in 13 trials (23.2%) and unclear risk of bias in all other trials.

Blinding

The outcome assessment was at low risk of bias in 47 trials (83.9%). The adequacy of blinding was unclear in nine trials (16.1%).

Incomplete outcome data

The reported drop-out rate ranged from 1% to 34%. Forty-one trials were at low risk of bias with regard to attrition bias, either due to no drop-outs, or drop-outs unlikely to influence findings. Thirteen trials were at unclear risk of bias due to insufficient data for assessment; two studies with high drop-out rates that did not present reasons for the losses were assessed as at high risk of bias (Glass 1965; Wilson 1993).

Selective reporting

All of the trials apart from one reported important outcomes and were assessed as at low risk of bias. Kallar 2011 failed to report gingivitis and was assessed as at high risk of bias for this domain.

Other potential sources of bias

Two trials were at unclear risk of bias due to other potential sources (Kallar 2011; Yukna 1993b) due to lack of information on the methods or insufficient detail regarding baseline comparison. All other trials were assessed as at low risk of bias for this domain.

Effects of interventions

See: **Summary of findings for the main comparison**

As mentioned in the methods section, the differences in plaque and gingivitis reduction between the powered and manual brushes were expressed as standardised mean differences (SMDs) unless all the studies used the same index in which case mean difference (MD) was used. The results are presented for both short-term and long-term studies.

All powered toothbrushes versus manual toothbrushes (Comparison 1)

Analysis 1.1; Analysis 1.2; Analysis 1.3; Analysis 1.4.

This primary analysis compared all powered brush types with manual.

Plaque

The meta-analyses for both short-term (40 trials n = 2871) and long-term (14 trials n = 978) plaque indices indicated that there was a reduction in plaque when the powered toothbrushes were used, short term (one to three months) SMD -0.50 (95% confidence interval (CI) -0.70 to -0.31) and long term (>3 months) SMD -0.47 (95% CI -0.82 to -0.11). Both meta-analyses showed high levels of heterogeneity (I^2 = 83% and 86% respectively). These were not explained by the different powered toothbrush type subgroups, and there was considerable heterogeneity within these.

Gingivitis

The meta-analyses for both short-term (44 trials n = 3345) and long-term (16 trials n = 1645) gingival indices indicated that there was a reduction in gingivitis when the powered toothbrushes were used, short term (1-3 months) SMD -0.43 (95% CI -0.60 to -0.25) and long term (>3 months) SMD -0.21 (95% CI -0.31 to -0.12). Both meta-analyses showed high levels of heterogeneity (I^2 = 82% and 51% respectively). These were not explained by the different powered toothbrush type subgroups, and there was considerable heterogeneity within these.

Side to side powered toothbrushes versus manual toothbrushes (Comparison 2)

Analysis 2.1; Analysis 2.2; Analysis 2.3; Analysis 2.4.

Ten studies (n = 988) compared side to side toothbrushes with manual, one of which was at low risk (McCracken 2009) and two at high risk of bias (Glass 1965; Walsh 1989), the remainder being unclear.

No significant differences were found between side to side action and manual brushes in the reduction of plaque or gingivitis in the long or short term.

Counter oscillation powered toothbrushes versus manual (Comparison 3)

Analysis 3.1; Analysis 3.2; Analysis 3.3; Analysis 3.4.

All five studies (n = 267) that compared counter oscillation powered toothbrushes with manual toothbrushes were at unclear (Baab

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1989; Khocht 1992; Stabholz 1996; Yukna 1993b) or high risk of bias (Wilson 1993). There was no evidence that counter oscillation powered toothbrushes were more effective than manual brushes for the removal of plaque or reduction of gingivitis with the exception of being associated with less plaque in the long term, where the MD was -0.27 (95% CI -0.48 to -0.07; two trials, n = 69; I^2=0) (Analysis 3.3).

Rotation oscillation powered toothbrushes versus manual (Comparison 4)

Analysis 4.1; Analysis 4.2; Analysis 4.3; Analysis 4.4.

Twenty-seven trials (n = 2159) compared rotation oscillation powered with manual toothbrushes. Only three of these were at low risk of bias (Clerehugh 1998; Haffajee 2001a; Silverman 2004) and one at high risk of bias (Lazarescu 2003), the remainder being unclear. This comparison contained the greatest number of trials, with 20 (n = 1404) and 21 (n = 1479) trials included in the meta-analyses for plaque and gingivitis respectively in the short term, and seven (n = 527) and eight (n = 684) trials included in the meta-analyses for plaque and gingivitis in the long term. Brushes with a rotation oscillation action removed more plaque and reduced gingivitis more effectively than manual brushes in the short term. For plaque at one to three months the SMD was -0.53 (95% CI -0.74 to -0.31; I^2 = 72%) (Analysis 4.1) and for gingivitis the SMD was -0.49 (95% CI -0.73 to -0.26; I^2 = 78%) (Analysis 4.2). Rotation oscillation brushes also reduced plaque and gingivitis in the long term. The SMD for plaque over 3 months was -0.66 (95% CI -1.28 to -0.03; I^2 = 91%) (Analysis 4.3) and for gingivitis was -0.35 (95% CI -0.50 to -0.20; I^2 = 53%) (Analysis 4.4). There was heterogeneity between the trials in the meta-analyses for both short-term and long-term follow-up, which is reported later in this section.

Three studies examined both outcomes but did not include sufficient information for meta-analysis (Costa 2007; Gugerli 2007; Zimmer 2005). Two suggested treatment benefits from using rotation oscillation toothbrushes (Analysis 4.5). All three were at unclear risk of bias.

Circular powered toothbrushes versus manual (Comparison 5)

Analysis 5.1; Analysis 5.2.

Two trials (n = 162) were included in this comparison, both were at unclear risk (Khocht 1992; Yankell 1996). Both trials were included in the analyses for plaque and gingivitis in the short term; there were no long-term data. There was no evidence that brushes with a circular action removed plaque or reduced gingivitis more effectively than manual brushes in either time period.

Ionic toothbrushes versus manual (Comparison 6)

Analysis 6.1; Analysis 6.2; Analysis 6.3; Analysis 6.4.

Four trials (n = 221) compared an ionic toothbrush with a manual brush. All four trials were at unclear risk of bias (Galgut 1996; Moreira 2007; Pucher 1999; Van Swol 1996). One trial (Moreira 2007) did not present data in a form suitable for meta-analysis (Analysis 6.5).

Three trials provided data for meta-analysis (Galgut 1996; Pucher 1999; Van Swol 1996). The short-term analyses (one to three months) indicated an effect on plaque in favour of the ionic brush (SMD -0.57 (95% CI -0.87 to -0.27)) but not gingivitis (MD -0.01 (95% CI -0.04 to 0.02)).

The single long-term trial showed a difference in favour of the ionic toothbrush on both plaque (MD -0.50 (95% CI -0.74 to -0.26)) and gingivitis (MD -0.36 (95% CI -0.59 to -0.13)).

Ultrasonic toothbrushes versus manual (Comparison 7)

Analysis 7.1; Analysis 7.2; Analysis 7.3; Analysis 7.4.

Seven trials (n = 506) compared ultrasonic toothbrushes with manual. One of the seven trials in this comparison was at low risk of bias (Sharma 2010) and all others were at unclear risk of bias. There were four trials for the meta-analysis for the short-term assessment of plaque and five for gingivitis; two trials did not provide data for meta-analysis (Analysis 7.5). Ultrasonic powered toothbrushes reduced plaque and gingivitis in the short term, with SMDs of -1.33 (95% CI -1.59 to -1.07; I^2 = 93%) (Analysis 7.1) and -0.99 (95% CI -1.21 to -0.76; I^2 = 84%) (Analysis 7.2) respectively. Only one trial presented long-term data and showed no statistically significant difference between brushes for either plaque or gingivitis (Terezhalmy 1995a) (Analysis 7.3; Analysis 7.4).

Unknown versus manual (Comparison 8)

Analysis 8.1; Analysis 8.2; Analysis 8.3.

Five studies (n = 1130) compared powered brushes of unknown action against manual brushes. One was assessed as being at high risk of bias (Kallar 2011) and four were at unclear risk. The data are presented in forest plots however, due to the lack of clarity about the toothbrushes being compared it is difficult to draw any conclusions.

Investigation of heterogeneity

Heterogenity was present for both plaque at one to three months and plaque at >3 months and gingivitis at >3 months for the rotation oscillation brushes compared with manual. We were unable to put forward covariates other than those considered in the sensitivity analyses below to explain this.

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Sensitivity analyses

Sensitivity analyses were limited to the data on all types of powered toothbrushes (Comparison 1: Analysis 1.1; Analysis 1.2; Analysis 1.3; Analysis 1.4) as this was the primary analysis for this review. These were conducted for trials with (1) full mouth indices only, (2) low risk of bias trials, (3) manufacturer funded (reported) and (4) excluding orthodontic patients (Additional Table 4). The effect estimates were similar to those for all trials apart from those for the low risk of bias studies. There are only five low risk of bias trials in total and two to three included in the sensitivity analyses. Due to the lack of evidence none of these were statistically significant although the effect estimates for plaque and gingivitis at one to three months were higher than those for all trials.

Converting SMDs back to original indices

As the results of both gingivitis and plaque meta-analyses were calculated as SMDs, which are unit-less and difficult to interpret, we re-expressed them in Summary of findings table 1 by calculating SMDs back into the most commonly reported indices (Quigley Hein for plaque and Löe Silness for gingivitis). In order to back translate we calculated the mean difference by multiplying the median standard deviation of the control group (end of study mean) by the pooled SMD. The table below shows this for plaque and gingivitis in both the short and long term. The differences are also expressed as percentage reductions of the median control group mean.

Plaque index	Time	Pooled SMD	Control mean*	Control standard deviation*	Difference in mean scores (95% CI)	Difference as % of control mean
Quigley Hein	1-3 months	-0.50 (-0.70 to -0.31)	2.16	0.46	-0.23 (-0.32 to -0.14)	11%
Quigley Hein	>3 months	-0.47 (-0.82 to -0.11)	1.05	0.46	-0.22 (-0.38 to -0.05)	21%

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Gingivitis index	Time	Pooled SMD	Control mean*	Control standard deviation*	Difference in mean scores (95% CI)	Difference as % of control mean
Löe Silness	1-3 months	-0.43 (-0.60 to -0.25)	1.1	0.16	-0.07 (-0.10 to -0.04)	6%
Löe Silness	>3 months	-0.21 (-0.31 to -0.12)	0.74	0.4	-0.08 (-0.12 to -0.05)	11%

*median values for all trials presenting data using chosen indices (i.e. Quigley Hein for plaque; Löe Silness for gingivitis).

Publication bias

Publication bias was assessed for the studies included in the meta-analysis for all powered toothbrushes versus manual for the one to three month assessments. Both funnel plots appear asymmetrical in visual interpretation (Figure 4; Figure 5) with some evidence of publication bias. A formal test of small study effects (Egger test) was undertaken for the Quigley Hein (Turesky) index for plaque and the Löe Silness index for gingivitis. The slope was not significant for either index (P value = 0.203; 0.56) and the hypothesis of no small study effects was also not significant (P value = 0.748; 0.15). From the statistical tests there was no evidence of any publication bias.

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Figure 4. Funnel plot of Comparison 1: All powered toothbrushes versus manual toothbrushes, Outcome 1.1: Plaque scores at 1 to 3 months at all sites.

