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Efficacy of homecare regimens for mechanical plaque removal in managing gingivitis a meta review

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Abstract

Focused question: Based on evidence as presented in systematic reviews what is the efficacy and safety of available homecare toothbrush regimens for mechanical plaque removal on plaque and gingivitis in adults?

Material & Methods: Three Internet sources were used (up to and including August 2014) to search for appropriate papers that satisfied the study purpose. Plaque scores and gingivitis scores were considered to be the primary parameter of interest. Safety was considered an important facet in relation to efficacy. Data and conclusions as presented in the selected papers were extracted. The potential risk of bias was estimated and the emerging evidence was graded.

Results: Independent screening of 176 unique reviews resulted in 10 published and eligible systematic reviews. They were categorized into one review evaluating the effect of an oral hygiene instruction with a toothbrush on plaque and gingivitis scores, five evaluating the efficacy of manual and power toothbrushes and three reviews evaluating toothbrush safety and one evaluating toothbrush contamination.

Conclusion: Tooth brushing is effective in reducing levels of dental plaque. With respect to gingivitis power toothbrushes have a benefit over manual toothbrushes. The greatest body of evidence was available for oscillating–rotating brushes. Tooth brushing generally can be considered safe for the teeth and their investing tissues.

Key words: dental plaque; gingivitis; manual toothbrush; meta-review; power toothbrush; safety; systematic review; tooth brushing; toothbrush contamination

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"Because we have become accustomed to the scientific terms applied to teeth and gums, we lose sight of the fact that teeth are bones protruding through soft tissues where conditions are extremely unfavourable to maintain health" (Smith 1940). With this introductory quote from 75 years ago, the need for oral self-care is clearly indicated. In fact, it makes the reader wonder how a healthy dentition can be maintained throughout

Conflict of interest and source of funding

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Ethical approval was not required.
Van der Weijden, Slot and their research team at ACTA have formerly received either external advisor fees, lecturer fees or research grants from toothbrush manufacturers. Among these were Braun AG, Colgate, Dentaid, GABA, Lactona, Oral-B, Philips, Procter & Gamble, Sara Lee, Sunstar and Unilever.

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life. What oral homecare regimens are needed to achieve, maintain, or promote oral health?

The experimental gingivitis studies form the 1960s produced a universal principle that bacterial plaque is essential to the initiation of gingivitis and, if unresolved, would lead to periodontitis. Removal and control of plaque became the critical element in the prevention and treatment of gingivitis and periodontitis (Lang 2014). The importance of plaque-control measures to contribute to the oral health status of an individual has been emphasized in all workshops on periodontology (Claydon 2008). The most widespread mechanical means of controlling plaque at home is the toothbrush, preferably used in combination with a fluoride toothpaste (ADA 2014a). Twice daily tooth brushing is widely promoted and plays a pivotal role in the prevention of periodontal diseases (Davies et al. 2003). The toothbrush is well designed to remove plaque from the facial, lingual and occlusal tooth surfaces preventing microbial plaque from accumulating on teeth and gingivae. Currently, the use of a toothbrush and fluoridated toothpastes is almost universal but despite its widespread use the majority of the population do not clean their teeth thoroughly enough to prevent plaque accumulation (Morris et al. 2001, Claydon 2008). This raises the question as to what the clinical effectiveness is of mechanical oral health care interventions in managing gingivitis? Also, in case optimal efficacy is achieved does this not become an unexpected patient safety issue?

Success in delivering evidence-based health care relies heavily on the ready availability of current best evidence. An evidence–based clinical decision integrates and concisely summarizes all relevant and important research evidence of acceptable quality that examines the same therapeutic question. The model to guide clinical decisions begins with original single studies at the foundation, and building up from these are syntheses which integrate the best available evidence from original single studies. The synthesis (or systematic review) is a comprehensive summary of all the research evidence related to a focused clinical question and is being advocated as a way to keep up with current medical literature (Shea et al. 2007a).