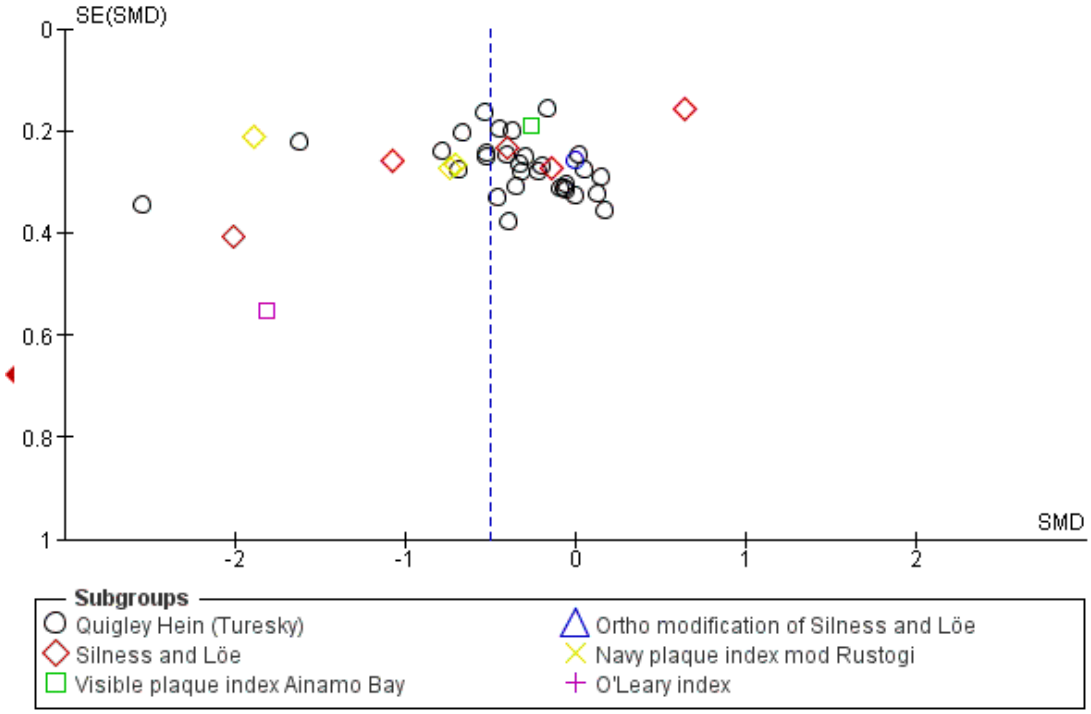

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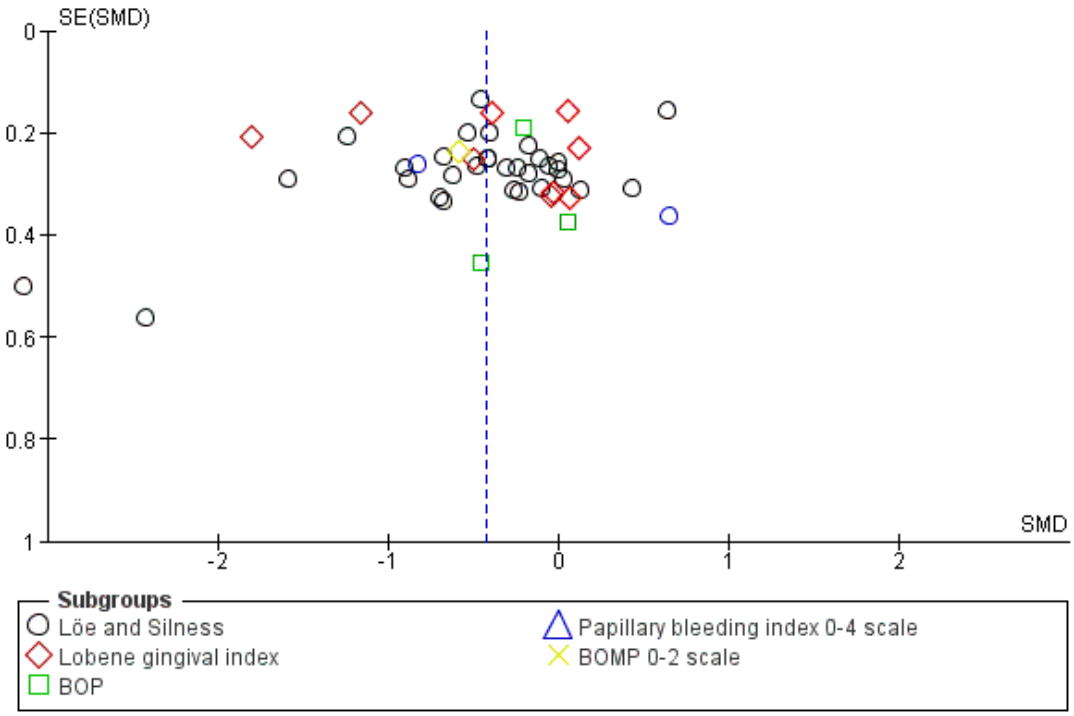
Figure 5. Funnel plot of Comparison 1: All powered toothbrushes versus manual toothbrushes, Outcome 1.2: Gingival scores at 1 to 3 months at all sites.



Secondary outcomes

Cost

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

Reliability

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

Calculus

Three trials (Dentino 2002; Glass 1965; van der Weijden 1994) reported on calculus, two reporting that there was no significant difference between the brush types (Glass 1965; van der Weijden 1994) and one reporting that, compared to the manual brush, the powered brush group showed a significant favourable difference in the accumulation of calculus at six months (P value < 0.01) (Dentino 2002).

Stain

Three trials reported that there was no difference in the degree of staining on the teeth between the brush types (Dentino 2002; Glass 1965; Walsh 1989).

Adverse events - Tissue trauma

There was no apparent relationship between the use of powered toothbrushes and soft tissue trauma. In part this finding was due to the very small number of adverse events reported in the trials. Sixteen trials did not report on adverse events (Biavati Silvestrini 2010; Costa 2007; Galgut 1996; Goyal 2007; Haffajee 2001a; Ho 1997; Lazarescu 2003; Lobene 1964a; Moritis 2008; Rosema 2008; Sharma 2010; Silverman 2004; Soparkar 1964; Van Swol 1996; Zimmer 2002; Zimmer 2005). Of the 40 trials that did report on adverse events, 27 reported no trauma to soft or hard tissues or both (Ainamo 1997; Biesbrock 2007; Clerehugh 1998; Dentino 2002; Dorfer 2009; Emling 1991; Forgas-B 1998;

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Galgut 1996; Garcia-Godoy 2001; Glass 1965; Heasman 1999; Hickman 2002; McCracken 2009; Moreira 2007; Pucher 1999; Sharma 2000; Singh unpublished; Soparkar 2000; Sowinski 2000; Stabholz 1996; Stoltze 1994; Toto 1966; Walsh 1989; Warren 2001; Wilson 1993; Yankell 1996; Yankell 1997) and six reported no significant differences between powered and manual toothbrushes, or that tissue trauma was negligible (Baab 1989; Barnes 1993; Cronin 1998; Lapiere unpublished; O'Beirne 1996; Terezhalmy 1995a).

Therefore, of the 56 studies, there were seven trials that described differences in tissue trauma between participants using manual and powered toothbrushes. One trial reported five cases of gingival abrasion in the manual and one case of abrasion in the powered group (Tritten 1996), another reported 12 cases of gingival abrasion in the manual and five cases of gingival abrasion in the powered group (van der Weijden 1994). One trial reported seven soft tissue abnormalities in six participants in the manual group and 10 abnormalities in seven participants in the powered group (Johnson 1994). In the trial by Yukna et al (Yukna 1993b) four cases of abrasion were reported in the powered toothbrush group and one in the manual group. Khocht 1992 reported soft tissue changes in four participants using the manual toothbrush, six using the experimental powered toothbrush and one participant using a control powered toothbrush. In the trial by McCracken 2004, soft tissue lesion which included abrasion and ulcer were reported in eight of manual toothbrushes group and five in powered toothbrushes group. Gugerli 2007 reported three cases of abrasion in both manual and powered toothbrushes. These soft tissue changes were seen as transient irritations that were possibly/probably due to the product.

DISCUSSION

We brush our teeth for many reasons: to feel fresh and confident; to have a nice smile; to avoid bad breath and to avoid disease. The selection of one's toothbrush is largely a matter of personal preference, affordability, availability and professional recommendation. Powered toothbrushes may have a particular appeal to some because they represent a 'high tech' solution to an everyday task. There is overwhelming evidence that toothbrushing reduces gingivitis (Lang 1973). It may prevent periodontitis and certainly prevents tooth decay if carried out in conjunction with fluoride toothpaste. These benefits occur whether the brush is manual or powered and the results of this review do not indicate that toothbrushing is only worthwhile with a powered toothbrush.

Summary of main results

The results of this review demonstrate that powered toothbrushes remove statistically significantly more plaque and gingivitis than manual brushes in both the short and long term. The results of the meta-analyses are presented as standardised mean differences (SMD), which do not relate to tangible differences in clinical indices. To help interpret the magnitude of the effect, the results of the 'all powered toothbrushes' meta-analysis have been back-translated to the most commonly reported plaque and gingivitis indices. An 11% reduction in plaque was shown at one to three months for the Quigley Hein (Turesky) index and a 21% reduction in plaque at longer than three months. The longer term result was based only on 14 trials, compared to 40 trials for the short-term analysis. With regard to gingivitis a 6% reduction was seen at one to three months for the Löe Silness index, based on 44 trials, and a greater reduction of 11% in the long term (16 trials).

When looking at individual modes of action of powered brushes there are inconsistencies with regard to reductions of plaque and gingivitis. Rotation oscillation brushes showed statistically significant reductions in both plaque and gingivitis at both time points. All other brushes, apart from side to side, showed some statistically significant findings but not consistently across both outcomes and time points. It is difficult to explain this inconsistency that a particular toothbrush design could affect plaque or gingivitis at one time but not at another and so the findings of these analyses may warrant further research, particularly given the small number of trials for some modes of action.

Overall completeness and applicability of evidence

The effectiveness of powered toothbrushes in removing plaque and reducing gingivitis can be related to destructive periodontal disease (periodontitis) only with some difficulty. Many factors are associated with the occurrence of periodontitis including plaque, tobacco use and individual medical factors. Periodontitis takes many years to develop whereas the trials have much shorter follow-up. There is little compelling evidence that plaque and gingivitis are reliable proxies for long-term destructive disease and it is difficult to estimate a threshold for clinically important reductions in either. We conclude that powered brushes reduce plaque accumulation and gingivitis but the clinical importance of these reductions cannot be assessed. More high quality long-term studies are required to investigate the effectiveness of rotation oscillation brushes in the treatment and prevention of periodontitis.

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

Few data were reported on the costs or reliability of the brushes or the side effects of their use. When reported, injuries to the gums

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were minor and transient.

Many factors may influence the effectiveness of toothbrushes including filament arrangement, orientation, size, shape and flexibility, brush head size and shape along with presence or absence and characteristics of a timer, that not all of them could be isolated and analysed. Whether the brush has a battery or rechargeable power source may also be important. These factors could be considered in subgroup analyses in the parallel review of different powered toothbrushes by Deacon and colleagues (Deacon 2010). More recently powered toothbrushes have been introduced with multidimensional actions (for example the filaments on some rotation oscillation brushes now also move in and out towards the tooth). Trials of such designs are yet to be identified.

The funnel plots for the trials of all powered toothbrushes were skewed for both plaque and gingivitis. This observation suggests but does not conclusively demonstrate publication bias. In the review intervention effects were measured by SMDs, which are naturally correlated with their standard error, which can produce spurious asymmetry in funnel plots. Other potential factors that may contribute to asymmetry include poor methodological quality of studies, true heterogeneity and the play of chance.

Publication bias might be expected in the reporting of toothbrush trials as manufacturers would like to have scientific support for the effectiveness of their products. Studies sponsored by pharmaceutical companies are more likely to favour the sponsor (Lexchin 2003). There was no evidence of this when publication bias was examined statistically, and no evidence of a difference in effect estimates when a sensitivity analysis was conducted for trials which did not mention commercial funding. It should be noted that the methods for detecting publication bias relate effect size to sample size, and in this review the trials tend to be of similar size. Therefore other methods may be required to examine publication bias in short-term, low cost studies.

Quality of the evidence

The current review focused purely on truly randomised trials. Five trials were assessed as at low risk of bias (8.9%), five at high risk of bias (8.9%) and the remaining 46 trials (82%) at unclear risk of bias. Only three trials were able to be used in the sensitivity analysis for trials at low risk of bias. These trials were unable to demonstrate statistically significant differences between powered and manual toothbrushes, although the effect estimates for plaque and gingivitis at one to three months were higher than those for all trials.

There was considerable unexplained heterogeneity in the meta-analyses for plaque and gingivitis for the primary analysis of powered toothbrushes versus manual brushes, and for the meta-analyses of individual modes of action. This heterogeneity could not be explained.

AUTHORS' CONCLUSIONS

Implications for practice

This review has found that compared with manual toothbrushes, powered toothbrushes are more effective than manual brushes in reducing plaque and gingivitis in the long and short term. An 11% reduction in plaque (Quigley Hein (Turesky) index) was shown at one to three months and a 21% reduction in plaque at longer than three months. With regard to gingivitis a 6% reduction (Löe Silness index) was seen at one to three months and a greater reduction of 11% in the long term. The clinical importance of these findings remains unclear.

Cost, reliability and side effects were inconsistently reported. Any reported side effects were localised and only temporary.

Implications for research

Trials of longer duration are required to fully evaluate the effects of powered toothbrushes. There are few trials reporting data over more than three months. Data on the long-term benefits of powered toothbrushes would be valuable in their own right and could be used to trial other outcomes such as the adverse effects and benefits in the prevention of periodontitis and dental caries.

This review continued to identify idiosyncrasies in the design of the trials and in some cases data could not be included for this reason. Whilst many of the trials were conducted before the current emphasis on experimental design, even recent trials lacked power calculations and had not been analysed on an intention-to-treat basis. Researchers in this field would be advised to study guidance on the design and reporting of clinical trials such as that provided in the CONSORT statement (http://www.consort-statement.org/) and Robinson and colleagues (Robinson 2006). Specific guidance exists for trials in the treatment or prevention of periodontal diseases (Imrey 1994) but greater standardisation of both the follow-up intervals and the indices used would benefit both trials and future meta-analyses. Thought should also be given to when the mouth should be examined in relation to when the teeth were last cleaned. Authors might also seek guidance on the analysis and presentation of cross-over trials.

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

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

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Finally, empirical data on thresholds for clinically important differences in plaque and gingivitis levels would help to determine whether oral hygiene aids provide important health benefits.

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* *Indicates the major publication for the study*

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CHARACTERISTICS OF STUDIES

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

Ainamo 1997

Methods	RCT, parallel, single blind, 12 months, n = 112 with 1 drop-out
Participants	Finland, adults, 20 to 63 years, 64 M 47 F, bleeding on probing >30% sites, no medical problems
Interventions	Braun Oral B Plak Control versus Jordan soft, 2 min twice daily. Use of timer not stated
Outcomes	Ainamo and Bay Visible plaque index and modified gingival bleeding index. 3, 6 and 12 months. Whole mouth recording PI and GI
Notes	No pre-examination instructions reported.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The study was randomised..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "... parallel group, single blind (to examiner), with a duration of 12 months."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 1/112. 1 withdrew from the electric toothbrush group for personal (non-clinical) reasons before the 3-month assessment. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Baab 1989

Methods	RCT, parallel, single blind, 1 month, n = 41, with 2 drop-outs
Participants	USA, adults, 18 to 59 years, 24 M:16 F, >20 teeth with moderate gingivitis, no medical problems
Interventions	Interplak versus Butler 411, 3 min twice daily. Use of timer not stated

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Baab 1989 (*Continued*)

Outcomes	O'Leary plaque index, Löe and Silness gingival index, Ainamo and Bay gingival bleeding index. Ramfjord teeth for GI, whole mouth for PI. Gingival abrasion reported to be not significant. Plaque scores awaiting assessment	
Notes	Manufacturer funded. No pre-examination instructions reported.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned.." Insufficient information.
Allocation concealment (selection bias)	Low risk	Quote: "....The manufacturer provided 20 Interplak electric toothbrushes and 20 Butler 411 toothbrushes... arranged randomly in consecutively-numbered boxes."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "...One investigator (DAB) served as the blind examiner and made all clinical. .."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 2/41. 1 participant did not comply (manual) and 1 other withdrew from study (electric). Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Barnes 1993

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

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Barnes 1993 (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned.." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "All clinical examinations were performed by the same evaluator. This study was conducted in a single-blind manner."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 1/70. Unlikely to influence results.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Biavati Silvestrini 2010

Methods	RCT, parallel, 8 weeks, n = 20, no drop-outs, F 12:M 8.
Participants	Italy, orthodontic patients, 10 to 14 years with permanent dentition, scheduled to receive multibracket
Interventions	Oral B 35 versus Oral B Pro Care 8500, 2 min twice daily.
Outcomes	O'Leary plaque index, Ainamo and Bay index, unsure full mouth sites or partial mouth score, not monitored compliance and adverse event
Notes	Source of funding unclear, no pre-examination instruction reported, low number of subjects

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly divided..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information.

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Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adeqaute reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Biesbrock 2007

Methods	RCT, parallel, single blind, 8 weeks, n = 179 with 5 drop-outs in full trial (n = 59 for powered versus manual comparison)
Participants	United States, adults, 18 to 69 years, ≥15 sites with bleeding on probing
Interventions	Oral B Pro Care series versus Oral B Cross Action, 2 min twice daily, use of timer not stated
Outcomes	Rustogi Mod of the Navy plaque index, Löe & Sillness gingival index at 0 and 8 weeks. Whole mouth recording of plaque and gingivitis. Adverse event reported; no different between groups
Notes	Manufacturer funded. This is a trial of 2 manual groups with different toothpaste. 3 other groups with numerous combinations - 2 powered toothbrushes and mouthwash were also assessed. We used the comparison of manual and powered using the same toothpaste. Pre-intervention prophylaxis done. Pre-examination instruction given; no brushing for 12 hours and no drinking, no eating or tobacco for 4 hours

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "Eligible subjects were stratified based on gender and the number of baseline sites (≤40 or ≥41), and randomly assigned to ....." Insufficient information.
Allocation concealment (selection bias)	Low risk	Quote: "... all test products were distributed in blinded kit boxes...."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "... all clinical assessment (efficacy and safety) were conducted by examiners who were blinded as to treatment assignment."

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Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 1/59. None due to product-related adverse events. Unlikely influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Clerehugh 1998

Methods	RCT, parallel, single blind, 8 weeks, n = 84 with 5 drop-outs
Participants	UK, children and adolescents, 10 to 20 years, orthodontic patients in practice, fixed appliances, gingival bleeding at 30% sites, no medical conditions
Interventions	Braun Plaque Remover with OD 5 head versus Reach medium compact head, 2 min twice daily. Timer used
Outcomes	Orthodontic modification of Silness and Löe plaque index, Eastman bleeding index at all buccal sites at 4, 8 weeks. No evidence of trauma. 1 mechanical brush failed
Notes	Manufacturer funded. Participants asked to brush in the morning and under supervision prior to assessment

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "...subjects were randomly allocated to groups using the minimisation methods..."
Allocation concealment (selection bias)	Low risk	Quote: "..and the clinical trial investigator remained blind to the toothbrush group allocation."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: " ..and the clinical trial investigator remained blind to the toothbrush group allocation."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 5/84 completed. Reason for drop-outs: electric toothbrush group (37/41) - 1 failed to attend final examination, 1 failed to follow brushing instruction, 1 failed to use the product for 7 days prior to the week 4 examination, 1 was put on tetracycline; manual group (42/43) - 1 de-

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		veloped chicken pox and could not attend for examination. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Costa 2007

Methods	RCT, single blind, cross-over, n = 21 with no drop-outs, 30 days (15 days wash-out period)
Participants	Brazil, orthodontics patients, aged 12 to 18 years, at least 20 teeth assessable, orthodontic treatment a minimum of 1 year, non-smokers with no history of periodontal disease
Interventions	Ultrasonex Ultima versus Oral B 3D versus Oral B Model 30, 2 min 3 times daily, use of timer not stated
Outcomes	Sillness and Löe plaque indices, Löe and sillness gingival indices, microbiological parameters assessed, no difference in clinical and microbiological parameters. No adverse effect reported
Notes	Funding unclear, pre-intervention prophylaxis done.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly divided into three groups ...." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information.
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Cronin 1998

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

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomly assigned to 2 groups by Zelen's method of permuted blocks of size 4
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..all subject were evaluated by the same examiner who was unaware of the type of toothbrush used by the subject."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 9/114 completed. Reasons for drop-outs: powered group - 8 with reasons unrelated to treatment; manual group - 1 failed to return for final examination. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Dentino 2002

Methods	RCT, parallel, single blind, 6 months, n = 172 with 15 drop-outs
Participants	USA, adults, mild to moderate gingivitis with >20 teeth, no previous powered brush experience. Excluded if pregnant/lactating
Interventions	Braun Oral B D9 versus ADA accepted standard soft bristle manual, 2 min twice daily. Use of timer not stated

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Dentino 2002 (*Continued*)

Outcomes	Quigley Hein (Turesky) plaque index and Lobene gingival index at 3 and 6 months. Powered brush removed more calculus. No difference in stain removal reported. PI and GI whole mouth	
Notes	Manufacturer funded. Participants asked to brush teeth (non-supervised) immediately prior to 6-month plaque assessment	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "Based on the screening visits, patients were stratified by gender, MGI, plaque index (PI), and smoking using a computer program, and were randomly assigned..."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "This 6-month, single-masked, parallel design.."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 15/172 but unclear as to which group these were from
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Dorfer 2009

Methods	RCT, parallel, single blind, 6 months, n = 109 with 3 drop-outs
Participants	Germany, adult with recession, 18 to 70 years, ≥18 teeth present, ≥2 sites with at least 2 mm recession
Interventions	Oral B 7000 (D17) versus ADA toothbrush, 2 min twice daily, use of timer not stated
Outcomes	Turesky modified Quigley Hein plaque indices and gingivitis indices at 0, 6 months. Whole mouth recording of plaque and gingivitis. Main outcome measured was gingival recession; reduced pre-existing gingival recession in both groups. Other outcomes: PPD, PAL. Adverse event reported; no different between both groups. All patients reported to be compliant

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Notes	Manufacturer funded. Pre-intervention instruction on use of each toothbrushes done. Matched or stratified groups	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "prospective randomized, controlled ..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "...examiner blind.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 3/109. Unlikely to influence results.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Emling 1991

Methods	RCT, parallel, single blind, 30 days, n = 60 with 3 drop-outs	
Participants	USA, adults, no medical problems, no current ortho, not pregnant, >17 teeth, 18 to 60 years	
Interventions	Plak Trac versus Colgate ADA approved, twice daily. Use of timer not stated	
Outcomes	Quigley and Hein (Turesky) plaque index. Yankell, interproximal plaque index, Löe and Sillness gingival index. Ramfjord teeth for both PI and GI	
Notes	Pre-brushing measurements used.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned ...." Insufficient information.

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Emling 1991 (*Continued*)

Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "The study was thus conducted in a single-blind manner."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 3/60.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Forgas-B 1998

Methods	RCT, parallel, single blind, 30 days, n = 62 with 6 drop-outs
Participants	USA, adults, mean age 37 years +/- 10 years, >16 teeth, plaque index >2, no medical problems, 21 M:35 F
Interventions	Ultrasonex versus manual Oral B, twice daily. Use of timer not stated
Outcomes	Quigley and Hein (Turesky) plaque index, Eastman gingival bleeding index at 30 days. Ramfjord teeth for PI and GI. Soft tissue trauma reported, no difference between groups
Notes	Manufacturer funded. Participants asked to refrain from brushing for 12 to 14 hours before assessment

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned ...." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Examiners were blind to group assignment."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 6/62 (5 from manual group; 1 from powered group). Uneven drop-outs across groups; reasons not stated
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.

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Forgas-B 1998 (*Continued*)

Other bias	Low risk	No other apparent biases.

Galgut 1996

Methods	RCT, parallel, single blind, 28 days, n = 70 with 7 drop-outs
Participants	UK, Caucasians, male, 19 to 36 years.
Interventions	Sangi Co Electronic (Active) versus Sangi Co Electronic (non-active), 3 minutes when brushing. No frequency stated. Use of timer not stated
Outcomes	Quigley and Hein (Turesky) plaque index, Löe and Silness gingival index at 2, 4 weeks. Whole mouth recording for indices. No adverse events recorded
Notes	Manufacturer funded. Assessment after 24 hours of no brushing

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "The company supplied 75 toothbrushes, numbered 1 to 75. Some ... were electrically active, and others...inactive" "Subjects received a trial toothbrush in numerical order.." Not explicit but probably appropriate method.
Allocation concealment (selection bias)	Low risk	Quote: "Subjects received a trial toothbrush in numerical order..." "After completion of the clinical trial, coding ...was revealed to the primary investigator."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..toothbrushes were indistinguishable by anyone concerned with the clinical trial...."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 7/70. Unclear as to drop-outs by group.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Garcia-Godoy 2001

Methods	RCT, parallel, single blind, 30 days, n = 70 with 4 drop-outs	
Participants	USA, children, 6 to 11 years, able to understand procedure.	
Interventions	Braun Oral B D10 per manufacturers instructions versus ADA approved manual brush as normal	
Outcomes	Quigley Hein (Turesky) plaque index. Whole mouth. No adverse events recorded	
Notes	Manufacturer funded. Assessment after 12 to 18 hours from last brushing	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomized to..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "...conducted by the same examiner who was blinded to the treatment group."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 4/70. Unlikely to influence results.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Glass 1965

Methods	RCT, parallel, single blind, 11 months, n = 250 with 84 drop-outs
Participants	USA, dental students, male, 20 to 29 years.
Interventions	GEC powered versus Pycopay brand manual twice daily. Use of timer not stated
Outcomes	Glass debris and gingival indices at 6 weeks, 7 and 11 months at all sites. Stain and calculus reported to be no different between brush types. Whole mouth recording PI and GI. No soft tissue trauma reported
Notes	Manufacturer funded. No pre-examination instructions reported.
Risk of bias	

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Glass 1965 (*Continued*)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "A random, binary digit was punched by a computer into each name card to provide identification of two groups" "A coin was tossed to determine the assignment of brushes."
Allocation concealment (selection bias)	Low risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..the examiner was unaware of the brush type used by the subject."
Incomplete outcome data (attrition bias) All outcomes	High risk	Drop-outs: 84/250 drop-outs. Unclear of drop-outs by group; could influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Goyal 2007

Methods	RCT, parallel, single blind, 30 days, n = 53 with no drop-outs
Participants	Canada, adults, 18 to 65 years, Löe and Sillness gingival index ≥ 1.5
Interventions	Ultreo Versus Oral B 35, twice daily, period of brushing not stated, use of timer not stated
Outcomes	Löe and Silness gingival indices at 0, 30 days at all sites. Whole mouth. Adverse event reported; no different between groups. Subjective experience of cleanliness assessed revealed higher score in Ultreo group. No adverse event reported
Notes	Manufacturer funded. No pre-intervention treatment and pre-examination instruction given

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned ...." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.

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Goyal 2007 (*Continued*)

Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: " ..was a randomised, examiner blind, parallel..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Gugerli 2007

Methods	RCT, parallel, single blind, 28 days, n = 70 with no drop-outs
Participants	Switzerland, adults, 18 to 70 years, M 46 F 46, minimun of 12 score able teeth, chronic periodontitis, Class II, good general health
Interventions	Oral B Pro Care 8000 versus ADA, twice daily, period of brushing not stated, use of timer not stated
Outcomes	Sillness and Löe plaque indices and Löe and Sillness gingival indices at 0, 28 days at all sites. Whole mouth recording of plaque and gingival indices. Compliance recorded in diaries. Abrasion reported in 3 patients of each groups
Notes	Manufacturer funded. Pre-intervention prophylaxis done, pre-intervention instructions on oral hygiene given for 15 min

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "Subjects were assigned randomly by a computer-generated table..."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "This was an examiner-masked..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.

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Other bias	Low risk	No other apparent biases.