Combining the results from many trials has more power to detect small but clinically significant effects and is a more sophisticated information service in the topic area of concern (Walker et al. 2008). At the next level, a synopsis which is a meta-review summarizes the findings of high-quality systematic reviews providing sufficient information to support the clinical action that matches the patient's specific circumstances (Smith et al. 2011, DiCenso et al., 2009). Meta-reviews in particular are appropriate for describing whether the current evidence base is complete or incomplete, since evidence from relevant previous systematic reviews or meta-reviews is synthesized (Sarrami-Foroushani et al. 2014). The reason for including only systematic reviews is because this kind of research generally provides more evidence than separate empirical studies (Francke et al. 2008). The advantages of a relevant synopsis of a synthesis are 2-fold: *first*, the synopsis provides a convenient summary of the corresponding synthesis (systematic reviews), and *second*, it addresses the methodological quality of the synthesis and the clinical applicability of its findings (DiCenso et al., 2009), thus allowing readers to determine for themselves the reasonableness of the decisions taken. Furthermore, given that many dental professionals do not have the time to review detailed systematic reviews, a synopsis that summarizes the findings of a high-quality systematic review can often provide sufficient information to support clinical action.

The purpose of this paper is to prepare a meta-review which summarizes the contemporary synthesized evidence with respect to the efficacy and safety of homecare self-support activities concerning mechanical plaque removal using a toothbrush in managing plaque and gingivitis.

Material and Methods

The protocol of this meta-review detailing the review method was developed "a priori" following initial discussion between members of the research team. This work complies with PRISMA (2014) reporting guidelines.

Focused question (PICOS)

Based on evidence as presented in systematic reviews what is the efficacy and safety of available homecare toothbrush regimens for mechanical plaque removal on plaque and gingivitis in adults?

Search strategy

For the comprehensive search strategy electronic databases were interrogated. Three Internet sources were used to search for appropriate papers that satisfied the study purpose. These sources included the National Library of Medicine, Washington, D. C. (MEDLINE-PubMed), the Cochrane Library which also includes the DARE database of systematic reviews and the ADA Center for Evidence-based Dentistry. All three databases were searched for eligible studies up to August 2014. The structured search strategy was designed to include any systematic review published on toothbrushes/tooth brushing. For details regarding the search terms used, see Box 1.

Screening and selection

Inclusion of titles, abstracts and ultimately full texts was based initially on consensus of full agreement between two reviewers (GAW & DES). In case of discrepancies, the final decision was made following discussion among both reviewers. No attempt was made to blind the reviewers to names of authors or institutions and journals while making the assessment. Hand searching of reference lists of reviews was conducted to ensure inclusion of additional published and potentially relevant papers. Systematic reviews and meta-analyses were included. When updates of systematic reviews were published the latest version was selected. Unpublished work was sought in PROSPERO (2014). One systematic review on power tooth brushing from the research group which is currently accepted for publication but not yet indexed in Pubmed (Rosema et al. 2014a) was added to the included reviews.

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Box 1

Search terms used for PubMed-MEDLINE, Cochrane Library and ADA Center for Evidence-based Dentistry. The search strategy was customized appropriately according to the database being searched taking into account differences in controlled vocabulary and syntax rules.

The following strategy was used in the search for toothbrushes/toothbrushing:
Filter/limits used: systematic review OR meta-analysis.

<[MeSH terms] Toothbrushing OR [text words] toothbrush OR tooth-brushing
OR toothbrush*>.
The asterisk (*) was used as a truncation symbol.

Eligibility criteria were as follows:

- Systematic reviews and/or meta-analysis on toothbrushes/tooth brushing
- Papers written in the English or Dutch language
- Synthesis of studies conducted in humans
  - ≥18 years old
  - In good general health

Exclusion criteria were as follows:

- Orthodontic patients

At the outset of this meta-review no attempt was made to separate specific variables associated with toothbrushes/tooth brushing such as efficacy, duration, force, bristle type or use of a dentifrice.

Assessment of heterogeneity

The heterogeneity across studies was detailed according to the following factors:

- Study and subjects characteristics
- Methodological heterogeneity (variability in study design and risk of bias)
- Analysis performed (Descriptive or meta-analysis)

Quality assessment

Two reviewers (GAW & DES) estimated the risk of bias by scoring the reporting and methodological quality of the included systematic reviews according to a combination of items described by the PRISMA (2009) guideline for reporting systematic reviews and the AMSTAR (2007) checklist for assessing the methodological quality of systematic reviews. A list of 27 items was assessed and if all individual items were given a positive rating by summing these item scores an overall 100% score was obtained. Only systematic reviews including meta-analysis could achieve a full score of 100% (Hidding et al.2014). The estimated risk of bias was interpreted as follows: 80% to 100% – low estimated risk of bias, 60% to 80% – moderate, 40% to 60% – substantial and 0% to 40% – as a high estimated risk of bias.