Haffajee 2001a

Methods	RCT, parallel, single blind, 6 months, n = 52 with 4 drop-outs
Participants	USA, systemically healthy participants with adult periodontitis, 20 to 64 years, minimum of 20 teeth
Interventions	Crest Complete versus Braun Oral B D15 Plaque Remover. Frequency unclear. Use of timer not stated
Outcomes	Turesky plaque index , Löe and Silness gingival index, bleeding on probing and probing attachment level at baseline, 3 and 6 months. Measurements taken for 6 sites per tooth for up to 28 teeth
Notes	Manufacturer funded. No pre-examination instructions reported.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: " ..toothbrushing group using a pre-determined randomisation schedule."
Allocation concealment (selection bias)	Low risk	Quote: " A copy of randomization schedule and study codes were kept by the principal investigator."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "In this 6 months, single-blind study,..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 4/52. Reasons for drop-outs: moving away from the area, did not want to use toothpaste provided and reasons unrelated to study. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Heasman 1999

Methods	RCT, parallel, single blind, 6 weeks, n = 75 with 1 drop-out
Participants	UK, adults, >permanent 20 teeth, 18 to 25 years, no medical problems
Interventions	Braun Oral B D7 versus Philips Jordan HP 735 versus Oral B Advantage B35, >90 seconds twice daily. Use of timer not stated
Outcomes	Quigley Hein (Turesky) plaque index at 24 hours and 6 weeks, Löe and Silness gingival index at 6 weeks, all sites. Whole mouth recording PI and GI.
Notes	Assessment done within 3 to 4 hours of last brushing. 2 powered groups combined for meta-analysis.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "...allocated ranomly..."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..single-blind clinical trial was undertaken.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 1/75. Unlikely to influence results.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Hickman 2002

Methods	RCT, parallel, blinding unclear, 8 weeks, n = 63 with 3 drop-outs
Participants	UK, orthodontic patients, 10 to 20 years, medically fit.
Interventions	Braun Plaque Remover 3D with orthodontic head versus Reach compact head manual, 2 min twice daily. Timer supplied
Outcomes	Silness and Löe plaque index (orthodontic modification) and Löe and Silness gingival index, full mouth at 4 and 8 weeks
Notes	Manufacturer funded. Brush as normal post-breakfast.

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Hickman 2002 (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "...randomly assigned...", "...prepared by the trial statistician..." Sequence generation not explicit, but assumed low risk of bias
Allocation concealment (selection bias)	Unclear risk	Quote: "The trial coordinator who opened a sealed envelopes, prepared by the trial statistician, containing the group allocation, undertook randomization." Unclear if sealed envelopes were sequentially numbered.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "The trial researcher was blinded to the group allocation.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 3/63. Unlikely to influence results.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Ho 1997

Methods	RCT, parallel, single blind, 4 weeks, n = 24, drop-outs unclear
Participants	USA, orthodontic patients, with fixed appliances, 11 to 18 years, gingival index >2, no medical conditions
Interventions	Sonicare Ultrasonic versus Oral B P35, 2 min twice daily. Timer supplied
Outcomes	Silness and Löe gingival and plaque indices on 6 sites per bonded tooth and bleeding on probing all at 4 weeks. Whole mouth recording PI and GI
Notes	Manufacturer funded. No pre-examination instructions reported.

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

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Random sequence generation (selection bias)	Low risk	Quote: "..subjects to the two groups was done through use of two tables of random numbers."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "A single investigator (HH), who was blinded as to which toothbrush was being used.."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs unclear.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Johnson 1994

Methods	RCT, parallel, single blind, 4 weeks, n = 53 with 10 drop-outs
Participants	USA, adults, >20 teeth, gingival index >1.5 on Ramjford teeth, no medical conditions, 20 to 54 years
Interventions	Philips Sonicare versus Oral B 30, 2 min twice daily. Timer supplied
Outcomes	Quigley Hein (Turesky) on all sites, Ainamo and Bay gingival index and sulcular bleeding indices on Ramfjord at 1, 2, 4 weeks. Soft tissue trauma "abnormalities" 7 sites in 6 subjects for manual and 10 sites in 7 subjects for powered
Notes	Manufacturer funded. Post-brushing evaluation.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned...." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..randomised, single-blind, controlled clinical study."

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Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 10/53. Even drop-outs, due to missed visits. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Kallar 2011

Methods	RCT, parallel, 12 weeks, n = 200 and unsure of drop-outs (assume no drop-outs)	
Participants	India, school children aged 6 to 13 years.	
Interventions	Unknown powered versus unknown manual toothbrush, no information on methods, time and duration of brushing	
Outcomes	Turesky Quigley Hein plaque index on all sites, full mouth at 3, 6, 9 and 12 weeks	
Notes	Funding source not stated. Mix of supervised and unsupervised brushing.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "Children were randomly divided into two groups." Insufficient information
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Unclear but assumed no drop-outs.
Selective reporting (reporting bias)	High risk	Gingivitis not reported.
Other bias	Unclear risk	Unclear as little text in the report.

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Khocht 1992

Methods	RCT, parallel, single blind, 4 weeks, n = 96 with 1 drop-out
Participants	USA, adults, >15 teeth with no restorations affecting cervical region plaque score >1.8 and gingival score >0.9, no medical conditions
Interventions	Epident and Interplak versus Oral B 40, twice daily. Use of timer not stated
Outcomes	Quigley Hein (Turesky) plaque index and Löe and Silness gingivitis index at all sites at 28 days. Whole mouth recording for PI and GI. No reported soft tissue abrasion
Notes	Manufacturer funded. Pre-brushing evaluation.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned...." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "This single (examiner) blind.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 1/96. Unlikely to influence results.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Lapiere unpublished

Methods	RCT, parallel, single blind, 12 weeks, n = 48 with no drop-outs stated
Participants	Belgium, periodontal patients, 18 to 65 years, 20 natural teeth, no removable dentures, probing pocket depth >2 mm but <5 mm, free from subgingival calculus
Interventions	Philips HP 550 versus P Oral B 35 versus Braun Oral B D5, 2 min 3 times a day. Use of timer not stated
Outcomes	Quigley Hein (Turesky) plaque index and Löe and Silness gingivitis index, whole mouth at 12 weeks

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Lapiere unpublished (*Continued*)

Notes	Funding unclear. No pre-examination instructions reported. Data for 2 powered brushes combined as same mode of action.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Only mentions randomised. Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Everything was done to keep the whole procedure as blinded as possible."
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Lazarescu 2003

Methods	RCT, parallel, single blind, 18 weeks, n = 80 with 2 drop-outs	
Participants	Romania, adults, >20 teeth, medically fit and no previous powered brush experience	
Interventions	Philips/Jordan HP 735 versus Oral B 40 manual with normal brushing pattern. Use of timer not stated	
Outcomes	Quigley Hein (Turesky) plaque index at 6 sites per tooth and gingival bleeding index at proximal smooth surfaces at 18 weeks. Whole mouth recording PI and GI	
Notes	Manufacturer funded. Assumed pre-brushing evaluation.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Quote: "..subjects were divided into two groups by an independent examiner not taking part in the further clinical assessment."

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Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "The investigator were blinded to the toothbrush used by the subjects."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 2/80. Unlikely to influence results.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Lobene 1964a

Methods	RCT, parallel, single blind, n = 185, 3 months, drop-outs unclear
Participants	USA, female college students, aged 17 to 21 years.
Interventions	General electric reciprocating action versus Oral B 40 manual with no instruction. Use of timer not stated
Outcomes	Lobene gingivitis index at 3 months. Whole mouth recording PI and GI
Notes	Manufacturer funded. No pre-examination instructions reported.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Only mentions randomised. Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..the examiner was unaware of the group to which any subject was assigned."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs unclear.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.

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Other bias	Low risk	No other apparent biases.

McCracken 2004

Methods	RCT, parallel, single blind, 16 months, n = 40 with 8 drop-outs
Participants	UK, patients who attended periodontal clinic, 25 to 70 years, periodontal disease identified clinically by minimum of 10 sites with PPD ≥5 mm confirmed by radiograph, full mouth plaque score at least 2.0, minimum of 20 permanent teeth. Excluded: previous use of powered toothbrush
Interventions	Philip Sensiflex 2000 brand versus Oral B Advantage. 2 min twice daily, use of timer not stated
Outcomes	Turesky modified Quigley Hein plaque indices and Papilla bleeding indices at 0, 3, 10, 16 months, whole mouth recordings. Other outcomes: pocket depth reported: no different between both groups. Soft tissue lesion (abrasion and ulcer) reported; 8 in manual and 5 in powered
Notes	Manufacturer funded. Pre-intervention prophylaxis at baseline. No prophylaxis done at different visit. Use of interdental cleaning was recommended for at least once a day

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "A numerically balanced, stratified (for gender,age,smoking status) and randomised allocation of patients produced two groups..", "A 75% weighted randomisation was used to balance the distribution of the stratification characteristics between the groups."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "A two group, parallel, single blind. ..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 8/40. Even distribution of drop-outs and reasons not linked to interventions. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.

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Other bias	Low risk	No other apparent biases.

McCracken 2009

Methods	RCT, parallel, single blind, 12 months, n = 60 with 8 drop-outs
Participants	UK, periodontal patients from dental hospital, 18 to 45 years, localised areas of buccal/labial gingival recession with at least 1 mm attachment loss with Miller classification I and II recession defects. Excluded: moderate to severe chronic and agressive periodontitis and routinely using powered toothbrushes
Interventions	Philips Sonicare Elite versus Oral B 35. 2 min twice daily, use of timer not stated
Outcomes	Turesky modified Quigley Hein plaque indices and bleeding on probing (dichotomous) at 0, 3, 6, 9 and 12 months. Whole mouth. Other outcomes on CAL, PD, recession, wear of the brushes reported; no differences between both groups. Adverse events reported not related to studies; 18 in manual and 16 in powered groups
Notes	Manufacturer funded. Pre-intervention prophylaxis and instruction done. Reinforced oral hygiene at each visits

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "The randomization sequence was generated using SPSS (version 14) using a block methodology..."
Allocation concealment (selection bias)	Low risk	Quote: "This remained concealed until the time of brush allocation..."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "two clinical examiners remained blinded to group allocation.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 8/60. Even distribution of drop-outs and reasons not linked to interventions. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Moreira 2007

Methods	RCT, cross-over, single blind, 28 days, n = 20 with no drop-outs, 14 days wash-out period
Participants	Brazil, first year dental students, 18-29 years old, 15 F 5 M, at least 20 teeth present, right handed subjects, 15% plaque visible at buccal and lingual surfaces. Excluded: subjects with orthodontics appliances, taking any medication would interfere plaque formation and antibiotics treatment during the 3/12 prior to study
Interventions	HyG ionic versus Close-up Essential, 2 min twice daily. Use of timer not stated
Outcomes	Turesky modified Quigley Hein plaque indices and gingival bleeding indices (Ainamo and Bay dichotomomization of the Löe gingival index) at 0 and 28 days. Full mouth score. No difference between groups. Adverse event reported in later study (Moreira 2008); no differences between groups
Notes	No external funding for initial study. Scholarship by CAPES acknowledged in Moreira 2008 Pre-intervention prophylaxis at baseline and between wash-out period. Refrained oral hygiene 10-12 hours prior to examination

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "..after the examination and by means of the flip of a coin, individuals were assigned to either one of the two tooth-brushes..."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "...blinded calibrated examiner..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important out-comes.
Other bias	Low risk	No other apparent biases.

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Moritis 2008

Methods	RCT, parallel, single blind, 4 weeks, n = 180 with 12 drop-outs
Participants	UK, adults, 18 to 65 years, 142 F 27 M, non-smokers with at least 20 natural teeth, gingival index of ≥2.0 on at least 20 sites and plaque index of ≥0.8, excluded: severe gingivitis and periodontitis
Interventions	Sonicare Elite versus manual. 2 min twice daily. Use of timer not stated
Outcomes	Sillness and Löe plaque indices and Löe and Sillness gingival indices at 0, 2, 4 weeks. Whole mouth. Abrasion reported: 1 in manual and 1 in powered. Compliance monitored at average subjects brushed 2 min twice daily. Adversed events not reported
Notes	Manufacturer funded. No pre-intervention treatment. Refrained from oral hygiene for 2 to 6 hours before baseline examination

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned...." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "...examiner calibrated and blinded to product assignment."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 12/180. 4 lost to follow-up, 5 drop-outs due to adverse event not related to study, 3 scheduling conflicts
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

O'Beirne 1996

Methods	RCT, parallel, single blind, 8 weeks, n = 40, drop-outs unclear
Participants	USA, adults with inflammatory periodontal disease, >20 teeth and received periodontal treatment, 22 M: 18 F, 18 to 65 years
Interventions	Sonicare Ultrasonex versus Oral B manual 2 min twice daily. Timer supplied

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O'Beirne 1996 (*Continued*)

Outcomes	Löe and Silness gingival index, Barnett papillary bleeding index at 2, 4 and 8 weeks, at all sites. Whole mouth recording PI and GI. Minor gingival trauma seen in 1 participant in each group	
Notes	Part funded by manufacturer.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: " devices were packaged in kits, arranged in random order and numbered in sequence by the sponsoring company, independednt of the investigators."
Allocation concealment (selection bias)	Low risk	Quote: " devices were packaged in kits, arranged in random order and numbered in sequence by the sponsoring company, independednt of the investigators."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: " ..single-blinded, randomised clinical investigation.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Pucher 1999

Methods	RCT, parallel, double blind, 6 weeks, n = 60 with 8 drop-outs
Participants	USA, orthodontic patients, >20 teeth, >12 years, 23 M: 29 F after drop-outs
Interventions	Hukuba ionic (active) versus Hukuba ionic (non-active) with usual technique twice daily. Use of timer not stated
Outcomes	Quigley and Hein (Turesky) plaque index, Löe and Silness gingival index, whole mouth at 6 weeks. No adverse events/effects recorded
Notes	Funding not stated. No brushing for 12 hours and pre-brushing data used
Risk of bias	

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Pucher 1999 (*Continued*)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "..randomly assigned.." Insufficient information.
Allocation concealment (selection bias)	Low risk	Quote: "The patients were given a prepackaged, coded toothbrush."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "...both participants and the examiner were unaware of which toothbrush the participants were using during..."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 8/60. Unclear as to which group drop-outs came from
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Rosema 2008

Methods	RCT, parallel, single blind, 9 months, n = 118 with 4 drop-outs
Participants	Nertherlands, general population (with intensive pre-intervention oral hygiene care), aged ≥18 years, minimun of 5 evaluable teeth per quadrant, gingival bleeding ≥40%, absence of oral lesion. No pocket depth >5 mm, no wearing partial denture, orthodontic wires
Interventions	Oral B D25 Pro Care 9000 versus ADA toothbrush, 2 min twice daily. Use of timer
Outcomes	Modified Quigley and Hein plaque indices, partial mouth score, bleeding on marginal probing index (BOMP 0-2 scale) at 0, 10 weeks, 6 and 9 months. Powered toothbrush maintained lower plaque levels for 9 months better than manual toothbrush. No adverse events reported
Notes	Manufacturer funded. Pre-intervention: very intensive oral home care for 3 weeks. Pre-intervention prophylaxis at baseline, reinforced oral hygiene intervention at 6 and 10 months

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Randomization was performed using true random numbers generated by ..."