Data extraction

Information extracted from the studies included publication details, focused question, search results, descriptive or (weighted) mean outcomes and conclusions. Selected systematic reviews were categorized by one author (GAW) according to various aspects related to mechanical plaque control. Categorization was confirmed with the second author (DES).

Grading the "body of evidence"

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, as proposed by the GRADE working group, was used to grade the evidence emerging from this meta-review of systematic reviews (Guyatt et al. 2008, GRADE 2011). Two reviewers (GAW & DES) rated the quality of the evidence as well as the strength of the recommendations according to the following aspects: Study design, risk of bias; consistency and precision among outcomes; directness of results, detection of publication bias and magnitude of the effect.

Results

Search and selection results

Figure 1 describes the search process. The searches resulted in 176 unique papers. The screening of titles and abstracts initially resulted in 11 papers. Based on detailed reading of full texts one paper was excluded (Vibhute & Vandana 2012) because it considered only studies from one single centre and one paper (Tomás et al. 2012) because it included both gingivitis and periodontitis patients. Hand searching of the reference lists did not reveal any additional suitable systematic reviews neither did PROSPERO (2014). As a result, 10 studies were identified as being eligible for inclusion in this synopsis.

Quality assessment

The majority of reviews were considered to have a low to moderate estimated risk of bias (Table 1). Van der Weijden & Hioe (2002) and Frazelle & Munro (2012) were estimated with a substantial to high risk of bias. Critical items in this evaluation were the development of a protocol 'a priori' and its registration, searches of additional sources including non-English literature, contacting authors for additional information, grading obtained evidence and the assessment of publication bias.

Study outcomes

It was considered that because of the heterogeneity of the reviews, such as their aims and methods of recording and reporting, a sophisticated level of data combination and analysis was neither possible nor indicated. A meta-analysis was therefore not undertaken. For the purpose of this synopsis, a summary of the selected systematic reviews was categorized and is presented by various topics related to mechanical oral hygiene and ordered by common characteristics.

Oral hygiene instruction

One systematic review was identified which evaluated the efficacy of self-performed mechanical plaque

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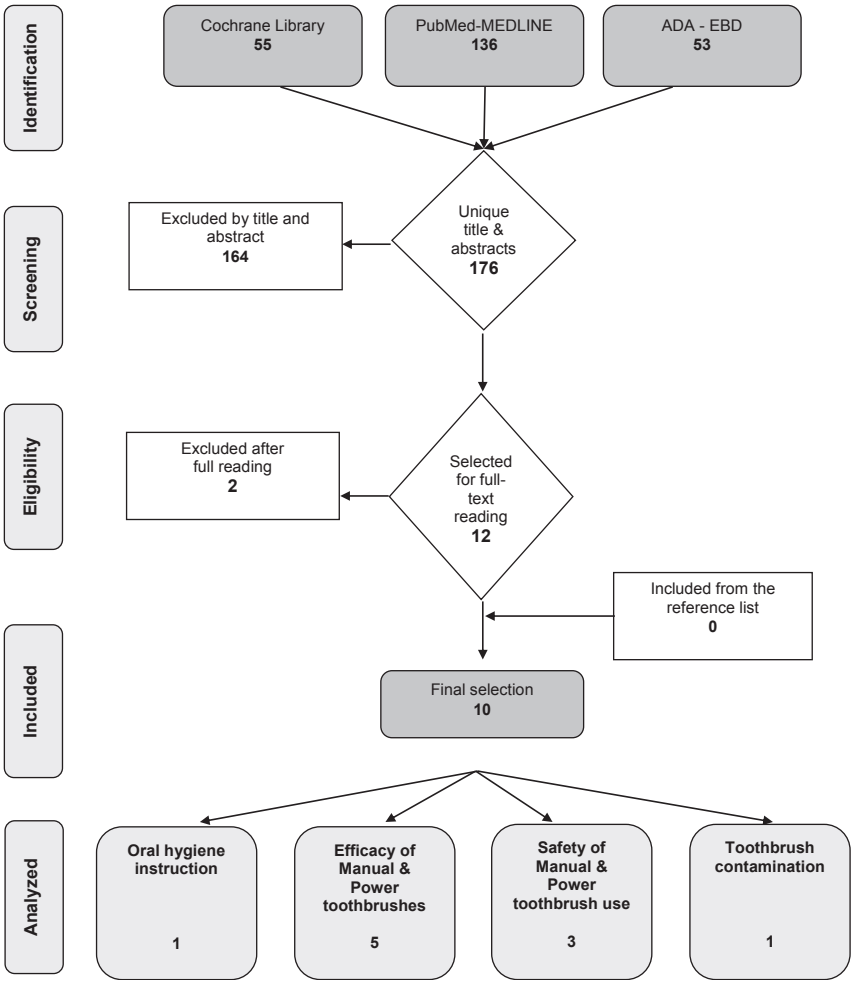

Fig. 1. Search and selection results.

removal in adults with gingivitis using a manual toothbrush (Van der Weijden & Hioe 2005b). The main challenge of this review was the choice of a comparison. Should manual tooth brushing be compared with no oral hygiene at all? Instead, these authors decided to systematically search the literature for controlled clinical trials of ≥6 months in duration that assessed the effect of various forms of plaque control in gingivitis subjects. From those trials, the manual toothbrush group could serve to provide data that would be analysed relative to the baseline intervention being either a professional oral hygiene instruction, a professional prophylaxis or both. Baseline and end trial data were compared with the effect of mechanical oral hygiene. In most studies, the manual toothbrush group with standard fluoride toothpaste was the control group. In this respect, there were no negative control groups. The authors therefore point out that part of the effect that was observed may have been the result of the Hawthorne effect (Snow 1927), which affects panellists involved in clinical trials. Of the 3223 titles and abstracts, 33 trials were found for data extraction. A meta-analysis could be conducted using eight studies. The mean difference (Mdiff) between baseline and end trial for plaque scores (Quigley & Hein 1962) was 0.10 and the bleeding tendency decreased by 6%. For plaque scores, the meta-analysis revealed a p-level of 0.06 and for bleeding a statistically significant improvement was established. The authors concluded that based on studies ≥6 months in duration, it appears that a single oral hygiene instruction, describing the use of a mechanical toothbrush, in addition to a single professional "oral prophylaxis" provided at baseline, had a significant, albeit small, positive effect on the reduction of gingivitis.

Efficacy of manual tooth brushing

One systematic review was identified which evaluated the efficacy of manual toothbrushes (Slot et al. 2012) following a brushing exercise.

The aim of this review (Slot et al. 2012) was to systematically collect the evidence concerning the efficacy of manual tooth brushing. It was determined "a priori" to perform subanalyses by bristle tuft configuration (flat trim, multilevel and angled) and by brushing duration. The search yielded 2119 titles and abstracts. Ultimately, 59 papers with 212 brushing exercises as separate legs of the experiments and meeting the eligibility criteria were selected. The estimated potential risk of bias was considered low in 53 of the studies, considered moderate for three studies and high for three studies. The overall treatment effect of a brushing exercise is estimated as a weighted mean 42% (21) (95%CI: 41; 42) plaque index score reduction from baseline. Overall, combining the outcomes of the 121 experiments that provided data with respect to the Quigley & Hein (1962) plaque index, the weighted mean plaque score reduction was 30% (95%CI: 27; 33). A subanalysis of the different bristle configurations showed a variation of 24–39%. The angled bristle tuft toothbrush design numerically provided the highest mean plaque score reduction of 39%. The flat trimmed toothbrushes scored the lowest mean plaque score reduction (24%). In the 91 experiments of the studies that used the Navy plaque index (Elliott et al.1972), the overall weighted mean reduction was 53% (95%CI: 50; 56). Subanalysis between the different bristle tuft configuration types also showed that there was variation in efficacy (Q&H: 24–39%, Navy: 47–61%). Again, the brushes with the angled bristle tuft configuration scored the highest mean plaque scores. In total, the 212 brushing exercises as separate legs of experiments which were used to calculate weighted mean overall percentage plaque score

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Table 1. Estimated the risk of bias by scoring a list of items related to the reporting and methodological quality of the included systematic reviews