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Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "... examiner masked..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 4/118. Even distribution of drop-outs and reasons not linked to interventions. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	The subjects who smoked were not balanced between the groups; 5 for manual group and 2 only for powered group but unlikely to influence results

Sharma 2000

Methods	RCT, parallel, single blind, 30 days, n = 62 with 1 drop-out
Participants	Canada, adults, 18 to 62 years, good general and oral health, 26 M: 36 F
Interventions	Colgate Actibrush versus Colgate diamond headed manual for 1 min twice daily. Use of timer not stated
Outcomes	Navy (Rustogi) plaque index, Löe and Silness (Chilton) gingival index, full mouth at 30 days, no adverse effects
Notes	Manufacturer funded. No pre-examination brushing for 8 hours

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "randomly assigned..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 1/62. Unlikely to influence results.

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Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Sharma 2010

Methods	RCT, parallel, single blind, 4 weeks, n = 132 with 3 drop-outs	
Participants	USA, adults, aged 18 to 56 years, ≥18 years old, good general health. Gingivitis 1.75-2.3	
Interventions	Oral B Pulsonic versus ADA manual toothbrush, 2 min and twice daily	
Outcomes	Rustogi modified Navy plaque index, modified gingival index, full mouth at 0, 4 weeks. No reported adverse events from both groups	
Notes	Manufacturer funded. Pre-examination instruction: abstain from oral hygiene procedure 12 hours prior to investigation	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "...randomly allocated via a computer-generated balance and assignment program to one of the two toothbrush test groups...."
Allocation concealment (selection bias)	Low risk	Quote: "... test product distribution processes were conducted in a separate area not accessible to the clinical examiner and data recorders."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "examiner blind, parallel group design."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 3/132. Unlikely to influence resutls.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Silverman 2004

Methods	RCT, parallel, single blind, 6 weeks, n = 59 with 2 drop-outs
Participants	USA, children, 4 to 5 years, excluded: history of periodontal disease
Interventions	Oralgiene 60 second time machine versus Oral B Mickey Mouse versus Oral B Rugrats 20; (2 powered and 1 manual), 60 seconds twice daily for Oralgiene, others 2 min twice daily. Own toothpaste used. Timer used
Outcomes	Turesky modified Quigley and Hein plaque indices and Löe and Sillness gingival indices at 0, 6 weeks. Whole mouth. No adverse effects reported. Mechanical reliability checked on compressive load needed to activate the powered toothbrush, revealed higher compressive load needed for Oralgiene 60 seconds
Notes	Manufacturer funded. Use own toothpaste. Less parents involvement. All examination done at school Baseline, pre-brushing and post-brushing data available but decided to use the baseline data. The Oral B Rugrats 20 (manual) and Oral B MIckey mouse (powered) are considered for analysis

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "Using random numbers table..."
Allocation concealment (selection bias)	Low risk	Quote: "..the assignment of toothbrushes and brushing were performed without the presence of examining investigator.."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Reported as blind.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 2/59. Reasons unclear, but unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases. Age of children?

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Singh unpublished

Methods	RCT, parallel, single blind, 60 days, n = 73 with 8 drop-outs
Participants	USA, orthodontic patients, 11 to 19 years, >19 teeth, good health, no prophylaxis within last month
Interventions	Pulse Plaque Remover versus Oral B 35, 2 min. Frequency not stated. Use of timer not stated
Outcomes	Quigley and Hein (Turesky) plaque index, papillary bleeding score (Loesche) for gingivitis
Notes	Manufacturer funded. No pre-examination brushing for 12 to 24 hours

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "The examiner were blinded with respects to the methods used for brushing. ."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 8/73. Unclear as to which group drop-outs came from
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Soparkar 1964

Methods	RCT, parallel, single blind, 11 weeks, n = 270 with 32 drop-outs
Participants	USA, college students non-dental.
Interventions	Unknown action powered versus old manual with normal regimen. Use of timer not stated
Outcomes	Gingival index (assumed Löe and Silness) on 0-3 scale at 11 weeks. Anterior teeth only
Notes	No pre-examination instructions reported.

Risk of bias

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Soparkar 1964 (*Continued*)

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "...divided at random..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "..the examiner was not aware of either the previous gingival score of the subject being examined or the type of toothbrush...."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 32/270. Reasons for drop-outs not discussed; unclear as to which group drop-outs came from
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Soparkar 2000

Methods	RCT, parallel, single blind, 30 days, n = 66 with 3 drop-outs
Participants	USA, healthy adults, 18 to 70 years, 25 M: 38 F (data on drop-outs not presented)
Interventions	Colgate Actibrush versus ADA approved manual brush, 1 min twice daily. Use of timer not stated
Outcomes	Rustogi modification of Navy plaque index and Mandel-Chilton modification of Löe Silness gingival index, all surfaces
Notes	Manufacturer funded. No pre-examination brushing for 8 hours

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "It was a parallel, examiner-blind, randomised, balanced, two-group design.. ." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.

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Soparkar 2000 (*Continued*)

Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "It was a parallel, examiner-blind, randomised, balanced, two-group design.. ."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 3/66 completed. 3 from ADA group failed to complete. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Sowinski 2000

Methods	RCT, parallel, single blind, 30 days, n = 110 with no drop-outs
Participants	USA, adults, 18 to 70 years, >15 teeth, no orthodontic appliances, no oral disease, 22 M: 88 F
Interventions	Colgate Actibrush versus Colgate diamond head manual, 1 min twice daily. Use of timer not stated
Outcomes	Quigley and Hein (Turesky) and Löe and Silness gingival index, full mouth at 30 days. No adverse events
Notes	Manufacturer funded. No pre-examination brushing for 24 hours

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	ADA guidelines followed but no word random. Only mentions that "Qualifying participants were stratified into two balanced treatment groups according to their baseline plaque index and gingivitis index scores." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "This independent clinical study, employed an examiner-blind, two-treatment...."
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.

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Sowinski 2000 (*Continued*)

Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Stabholz 1996

Methods	RCT, parallel, single blinded, n = 56 with 4 drop-outs, 60 days	
Participants	Israel, general population, no medical conditions.	
Interventions	Plaq and White A to Z technology versus Oral B 35 as per normal regimen. Use of timer not stated	
Outcomes	Quigley and Hein (Turesky) and Löe and Silness gingival and Eastman bleeding on probing indices on Ramfjord teeth at 15 and 30 days. No difference in soft tissue trauma between brush types	
Notes	Participants asked to refrain from brushing for 12 hours prior to each assessment	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Quote: "An independent person was responsible for distributing the different toothbrushing and was the only..." Insufficient information given lack of detail regarding randomisation
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Each examiner recorded 28 participants of both groups without knowing their brush assignment.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 4/56. 2 participants from each group did not complete for reasons not related to the protocol
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Stoltze 1994

Methods	RCT, parallel, unclear blinding method used, n = 40 with 2 drop-outs, 6 weeks	
Participants	Denmark, young adults 18 to 30 years, with plaque and gingival scores >1, >20 teeth, no medical problems	
Interventions	Braun Oral B Plak Control D5 versus Tandex 40 manual, 2 min twice daily. Use of timer not stated	
Outcomes	Silness and Löe plaque index, Löe and Silness gingival index at all sites, 1, 2 and 6 weeks. Whole mouth recording PI and GI. No gingival abrasion reported	
Notes	No pre-examination instructions reported.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...participants were at random allocated to a group..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 2/40. Reasons not stated. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Terezhalmy 1995a

Methods	RCT, parallel, single blind, 6 months, n = 54 with 4 drop-outs
Participants	USA, adults, good health and free of oral pathology.
Interventions	Ultra-sonex ultrasonic versus Oral B manual 3 min twice daily. Use of timer not stated
Outcomes	Quigley and Hein (Turesky) plaque index and Löe and Silness gingival index at all sites and Eastman bleeding on probing index on contralateral Ramjford teeth. Assessed at 15 and 30 days and 6 months. No soft tissue trauma
Notes	Participants asked to refrain from brushing 12 to 14 hours prior to assessment

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Terezhalmy 1995a (*Continued*)

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 4/54. Reasons for drop-outs was breach of compliance. Unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Toto 1966

Methods	RCT, parallel, blinding unclear, 120 days, n = 527 with 17 drop-outs
Participants	USA, boarding school children, 6 to 18 years.
Interventions	Sunbeam cordless versus unspecified manual. Frequency not stated. Use of timer not stated
Outcomes	PMA index, whole mouth.
Notes	Funding not clear. No pre-examination instructions.

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...distributed at random..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information.

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Toto 1966 (*Continued*)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 17/527. Reasons not discussed but unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Tritten 1996

Methods	RCT, parallel, single blind, 12 weeks, n = 60 with 4 drop-outs
Participants	USA, adults 18 to 65 years, dental hospital patients, no professional cleaning previous 3 months, minimum 20 teeth, no previous periodontal treatment and unaware of active pregnancy
Interventions	Sonicare versus Butler 311, 2 min twice daily. Timer supplied
Outcomes	Quigley and Hein (Turesky) plaque index all teeth, Löe and Silness gingival index Ramfjord teeth. Gingival abrasion seen in 5 manual and 1 powered brush subjects
Notes	Manufacturer funded. Pre-brushing evaluation.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "..patients were randomised by having them draw their group assignment from a box containing a mixture of 30 labels marked 'manual group' and 30 labels marked ..."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "One investigator (CT), who was blinded to the brush assignments of each group.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 4/60. Excluded from analysis; either received antibiotics therapy (2) or failed to appear for 1 of the scheduled study visit (2). Drop-outs unlikely to influence results

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Tritten 1996 (*Continued*)

Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

van der Weijden 1994

Methods	RCT, parallel, single blind, 8 months, n = 87 with 10 drop-outs	
Participants	Netherlands, non-dental students, bleeding on probing at least 35% of sites and modified gingival index of at least 1, no previous experience of electric toothbrush. Healthy. No ortho. No pockets >5 mm	
Interventions	Braun Plak control versus Butler Gum 311 for 2 min. Timer supplied	
Outcomes	Silness and Löe plaque index, Lobene gingival index at all sites at 1, 2, 5, 8 months. Whole mouth recording PI and GI. 12 manual brush subjects and 5 powered brush subjects with gingival abrasion. Calculus scored no difference in change between groups	
Notes	Participants asked to brush thoroughly, but not within 1 hour of assessment	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly divided..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Therefore in the course of the experiment, the examiner was unaware of the brush types used by the subject.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 10/87. 8 particpants (control group) and 2 particpants (powered brush) left the study because of scheduling conflicts with clinical examination
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Van Swol 1996

Methods	RCT, parallel, double blind, 6 months, n = 71 with 7 drop-outs	
Participants	USA, adults, >20 teeth, not using mouthrinse, 9 M: 55 F.	
Interventions	HyG ionic brush (active) versus HyG ionic brush (non-active), usual time twice daily. Use of timer not stated	
Outcomes	Quigley and Hein plaque index and Löe and Silness gingival index, whole mouth at 3 and 6 months. Adverse events not reported despite being collected	
Notes	Manufacturer funded. No pre-examination instructions.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "The subject were given prepackaged and coded hyG ionic action toothbrush. The toothbrushes were received evenly divided (36 of each) between those that had active batteries .."
Allocation concealment (selection bias)	Low risk	Quote: "Each packet had a code number that was recorded for the subject at the time of delivery neither the researchers nor the subjects knew whether their toothbrush contained an active or inactive battery."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Neither the researcher nor the subject knew wether their toothbrush contained an active or inactive battery."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 7/71. Reasons were "four did not use their assigned toothbrush exclusively during the test period, and three took physician prescribed antibiotics." Number of drop-outs by group unlcear but unlikely to influence results
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Walsh 1989

Methods	RCT, parallel, single blind, n = 108, 6 months, drop-outs unclear	
Participants	USA, adults from university and dental clinics, 18 to 65 years, >20 teeth, no dental/ medical problems, gingival index >1 on 6+ sites of 18 sites probed on Ramfjord teeth	
Interventions	LPA/Broxo powered versus Oral B 40 manual, twice daily. Use of timer not stated	
Outcomes	Silness and Löe plaque index on Ramfjord teeth, bleeding on probing on Ramfjord teeth at 3, 6 months. No soft tissue changes reported. Stain reported as no difference between brush types	
Notes	No pre-examination instructions reported.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Quote: "...subjects were randomly allocated to groups in consecutive order by time and date of entry into study."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "examiners did not known to which groups the patients belonged....."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Insufficient information to determine drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Warren 2001

Methods	RCT, parallel, single blind, 12 weeks, n = 110 with 9 drop-outs
Participants	USA, adult volunteers, 18 to 65 years, >18 teeth, plaque index >1.8, non-smokers, with no medical problems
Interventions	Braun Oral B D 17 versus ADA standard manual, 2 min twice daily. Timer supplied
Outcomes	Quigley and Hein (Turesky) plaque index, Löe and Silness gingival index and modified Löe and Silness bleeding index, on all sites at 1, 3 months. Whole mouth recording PI and GI. No soft tissue changes reported

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Notes	Manufacturer funded. Participants asked to refrain from brushing 12 to 18 hours prior to assessment	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "...were randomly assigned to one of two treatment groups, according to the method of Zelen."
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..all subjects were evaluated by the same examiner who was unaware of the types of toothbrush..."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 9/110. Reasons unrelated to intervention and drop-outs evenly balanced
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Wilson 1993

Methods	RCT, parallel, single blind, 12 months, n = 32 with 3 drop-outs
Participants	USA, adults, 18+ years, minimum 20 teeth, at least 50% tooth surface plaque coverage (O'Leary), bleeding score >0.75. Barnett-Muhleman bleeding index, no medical problems, no orthodontics, no untreated perio or pockets >6 mm
Interventions	Interplak, Bausch and Lomb versus Butler 311, 3 min. Use of timer not stated
Outcomes	Quigley and Hein (Turesky) plaque index, Barnett Muhleman gingival index on all sites at 1, 2, 6, 9 and 12 months. Whole mouth recording PI and GI. No difference in gingival abrasion found between brush types
Notes	Participants asked to brush 1 hour prior to assessment.