Quality criteria:	Author (year)									
	Van der Weijden & Hioe (2002)	Slot et al. (2012)	Rosema et al. (2014)	Sicilia et al. (2002)	Yaacob et al. (2014)	Deacon et al. (2010)	Oliveira et al. (2014)	Rajapakse et al. (2007)	Van der Weijden et al. (2011)	Frazelle & Munro (2012)
Aspect reviewed	**OHI**	**Manual Brush Efficacy**	**Power brush Efficacy**	**Manual *versus* Power**	**Manual *versus* Power**	**Power *versus* Power**	**Safety**	**Recession**	**Safety Power**	**Toothbrush Contamination**
1] Defined outcome criteria of interest	+	+	+	+	+	+	±	+	±	±
2] Describes the rationale	±	+	+	+	+	+	+	+	+	+
3] Describes the focused (PICO)[S] question/ hypothesis	+	+	+	+	+	+	+	+	+	–
4] Describes if a protocol was developed "a priori".	–	–	–	+	+	+	–	+	–	–
5] Protocol registration/publication	–	–	–	–	+	+	–	–	–	–
6] Presented eligibility criteria (in/exclusion criteria)	+	+	+	+	+	+	+	+	+	+
7] Presents the full search strategy	+	+	+	+	+	+	+	+	+	–
8] Various databases searched	+	+	+	+	+	+	+	+	+	+
9] Performed (hand) search in additional sources (f.i. grey literature or trial registers)	–	–	–	+	–	+	–	+	–	–
10] Review selection by more than 1 reviewer	+	+	+	+	+	+	+	+	+	?
11] Non-English papers included	–	–	–	–	+	+	–	+	–	–
12] Provide details on the performed study selection process/flow chart	+	+	+	+	+	+	+	+	+	+
13] Report included study characteristics	+	+	+	+	+	+	+	+	+	+
14] Provide data of the selected studies on the outcome measures of interest	+	+	+	+	+	+	+	+	+	+
15] Data were extracted by more than 1 reviewer	+	+	+	+	+	+	+	+	+	?
16] contacted authors for additional information	–	–	–	–	+	+	–	+	–	–
17] Report heterogeneity of the included studies	+	+	+	+	+	+	+	+	+	–
18] Estimated risk of bias in individual studies	–	+	+	+	+	+	+	+	+	–
19] Performed a meta-analysis	+	+	+	–	+	+	NA	–	+	–
20] Performed a descriptive analysis	–	NA	NA	+	±	±	+	+	+	±
21] Describe additional sub-analysis	+	+	+	+	+	+	+	–	+	+
22] Grading of the obtained evidence	–	–	–	–	+	–	–	–	+	–
23] Present limitations of the systematic review	–	+	+	+	+	+	±	+	+	±
24] Provide a conclusion that respond to the objective	+	+	+	+	+	+	+	+	+	+
25] Publication bias assessed	–	–	–	–	+	–	–	–	–	–
26] Funding source	–	+	+	–	+	+	+	+	+	–
27] Conflict of interest statement	–	+	+	–	+	+	+	+	+	–
Original Review authors estimated level of evidence	Not reported	High	High	Limited	Moderate	Limited	Circumstantial	Limited	High	Not reported
Synopsis authors estimated quality score	52%	77%	77%	74%	96%	93%	65%	81%	74%	30%
Synopsis authors estimated risk of bias	**Substantial**	**Moderate**	**Moderate**	**Moderate**	**Low**	**Low**	**Moderate**	**Low**	**Moderate**	**High**

Each aspect of the reporting and methodological quality item score list was given a rating of a plus "+" for informative description of the item at issue and a study design meeting the quality standard was assigned, plus-minus (±) was assigned if the item was incompletely described, and minus "–" was used if the item was not described at all and "?" for lacking or insufficient information (Hidding et al.2014).
For the quality assessment score individual items with a positive rating were summed to obtain an overall percentage score.
NA= not applicable.

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reductions included 10,806 participants.

Based on the outcome, the review authors concluded that the efficacy of plaque removal following a brushing exercise is an overall reduction from baseline in plaque scores of 42% on average, with a range of 30–53% dependent on the plaque index used. The available evidence indicates that bristle tuft arrangement (flat trim, multilevel and angled) and brushing duration are factors that contribute to this variation in observed efficacy.