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned..." Insufficient information.

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Wilson 1993 (*Continued*)

Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..a single-blind, ..."
Incomplete outcome data (attrition bias) All outcomes	High risk	Drop-outs: 3/32. All drop-outs from control group. Reasons were: 1 generalised periodontal diseases progression; 2 non-compliance/withdrawn from study
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Yankell 1996

Methods	RCT, parallel, single blind, 4 weeks, n = 66 with 1 drop-out	
Participants	USA, children with 4 of 6 Ramfjord teeth present, no medical problems	
Interventions	Rowenta Dentiphant versus Oral B 20, 1 min twice daily. Use of timer not stated	
Outcomes	Quigley and Hein (Turesky) plaque and Löe and Silness (Lobene) gingival indices on Ramjford teeth at 2 and 4 weeks. No soft tissue changes reported	
Notes	Manufacturer funded. Pre-brushing evaluation.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned.." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "The same clinical investigators saw and assessed the same subjects at each examination period and were unaware of the toothbrush product being used by the subjects."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "...attrition not related to product use.."

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		Insufficient information.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Yankell 1997

Methods	RCT, parallel, single blind, 30 days, n = 128 with 13 drop-outs	
Participants	USA, adults, 18 to 50 years, >18 teeth, no current orthodontic bands, no medical problems	
Interventions	Rowenta Plaque Dentacontrol Plus versus Sonicare versus Braun Oral B Ultra versus Oral B P35, 2 min twice daily. Timer specified for powered. Excluded Rowenta data which were 5 min twice daily.	
Outcomes	Quigley and Hein (Turesky) plaque and Eastman bleeding indices on Ramfjord teeth and also Löe and Silness (Lobene) gingival index on whole mouth at 4 weeks. No soft tissue changes reported	
Notes	Rowenta data excluded due to extended brushing period. Participants asked to refrain from brushing 10 to 16 hours before evaluation	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned..." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "..single-blind.."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Drop-outs: 13/128. Quote: "..attrition not related to product use.."
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

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Yukna 1993b

Methods	RCT, parallel, single blind, 6 months, n = 42 with 2 drop-outs
Participants	USA, adults with past periodontal surgical treatment. Excluded if on antibiotics/NSAIDS or orthodontic appliances
Interventions	Interplak, Bausch and Lomb versus unspecified manual brush. Use of timer not stated
Outcomes	Quigley and Hein and O'Leary plaque indices, Lobene gingival index and bleeding on probing. Whole mouth recording PI and GI. 4 of 20 powered brushes had mechanical failure
Notes	Manufacturer funded.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned.." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Quote: "All the instruction and device distribution were performed by auxiliary personal without examiner being present."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "All intraoral examinations for a given patient were performed by one of the two examiners, who were blinded to the grouping of the subjects."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 2/42. Reasons for drop-outs were non-compliance with appointments (manual brush) and restorative dentistry resulted in too few scorable teeth (powered brush)
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Unclear risk	Comparibility of groups at baseline unclear.

Zimmer 2002

Methods	RCT, parallel, single blind, 8 weeks, n = 64 with 1 drop-out
Participants	Germany, adults, 18 to 56 years good general health, no periodontal disease, 32 M: 32 F
Interventions	Ultra Sonex Ultima versus Aronal compact manual, 3 min twice daily. Timer supplied

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Outcomes	Quigley and Hein (Turesky) and papillary bleeding index, full mouth at 4 and 8 weeks	
Notes	Manufacturer funded.	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned.." Insufficient information.
Allocation concealment (selection bias)	Low risk	Quote: "..each participant received the assigned toothbrush and instructions for use by a person not involved in the study."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "All examinations were treatment blind and performed by one examiner."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Drop-outs: 1/64.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

Zimmer 2005

Methods	RCT, parallel, single blind, 8 weeks, n = 120, no drop-outs.	
Participants	Germany, adults, 18 to 65 years, exclusion: orthodontic fixed appliance patient, severe periodontal disease, long-term use of NSAIDs, wear removable partial denture, less than 20 teeth, regular use of electric toothbrush, dental professionals	
Interventions	2 electric toothbrushes: Cybersonic and Oral B 3D excel versus Elmex Super 29 manual, 2 min twice daily. Digital timer supplied	
Outcomes	Quigley and Hein (Turesky) and papillary bleeding index, full mouth at 4 and 8 weeks. Nor report on adverse events	
Notes	Peer review grant and other source of funding. Pre-intervention scaling ad prophylaxis	
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

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Random sequence generation (selection bias)	Unclear risk	Quote: "...randomly assigned.." Insufficient information.
Allocation concealment (selection bias)	Unclear risk	Insufficient information.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote "All examination were treatment blind.."
Incomplete outcome data (attrition bias) All outcomes	Low risk	No drop-outs.
Selective reporting (reporting bias)	Low risk	Adequate reporting of important outcomes.
Other bias	Low risk	No other apparent biases.

ADA = American Dental Association; BOMP = bleeding on marginal probing; CAL= clinical attachment level; F = female; GI = gingival index; M = male; PAL = probing attachment level; PD = pocket depth; PI = plaque index; PMA = papillary marginal attachment; PPD = periodontal pocket depth; RCT = randomised controlled trial.

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

Study	Reason for exclusion
Aass 2000	Less than 28 days.
Ainamo 1991	Contacted authors for more information, no reply after 3 months
Albers 1988	Less than 28 days.
Anaise 1976	Less than 28 days.
Andreana 1998	No movement of powered head.
Arceneaux 1996	Less than 28 days.
Ash 1967	Contacted authors for more information, no reply after 3 months
Barnes 2003	Less than 28 days.
Bartizek 2002	Less than 28 days.
Bhanji 2002	Outcome not under consideration.

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Biesbrock 2005	Potential high for compromised self toothbrushing efficacy.
Blahut 1993	Brush used by another person.
Buchmann 1987	Less than 28 days.
Chaikin 1965	Less than 28 days.
Chilton 1962	Split-mouth study.
Ciancio 1990	Less than 28 days.
Ciancio 1998	Contacted authors for more information, no reply after 3 months
Cohen 1964	Potential high for compromised self toothbrushing efficacy.
Conforti 2003	Less than 28 days.
Conroy 1965	Less than 28 days.
Conroy 1966	Less than 28 days.
Coontz 1983	Less than 28 days.
Coontz 1985	Less than 28 days.
Cronin 1996a	Combined intervention.
Cronin 2000	Less than 28 days.
Cronin 2001	Data on number of participants in each group not presented. The study will be included once these data are determined
Cross 1962b	Less than 28 days.
Danser 2000	Less than 28 days.
Danser 2003	Split-mouth design.
de Leeuw 1977	Abstract only.
Dentino 1999	Outcomes not under consideration.
Derbyshire 1964	Less than 28 days.
Dogan 2004	Less than 28 days.

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Doherty 1999	Less than 28 days.
Doll 1999	Less than 28 days.
Dorfer 2001	Less than 28 days.
Dorfer 2001a	Split-mouth design.
Dunkin 1975	Less than 28 days.
Elliott 1963	Less than 28 days.
Farrell 2006	Potential high for compromised self toothbrushing efficacy.
Fourel 1974	Split-mouth design.
Fraleigh 1965	Split-mouth design.
Galustian 2002	Less than 28 days.
Goldman 1975	Less than 28 days.
Grossman 1994	Less than 28 days.
Hall 1971	Potential high for compromised self toothbrushing efficacy.
Heasman 2001	Less than 28 days.
Heins 2002	Less than 28 days.
Heintze 1996	Combined intervention.
Hoover 1962	Less than 28 days.
Hotta 1992	Less than 28 days.
Hou 2002	Single used study design.
Howorko 1993	Less than 28 days.
Johnson 1994a	Abstract with insufficient information.
Jongenelis 1997	Less than 28 days.
Killoy 1988	Previously author was contacted for information but no reply after 3 months
Killoy 1989	Contacted authors for more information, no reply after 3 months

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Killoy 1993	Contacted authors for more information, no reply after 3 months
Lamendola-Sitenga 1998	No mechanical action of brush head.
Lange 1978	Less than 28 days.
Leftkowitz 1962	Less than 28 days.
Lim 1995	Contacted authors for more information, no reply after 3 months
Long 1985	Split-mouth design.
Love 1988	Contacted authors for more information, no reply after 3 months
Lundergan 1988	Less than 28 days.
Mantokoudis 2001	Less than 28 days.
Mascarenhas 2005	Less than 28 days.
Mayer 1978	Less than 28 days.
Mayer 1988	Split-mouth design.
McAllan 1976	Not true randomisation; alternate allocation.
Moritis 2002	Less than 28 days.
Morris 1997	Contacted authors for more information, no reply after 3 months
Moschen 1999	Less than 28 days.
Mueller 1987	Contacted authors for more information, after reply still not adequate to be included
Murray 1989	Outcomes not under consideration.
Niemi 1986	Less than 28 days.
Niemi 1987	Less than 28 days.
Niemi 1988	Split-mouth design.
Ojima 2003	Less than 28 days.
Ousehal 2011	Participants selected from population at random, but not allocated to groups at random

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Owen 1972	Cross-over study, contacted authors for more information, no reply after 3 months
Palmer 1999	Contacted authors for more information, no reply after 3 months
Parizi 2011	Less than 28 days.
Pelka 2008	Split-mouth design.
Pizzo 2010	Single used study design.
Platt 2002	Less than 28 days.
Powers 1967	Less than 28 days.
Preber 1991	Less than 28 days.
Quigley 1962	Less than 28 days.
Quirynen 1994	Split-mouth design.
Rashid 1998	Less than 28 days.
Renton-Harper 2001	Less than 28 days.
Roscher 2004	Less than 28 days.
Ruhlman 2001	Less than 28 days.
Ruhlman 2002	Less than 28 days.
Sato 1995	Less than 28 days.
Schifter 1983	Less than 28 days.
Schmage 1999	Split-mouth design.
Schuler 1996	Abstract only.
Sharma 2001a	Split-mouth design.
Sharma 2005	Potential high for compromised self toothbrushing efficacy.
Sharma 2006	Potential high for compromised self toothbrushing efficacy.
Sharma 2011	Potential high for compromised self toothbrushing efficacy.

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(*Continued*)

Silverstone 1992	Contacted authors for more information, no reply after 3 months
Singh 2005	Potential high for compromised self toothbrushing efficacy.
Smith 1964	Cross-over study, contacted authors for more information, no reply after 3 months
Stadtler 1984	Less than 28 days.
Swenson 1967	Contacted authors for more information, no reply after 3 months
Taylor 1995	Less than 28 days.
Tenenbaum 1984	Less than 28 days.
Terezhalmy 2005	Less than 28 days.
Thienpont 2001	Cross-over study, contacted authors for more information, no reply after 3 months
Trimpeneers 1997	Cross-over study, contacted authors for more information, no reply after 3 months
Trombeli 1995	Less than 28 days.
Tscharre-Z 1989	Combined interventions.
van der Weijden 1993	Less than 28 days.
van der Weijden 1998	Split-mouth study.
van der Weijden 2002a	Split-mouth study.
van Venrooy 1985	Less than 28 days.
Vandana 2004	Potential for compromised self toothbrushing efficacy.
Versteeg 2006	Teeth brushed by other person.
Vervliet 1989	Split-mouth design.
Walsh 1984	Less than 28 days.
Warren 2007	Less than 28 days.
Whitmyer 1998	Potential high for compromised self toothbrushing efficacy.
Wiedemann 2001	Split-mouth design.
Wilcoxon 1991	Cross-over study, contacted authors for more information, no reply after 3 months

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(*Continued*)

Williams 2003a	Less than 28 days.
Williams 2004	Less than 28 days.
Williams 2010	No movement of brush head.
Wilson 1991	Contacted authors for more information, no reply after 3 months
Yankell 1994	Less than 28 days.
Yukna 1993a	Combined intervention.
Zimmer 1999	Less than 28 days.

Characteristics of studies awaiting assessment *[ordered by study ID]*

Borutta 2002

Methods	
Participants	
Interventions	
Outcomes	
Notes	Unable to locate a copy to date.

De Beule 1990

Methods	
Participants	
Interventions	
Outcomes	
Notes	Unable to locate a copy to date.

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Horton 1989

Methods	
Participants	
Interventions	
Outcomes	
Notes	Unable to locate a copy to date.