Efficacy of power tooth brushing

One systematic review was identified which evaluated the efficacy of power toothbrushes (Rosema et al. 2014a) following a brushing exercise.

The primary objective of this review was to determine, based on the available published evidence, the efficacy of powered tooth brushing following a brushing exercise, and secondary to what magnitude this effect is dependent on, power supply, and mode of action (Rosema et al. 2014a).

The search yielded 2418 titles and abstracts. Ultimately, 58 papers with 146 brushing exercises as separate legs were selected. The estimated potential risk of bias was considered low in 51 of the studies, considered moderate for six studies and high for one study. The overall effect of a powered brushing exercise provides a weighted mean plaque score reduction of 46%. Overall, combining the outcomes of the 106 experiments that provided data with respect to the Quigley & Hein (1962) plaque index, the weighted mean plaque score reduction was 36% (95%CI: 35; 36). In the 39 experiments of the studies that used the Navy plaque index (Elliott et al.1972), the overall weighted mean reduction was 65% (95%CI: 65; 66). Subanalysis on power supply showed a numerical difference in favour of the rechargeable brush as opposed to the brushes with replaceable batteries (Q&H: 38% *versus* 33%; Navy: 68% *versus* 61%). Considering the rechargeable brushes the oscillating/rotating had a numerical difference as compared to those that moved side to side (Q&H: 39% *versus* 33%; Navy: 71% *versus* 64%). Based on the outcome, the review authors concluded that the efficacy in plaque removal following a brushing exercise using a powered toothbrush provides an overall weighted mean plaque score reduction of 46%, with a range of 35–67% dependent on the index scale to score plaque. The available evidence indicated that the power supply (rechargeable or replaceable battery), mode of action, as well as brushing duration and type of instructions are factors which contribute to the variation in the observed efficacy.

A finding in both systematic reviews (Slot et al. 2012, Rosema et al. 2014a) on the effect of a brushing exercise was the fact that the magnitude of the estimated effect size of tooth brushing appears to depend on the plaque scoring method.

Efficacy of manual *versus* power tooth brushing

Two systematic reviews were identified which evaluated the efficacy of manual versus powered toothbrushes (Sicilia et al. 2002, Yaacob et al. 2014).

The first systematic review evaluated powered versus manual toothbrushes in periodontal cause-related therapy (Sicilia et al. 2002) and was prepared for the 4th European Workshop on Periodontology. The aim of the review was to evaluate the efficacy of the use of a power toothbrush as compared with a manual toothbrush, in terms of gingival bleeding or inflammation resolution, in cause-related periodontal therapy. The main outcome variable was the reduction of the gingivitis, as measured by the reduction of gingival bleeding or inflammation.

The search identified 343 potentially suitable papers of which 21 were considered valid to provide an answer for the focused question. All selected studies were defined by their authors as randomized. However, a precise description of the procedure employed was only found in seven cases. The heterogeneity of the extracted data prevented a quantitative analysis. A descriptive analysis showed a higher efficacy in the reduction of gingival bleeding or inflammation in the power toothbrush group as compared to the manual toothbrush users in 10 studies. This effect appears to be related to the capacity to reduce plaque, and was more evident in counter-rotational and oscillating–rotating power toothbrushes. No solid evidence was found for a higher efficacy of sonic (side-to-side mode of action) brushes.

Based on the outcome of the selected studies, the review authors concluded that use of power toothbrushes, especially counter-rotational and oscillating–rotating brushes, can be beneficial in reducing the levels of gingival bleeding or inflammation. They also suggested that there is a need for methodological homogeneity in future studies in this field to enable quantitative analysis of their results.

A second (Cochrane) systematic review evaluated powered versus manual tooth brushing for oral health (latest update by Yaacob et al. 2014).