Jain 2013

Methods	6-week, parallel arm RCT.
Participants	Adults (aged 18-28) with moderate gingivitis (at least 25% of test sites showing bleeding on probing) Excludes orthodontic patients.
Interventions	Group 1 - Oral B Classic Ultraclean medium manual toothbrush Group 2 - Oral B Vitality Dual Clean powered toothbrush (rotation oscillation) Both groups' intervention was combined with commercially available fluoridated toothpaste (Pepsodent Regular)
Outcomes	Gingivitis (Löe and Silness gingival index, 1963) recorded at 1, 2, and 6 weeks. Plaque (O'Leary plaque index, 1972) recorded at 1, 2, and 6 weeks Oral hygiene (Green and Vemillion Oral Hygiene Index Simplified (OHI-S), 1964) recorded at 1, 2, and 6 weeks
Notes	

Marini 2014

Methods	20-week, 4-parallel arm RCT.
Participants	Adolescent fixed-orthodontic treatment patients.
Interventions	Group 1 - Oral B Triumph 5000 powered toothbrush (rotation oscillation), combined with oral hygiene instruction and motivation at baseline and at 4, 8, 12, 16, and 20 weeks Group 2 - Oral B Triumph 5000 powered toothbrush (rotation oscillation), combined with oral hygiene instruction and motivation at baseline Group 3 - Oral B Ortho P35, combined with oral hygiene instruction and motivation at baseline and at 4, 8, 12, 16, and 20 weeks Group 4 - Oral B Ortho P35, combined with oral hygiene instruction and motivation at baseline All groups' intervention was combined with commercially available fluoridated toothpaste (Colgate Total, 1450 ppm fluoride) All groups also received an interdental brush (Plakkontrol, 7 mm) at baseline and at 8 and 16 weeks Replacement brushes (both manual and powered groups) were also issued at 8 and 16 weeks
Outcomes	Plaque index (Quigley Hein plaque index, 1962) recorded at baseline and at 4, 8, 12, 16, and 20 weeks

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Notes	

Mayer 1990

Methods	16-week, parallel arm RCT.
Participants	Adults (aged 20-30) with poor oral hygiene (scoring between 76-90 on approximal area plaque index)
Interventions	Group 1 - Oral B Plus 30 manual toothbrush. Group 2 - Braun dental timer D31 electric toothbrush. Both groups' intervention was combined with commercially available toothpaste (Oral-B Zendium)
Outcomes	Plaque (Lange approximal area plaque index, 1987), recorded at 1, 2, 3, 4, 9, 10, and 11 weeks
Notes	

Nathoo 2012

Methods	12-week, parallel arm RCT.
Participants	Adults (aged 18-70) with mild gingivitis (at least scoring 1 on Löe and Silness gingival index) and mild plaque (at least scoring 0.6 on Rustogi modification of the modified Navy plaque index) Excludes orthodontic patients.
Interventions	Group 1 - Colgate ProClinical A1500 powered toothbrush with Triple Clean Brush Head (auto mode) Group 2 - Oral B Indicator manual flat-trim toothbrush. Both groups' intervention was combined with commercially available fluoridated toothpaste (Colgate Cavity Protection)
Outcomes	Gingivitis (Löe and Silness gingival index, 1963), recorded at baseline and at 4 and 12 weeks Gingival bleeding (gingivitis severity index, 1990), recorded at baseline and at 4 and 12 weeks Plaque (Rustogi modification of the modified Navy plaque index, 1992), recorded at baseline and at 4 and 12 weeks
Notes	Study supported by Colgate-Palmolive.

Sharma 2001

Methods	30-day, parallel arm RCT.
Participants	Healthy adults.
Interventions	Group 1 - Colgate Actibrush battery-powered toothbrush. Group 2 - Colgate Plus Diamond Head, full-head soft-bristled manual toothbrush Both groups' intervention was combined with commercially available toothpaste (type not mentioned)

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Sharma 2001 (*Continued*)

Outcomes	Plaque (index not mentioned), reported at baseline and 30 days Ginigivitis (index not mentioned), reported at baseline and 30 days
Notes	Abstract only.

Sharma 2012

Methods	4-week, parallel arm RCT.
Participants	Adults with mild-moderate gingivitis. Excludes orthodontic patients.
Interventions	Group 1 - Oral B Professional Deep Clean TRICLEAN 1000 multi-directional power toothbrush (D16u/EB30) (AKA Oral-B TriZone) Group 2 - ADA reference standard soft manual control toothbrush Both groups' intervention was combined with commercially available fluoridated toothpaste (Crest Cavity Protection, 0.243% sodium fluoride)
Outcomes	Gingivitis (Lobene modified gingival index), reported at baseline and 4 weeks Gingival bleeding (gingival bleeding index), reported at baseline and 4 weeks Plaque (Rustogi modified Navy plaque index), reported at baseline, and 1 and 4 weeks
Notes	

Swierkot 2013

Methods	52-week, parallel arm RCT.
Participants	Partially edentulous adults (aged 45-78), with at least 1 posterior implant
Interventions	Group 1 - Philips Sonicare FlexCare sonic toothbrush. Group 2 - Oral B P40 manual toothbrush. Both groups' intervention was combined with commercially available fluoridated toothpaste (Colgate Total)
Outcomes	Gingivitis (Löe and Silness gingival index, 1963; bleeding on probing scale), recorded at baseline and at 3, 6, 9 and 12 months (for both tooth and implant) Plaque (Silness and Löe plaque index, 1964), recorded at baseline and at 3, 6, 9 and 12 months (for both tooth and implant)
Notes	Study supported by Philips Healthcare Systems.

ADA = American Dental Association; ppm = parts per million; RCT = randomised controlled trial.

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DATA AND ANALYSES

Comparison 1. All powered toothbrushes versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 month at all sites	40	2871	Std. Mean Difference (IV, Random, 95% CI)	-0.50 [-0.70, -0.31]
1.1 Quigley Hein (Turesky)	28	2000	Std. Mean Difference (IV, Random, 95% CI)	-0.39 [-0.56, -0.22]
1.2 Silness and Löe	6	431	Std. Mean Difference (IV, Random, 95% CI)	-0.94 [-1.83, -0.05]
1.3 Visible plaque index Ainamo Bay	1	111	Std. Mean Difference (IV, Random, 95% CI)	-0.26 [-0.63, 0.12]
1.4 Ortho modification of Silness and Löe	1	60	Std. Mean Difference (IV, Random, 95% CI)	0.0 [-0.51, 0.51]
1.5 Navy plaque index mod Rustogi	3	249	Std. Mean Difference (IV, Random, 95% CI)	-1.13 [-1.94, -0.31]
1.6 O'Leary index	1	20	Std. Mean Difference (IV, Random, 95% CI)	-1.81 [-2.88, -0.73]
2 Gingival scores at 1 to 3 months at all sites	44	3345	Std. Mean Difference (IV, Random, 95% CI)	-0.43 [-0.60, -0.25]
2.1 Löe and Silness	30	2109	Std. Mean Difference (IV, Random, 95% CI)	-0.46 [-0.66, -0.25]
2.2 Lobene gingival index	8	907	Std. Mean Difference (IV, Random, 95% CI)	-0.43 [-0.88, 0.03]
2.3 BOP	3	159	Std. Mean Difference (IV, Random, 95% CI)	-0.19 [-0.50, 0.12]
2.4 Papillary bleeding index 0-4 scale	2	95	Std. Mean Difference (IV, Random, 95% CI)	-0.11 [-1.55, 1.33]
2.5 BOMP 0-2 scale	1	75	Std. Mean Difference (IV, Random, 95% CI)	-0.58 [-1.04, -0.12]
3 Plaque scores at >3 months	14	978	Std. Mean Difference (IV, Random, 95% CI)	-0.47 [-0.82, -0.11]
3.1 Quigley Hein (Turesky)	11	736	Std. Mean Difference (IV, Random, 95% CI)	-0.51 [-0.97, -0.04]
3.2 Silness and Löe	2	131	Std. Mean Difference (IV, Random, 95% CI)	-0.38 [-1.09, 0.34]
3.3 Visible plaque index Ainamo Bay	1	111	Std. Mean Difference (IV, Random, 95% CI)	-0.28 [-0.66, 0.09]
4 Gingival scores at >3 months	16	1645	Std. Mean Difference (IV, Fixed, 95% CI)	-0.21 [-0.31, -0.12]
4.1 Löe and Silness	5	318	Std. Mean Difference (IV, Fixed, 95% CI)	-0.27 [-0.49, -0.05]
4.2 Lobene gingival index	4	440	Std. Mean Difference (IV, Fixed, 95% CI)	-0.14 [-0.33, 0.04]
4.3 BOP	4	270	Std. Mean Difference (IV, Fixed, 95% CI)	-0.46 [-0.70, -0.22]
4.4 Papillary bleeding index 0-4 scale	1	32	Std. Mean Difference (IV, Fixed, 95% CI)	0.65 [-0.07, 1.36]
4.5 BOMP 0-2 scale	1	75	Std. Mean Difference (IV, Fixed, 95% CI)	-0.24 [-0.69, 0.22]
4.6 PMA	1	510	Std. Mean Difference (IV, Fixed, 95% CI)	-0.16 [-0.34, 0.02]

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Comparison 2. Side to side powered toothbrushes versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 month at all sites	7	570	Std. Mean Difference (IV, Random, 95% CI)	-0.27 [-0.77, 0.23]
1.1 Quigley Hein (Turesky)	4	324	Std. Mean Difference (IV, Random, 95% CI)	-0.14 [-0.36, 0.08]
1.2 Silness and Löe	3	246	Std. Mean Difference (IV, Random, 95% CI)	-0.78 [-2.25, 0.68]
2 Gingival scores at 1 to 3 months at all sites	9	795	Std. Mean Difference (IV, Random, 95% CI)	-0.32 [-0.81, 0.17]
2.1 Löe and Silness	6	385	Std. Mean Difference (IV, Random, 95% CI)	-0.28 [-0.88, 0.32]
2.2 Lobene gingival index	3	410	Std. Mean Difference (IV, Random, 95% CI)	-0.39 [-1.24, 0.46]
3 Plaque scores at >3 months	3	272	Std. Mean Difference (IV, Fixed, 95% CI)	0.02 [-0.21, 0.26]
3.1 Quigley Hein (Turesky)	2	218	Std. Mean Difference (IV, Fixed, 95% CI)	0.03 [-0.24, 0.30]
3.2 Silness and Löe	1	54	Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [-0.53, 0.53]
4 Gingival scores at >3 months	3	272	Std. Mean Difference (IV, Fixed, 95% CI)	0.10 [-0.14, 0.34]
4.1 Löe and Silness	1	54	Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [-0.53, 0.53]
4.2 Lobene gingival index	1	166	Std. Mean Difference (IV, Fixed, 95% CI)	0.16 [-0.14, 0.47]
4.3 BOP	1	52	Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [-0.54, 0.54]

Comparison 3. Counter oscillation powered toothbrushes versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 month at all sites	4		Mean Difference (IV, Random, 95% CI)	Subtotals only
1.1 Quigley Hein (Turesky)	4	184	Mean Difference (IV, Random, 95% CI)	-0.03 [-0.15, 0.10]
2 Gingivitis scores at 1 to 3 months at all sites	4	172	Std. Mean Difference (IV, Fixed, 95% CI)	0.01 [-0.30, 0.31]
2.1 Löe and Silness	2	103	Std. Mean Difference (IV, Fixed, 95% CI)	0.01 [-0.39, 0.40]
2.2 Lobene gingival index	1	40	Std. Mean Difference (IV, Fixed, 95% CI)	-0.03 [-0.65, 0.59]
2.3 BOP	1	29	Std. Mean Difference (IV, Fixed, 95% CI)	0.06 [-0.68, 0.79]
3 Plaque scores at >3 months	2		Mean Difference (IV, Fixed, 95% CI)	Subtotals only
3.1 Quigley Hein (Turesky)	2	69	Mean Difference (IV, Fixed, 95% CI)	-0.27 [-0.48, -0.07]
4 Gingival scores at >3 months	2	69	Std. Mean Difference (IV, Fixed, 95% CI)	-0.19 [-0.66, 0.29]
4.1 Lobene gingival index	1	40	Std. Mean Difference (IV, Fixed, 95% CI)	-0.18 [-0.80, 0.44]
4.2 BOP	1	29	Std. Mean Difference (IV, Fixed, 95% CI)	-0.19 [-0.93, 0.54]

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Comparison 4. Rotation oscillation powered toothbrushes versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 month at all sites	20	1404	Std. Mean Difference (IV, Random, 95% CI)	-0.53 [-0.74, -0.31]
1.1 Quigley Hein (Turesky)	13	979	Std. Mean Difference (IV, Random, 95% CI)	-0.44 [-0.69, -0.20]
1.2 Silness and Löe	2	115	Std. Mean Difference (IV, Random, 95% CI)	-1.17 [-2.74, 0.40]
1.3 Visible plaque index Ainamo Bay	1	111	Std. Mean Difference (IV, Random, 95% CI)	-0.26 [-0.63, 0.12]
1.4 Ortho modification of Silness and Löe	1	60	Std. Mean Difference (IV, Random, 95% CI)	0.0 [-0.51, 0.51]
1.5 Navy plaque index mod Rustogi	2	119	Std. Mean Difference (IV, Random, 95% CI)	-0.72 [-1.09, -0.35]
1.6 O'Leary index	1	20	Std. Mean Difference (IV, Random, 95% CI)	-1.81 [-2.88, -0.73]
2 Gingival scores at 1 to 3 months at all sites	21	1479	Std. Mean Difference (IV, Random, 95% CI)	-0.49 [-0.73, -0.26]
2.1 Löe and Silness	14	952	Std. Mean Difference (IV, Random, 95% CI)	-0.68 [-0.99, -0.38]
2.2 Lobene gingival index	3	290	Std. Mean Difference (IV, Random, 95% CI)	-0.11 [-0.46, 0.24]
2.3 BOP	2	130	Std. Mean Difference (IV, Random, 95% CI)	-0.25 [-0.59, 0.10]
2.4 Papillary bleeding index	1	32	Std. Mean Difference (IV, Random, 95% CI)	0.65 [-0.07, 1.36]
2.5 BOMP 0-2 scale	1	75	Std. Mean Difference (IV, Random, 95% CI)	-0.58 [-1.04, -0.12]
3 Plaque scores at >3 months	7	527	Std. Mean Difference (IV, Random, 95% CI)	-0.66 [-1.28, -0.03]
3.1 Quigley Hein (Turesky)	5	339	Std. Mean Difference (IV, Random, 95% CI)	-0.73 [-1.69, 0.24]
3.2 Silness and Löe	1	77	Std. Mean Difference (IV, Random, 95% CI)	-0.73 [-1.19, -0.26]
3.3 Visible plaque index Ainamo Bay	1	111	Std. Mean Difference (IV, Random, 95% CI)	-0.28 [-0.66, 0.09]
4 Gingival scores at >3 months	8	684	Std. Mean Difference (IV, Fixed, 95% CI)	-0.35 [-0.50, -0.20]
4.1 Lobene gingival index	2	234	Std. Mean Difference (IV, Fixed, 95% CI)	-0.36 [-0.62, -0.10]
4.2 BOP	2	189	Std. Mean Difference (IV, Fixed, 95% CI)	-0.64 [-0.93, -0.34]
4.3 Löe and Silness	2	154	Std. Mean Difference (IV, Fixed, 95% CI)	-0.25 [-0.57, 0.07]
4.4 Papillary bleeding index 0-4 scale	1	32	Std. Mean Difference (IV, Fixed, 95% CI)	0.65 [-0.07, 1.36]
4.5 BOMP 0-2 scale	1	75	Std. Mean Difference (IV, Fixed, 95% CI)	-0.24 [-0.69, 0.22]
5 Rotation oscillation versus manual: data not suitable for meta-analysis			Other data	No numeric data

Comparison 5. Circular powered toothbrushes versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 month at all sites	2	128	Std. Mean Difference (IV, Fixed, 95% CI)	-0.02 [-0.37, 0.33]
1.1 Quigley Hein (Turesky)	2	128	Std. Mean Difference (IV, Fixed, 95% CI)	-0.02 [-0.37, 0.33]
1.2 Silness and Löe	0	0	Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

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2 Gingival scores at 1 to 3 months at all sites	2	128	Std. Mean Difference (IV, Fixed, 95% CI)	-0.18 [-0.53, 0.17]
2.1 Löe and Silness	1	63	Std. Mean Difference (IV, Fixed, 95% CI)	0.13 [-0.36, 0.63]
2.2 Lobene gingival index	1	65	Std. Mean Difference (IV, Fixed, 95% CI)	-0.50 [-0.99, -0.00]

Comparison 6. Ionic toothbrushes versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 months	3	186	Std. Mean Difference (IV, Fixed, 95% CI)	-0.57 [-0.87, -0.27]
1.1 Quigley Hein (Turesky)	2	116	Std. Mean Difference (IV, Fixed, 95% CI)	-0.30 [-0.67, 0.06]
1.2 Silness and Löe	1	70	Std. Mean Difference (IV, Fixed, 95% CI)	-1.07 [-1.57, -0.57]
2 Plaque scores at >3 months at all sites	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Quigley Hein (Turesky)	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3 Gingivitis at 1 to 3 months	2	116	Mean Difference (IV, Fixed, 95% CI)	-0.01 [-0.04, 0.02]
3.1 Löe and Silness	2	116	Mean Difference (IV, Fixed, 95% CI)	-0.01 [-0.04, 0.02]
4 Gingival scores at >3 months at all sites	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4.1 Löe and Silness	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
5 Ionic versus manual: data not suitable for meta-analysis			Other data	No numeric data

Comparison 7. Ultrasonic powered toothbrushes versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 month at all sites	4	301	Std. Mean Difference (IV, Fixed, 95% CI)	-1.33 [-1.59, -1.07]
1.1 Quigley Hein (Turesky)	3	171	Std. Mean Difference (IV, Fixed, 95% CI)	-0.97 [-1.30, -0.63]
1.2 Navy plaque index mod Rustogi	1	130	Std. Mean Difference (IV, Fixed, 95% CI)	-1.89 [-2.30, -1.47]
2 Gingival scores at 1 to 3 months at all sites	5	354	Std. Mean Difference (IV, Fixed, 95% CI)	-0.99 [-1.21, -0.76]
2.1 Löe and Silness	3	161	Std. Mean Difference (IV, Fixed, 95% CI)	-0.56 [-0.88, -0.25]
2.2 Lobene gingival index	1	130	Std. Mean Difference (IV, Fixed, 95% CI)	-1.80 [-2.21, -1.39]
2.3 Papillary bleeding index 0-4 scale	1	63	Std. Mean Difference (IV, Fixed, 95% CI)	-0.82 [-1.34, -0.31]
3 Plaque scores at >3 months at all sites	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3.1 Quigley Hein	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 Gingival scores at >3 months	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4.1 Löe and Silness	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

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5 Ultrasonic versus manual: data not suitable for meta-analysis	Other data	No numeric data

Comparison 8. Unknown or other action versus manual toothbrushes

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Plaque scores at 1 to 3 months at all sites	2		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 Quigley Hein (Turesky)	2		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 Gingival scores at 1 to 3 months at all sites	3		Std. Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Löe and Sillness	3		Std. Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
3 Gingival scores >3 months at all sites	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3.1 PMA	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

ADDITIONAL TABLES

Table 1. Summary of inclusion criteria categories within included studies

Inclusion criteria	Number (n = 56)
Adults	43
Minimum number of teeth	31
Minimum periodontal baseline measures	28
Participants recruited from dental clinics	9
Concurrent fixed orthodontic treatment	8
Some participants aged less than 16 years	11
Volunteer university students	3
Dental students	2
School children	3

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Table 2. Summary of exclusion criteria categories within included studies

Exclusion criteria[1]	Number (n = 56)
Exclusion criteria related to medical history	31
Pregnancy or lactation	5
Previous use of powered toothbrushes	6
Patients undergoing orthodontic treatment	9
Previous periodontal treatment	3
Dental students	2
Cervical restorations	1
Smoking	3
Maximum periodontal measure	8
Wearing partial denture	2

[1] Not all trials explicitly stated exclusion criteria

Table 3. Summary of toothbrush modes of action, number of trials and participants

Mode of action	Trial ID	Number of trials	Number in trials
Side to side	Glass 1965, Ho 1997, Johnson 1994, Lobene 1964, McCracken 2009, Moritis 2008, O'Beirne 1996, Tritten 1996, Walsh 1989, Yankell 1997	10	988
Counter oscillation	Baab 1989, Khocht 1992, Stabholz 1996, Wilson 1993, Yukna 1993	5	267
Rotation oscillation	Ainamo 1997, Barnes 1993, Biavati Silvestrini 2010, Biesbrock 2007, Clerehugh 1998, Costa 2007, Cronin 1998, Dentino 2002, Dorfer 2009, Garcia-Godoy 2001, Gugerli 2007, Haffajee 2001a, Heasman 1999, Hickman 2002, Lapiere unpublished, Lazarescu unpublished, McCracken 2004, Rosema 2008, Sharma 2000, Sil-	27	2159

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Table 3. Summary of toothbrush modes of action, number of trials and participants (*Continued*)

	verman 2004, Soparkar 2000, Sowinski 2000, Stoltze 1994, van der Weijden 1994, Warren 2001, Yankell 1997, Zimmer 2005		
Circular	Khocht 1992, Yankell 1996	2	162
Ultrasonic	Costa 2007, Forgas-B 1998, Goyal 2007, Sharma 2010, Terezhalmy 1995, Zimmer 2002, Zimmer 2005	7	506
Unknown	Emling 1991, Kallar 2011, Singh unpublished, Soparkar 1964, Toto 1966	5	1130
Ionic	Galgut 1996, Moreira 2007, Pucher 1999, van Swol 1996	4	221

Four trials evaluated two powered toothbrushes

Table 4. Sensitivity analyses of all trials for all indices

Index	Group selected	Number of trials	SMD	Effect P value	Het. P value	I^2
Plaque 1-3 months	All trials	40	-0.50 (-0.70 to -0.31)	<0.0001	<0.0001	88
	Full mouth	34	-0.58 (-0.80 to -0.36)	<0.0001	<0.0001	85
	Low risk of bias	3	-0.83 (-2.02 to 0.36)	0.17	<0.0001	94
	Manufacturer funded	26	-0.56 (-0.82 to -0.29)	<0.0001	<0.0001	88
	Trials excluding ortho patients	36	-0.46 (-0.66 to -0.27)	<0.0001	<0.0001	83
Plaque >3 months	All trials	14	-0.37 (-0.50 to -0.24)	<0.0001	<0.0001	86
	Full mouth	13	-0.39 (-0.53 to -0.26)	<0.0001	<0.0001	87

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Table 4. Sensitivity analyses of all trials for all indices (*Continued*)

	Low risk of bias	2	0.12 (-0.27 to 0.52)	0.53	0.51	0
	Manufacturer funded	9	-0.41 (-0.56 to -0.25)	<0.0001	<0.0001	91
	Trials excluding ortho patients	14 (all)	-0.37 (-0.50 to -0.24)	<0.0001	<0.0001	86
Gingivitis 1-3 months	All trials	44	-0.43 (-0.60 to -0.25)	<0.0001	<0.0001	82
	Full mouth	35	-0.47 (-0.68 to -0.25)	<0.0001	<0.0001	85
	Low risk of bias	3	-0.96 (-1.95 to 0.03)	0.06	<0.0001	93
	Manufacturer funded	32	-0.47 (-0.68 to -0.26)	<0.0001	<0.0001	84
	Trials excluding ortho patients	38	-0.42 (-0.61 to -0.23)	<0.0001	<0.0001	83
Gingivitis >3 months	All trials	16	-0.21 (-0.31 to -0.12)	<0.0001	<0.0001	51
	Full mouth	14	-0.25 (-0.37 to -0.13)	<0.0001	0.006	56
	Low risk of bias	2	-0.12 (-0.52 to 0.27)	0.54	0.52	0
	Manufacturer funded	10	-0.21 (-0.35 to -0.07)	0.003	0.003	68
	Trials excluding ortho patients	16 (all)	-0.21 (-0.31 to -0.12)	<0.0001	<0.0001	51

SMD = standardised mean difference

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WHAT'S NEW

Last assessed as up-to-date: 23 January 2014.

Date	Event	Description
2 June 2014	New search has been performed	Searches updated to January 2014.
2 June 2014	New citation required but conclusions have not changed	The review has been repeated 10 years after it was first completed. The update now includes 56 trials. 51 trials involving 4624 participants were available for meta-analysis. The update has findings consistent with the previous reviews that powered toothbrushes with a rotation oscillation action are more effective than manual brushes at removing plaque and reducing gingivitis

HISTORY

Protocol first published: Issue 2, 2000

Review first published: Issue 1, 2003

Date	Event	Description
20 August 2008	Amended	Converted to new review format.
17 February 2005	New search has been performed	This review has been repeated, 2 years after it was first completed. The original review included 29 trials involving 2547 subjects. 42 trials are now included, involving 3855 participants
17 February 2005	New citation required and conclusions have changed	Substantive amendment. More studies have been included for brushes that work with a rotation oscillation action. The update confirms that these brushes removed more plaque and reduced gingivitis more effectively than manual brushes in the short term. Brushes of this design reduced gingivitis scores over 3 months. A refinement of the data analysis for brushes that work with a rotation oscillation action excluded 1 study from the current review for plaque over 3 months. Excluding this study does not substantially change our estimate of the treatment effect. However, because there are fewer studies in the analysis the 95% confidence intervals are wider and the findings are no longer statistically significant for this analysis. Trials of ionic brushes that impart a charge to the tooth

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(*Continued*)

		surface have been included for the first time. The analyses show no benefit from these brushes on plaque or gingivitis in studies lasting 1 to 3 months but effects in studies over 3 months. This inconsistency cannot be explained but only 1 study was included in the long-term analyses

CONTRIBUTIONS OF AUTHORS

Bill Shaw and Helen Worthington wrote the protocol. Anne-Marie Glenny, Bill Shaw, Mike Heanue, Peter Robinson, Damien Walmsley and Munirah Yaacob co-ordinated the review. Bill Shaw and Peter Robinson wrote the letters to the authors. Bill Shaw, Scott Deacon, Chris Deery, Mike Heanue, Peter Robinson, Damien Walmsley and Munirah Yaacob independently and in duplicate assessed the eligibility of trials, extracted data and assessed the quality of the trials. Damien Walmsley and Peter Robinson provided the background and sourced information on brush action and plaque and gingival indices. Helen Worthington conducted the statistical analysis. Scott Deacon, Anne-Marie Glenny, Munirah Yaacob and Mike Heanue checked and entered data. Anne-Mare Glenny, Helen Worthington and Munirah Yaacob wrote this version of the review, and checked for numerical consistency. Chris Deery updated the background.

DECLARATIONS OF INTEREST

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

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INDEX TERMS

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*Dental Devices, Home Care [adverse effects; economics]; Dental Plaque [complications; *prevention & control]; Gingival Diseases [prevention & control]; Gingivitis [*prevention & control]; Oral Health; Periodontal Diseases [prevention & control]; Randomized Controlled Trials as Topic; Toothbrushing [*instrumentation; methods]

MeSH check words

Humans

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