The aim of this review was 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, and adverse effects (Yaacob et al. 2014). Selection criteria were randomized, controlled trials of at least 4 weeks of unsupervised powered tooth brushing *versus* manual tooth brushing for oral health in children and adults. The search identified 1149 potentially relevant papers out of which 56 studies met the inclusion criteria. The estimated potential risk of bias was considered low in five studies, high for five studies and 46 studies were considered at unclear risk of bias. In total, 51 studies, involving 4624 participants, provided data for meta-analysis. The results of the meta-analyses are presented as standardized mean differences (SMD), which do not relate to tangible differences in clinical indices. With regard to the reduction of plaque, there is moderate quality evidence that powered toothbrushes provide a statistically significant benefit compared with manual toothbrushes. To help interpret the magnitude of the effect, the results of the 'all powered toothbrushes' meta-analysis have been backtranslated to the most commonly reported plaque and gingivitis indices. The

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results of the meta-analysis correspond to an 11% reduction in plaque for the Quigley & Hein index (1962) in the short term and 21% reduction in the long term. With regard to gingivitis, there is moderate quality evidence that powered toothbrushes provide a statistically significant benefit when compared with manual toothbrushes which corresponds to a 6% and 11% reduction in gingivitis respectively for the Silness & Löe (1964) index. The meta-analyses showed high levels of heterogeneity that was not explained by the different powered toothbrush type subgroups.

The number of trials for each type (based on mode of action) of powered toothbrush varied: side-to-side (10 trials), counter oscillation (five trials), rotation oscillation (27 trials), circular (two trials), ultrasonic (seven trials) and unknown (five trials). The greatest body of evidence was for oscillating–rotating brushes which demonstrated a statistically significant reduction in plaque and gingivitis. There was no apparent relationship between the use of powered toothbrushes and soft tissue trauma.

Publication bias might be expected in the reporting of toothbrush trials as manufacturers would likely want to have scientific support for the effectiveness of their products. 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 (Yaacob et al. 2014). Based on the outcome of this review, the authors concluded that powered toothbrushes reduce plaque and gingivitis more than manual tooth brushing in the short and long term. The clinical importance of these findings remains unclear. Observation of methodological guidelines and greater standardization of design would benefit both future trials and meta-analyses. Side effects were inconsistently reported and were localized and only temporary.

Efficacy of different power toothbrushes

In the above Cochrane systematic review by Yaacob et al. 2014, it was observed that in relation to individual modes of action of powered brushes, there are inconsistencies with regard to reductions of plaque and gingivitis. Oscillating–rotating brushes showed statistically significant reductions in both plaque and gingivitis. All other brushes, apart from side to side, showed some statistically significant findings but not consistently across both outcomes and time points. It was considered difficult to explain this inconsistency that a particular toothbrush design could affect plaque or gingivitis at one time but not at another.

One other Cochrane systematic review evaluated studies that compared different powered toothbrushes for plaque control and gingival health (Deacon et al. 2010).

The aim of this review was to compare different designs of powered toothbrushes against each other for plaque reduction and the health of the gingivae, and adverse effects (Deacon et al. 2010). Selection criteria for inclusion were as follows: random allocation of participants; no compromised manual dexterity; unsupervised powered tooth brushing for at least 4 weeks; with primary outcomes plaque and gingivitis scores after powered toothbrush use. The search identified 396 potentially relevant papers out of which 17 studies met the inclusion criteria. The estimated potential risk of bias was considered high for two studies and 15 studies were considered at unclear risk of bias. No trial was assessed as being at low risk of bias. The review included data from 1369 participants. There is evidence from seven trials in the short term (1–3 months) and at unclear/high risk of bias that oscillating–rotating brushes reduce plaque and gingivitis more than side-to-side brushes. This difference is small and its clinical importance is unclear. Due to the dearth of trials, no other definitive conclusions can be stated regarding the superiority of one mode of powered toothbrush over any other. Only minor and transient side effects were reported.

Based on the outcome of the review, the authors concluded that there is some evidence that oscillating–rotating brushes reduce plaque and gingivitis more than side-to-side brushes in the short term. At present, the superiority of any other mode of powered brushing has not been established. Further research is required before evidence-based advice concerning the relative performance of the different powered toothbrushes can be given by health care professionals to the public.

Side (adverse) effects

One systematic review evaluated whether it is safe to use a toothbrush (Oliveira et al. 2014). The aim of this review was to systematically gather and summarize case reports describing the adverse events resulting from the oral use of a toothbrush, as available in both the dental and medical literature, using a comprehensive search strategy (Oliveira et al. 2014).

The search identified 419 unique titles and abstracts of which 94 papers met the eligibility criteria. In total, 118 subjects (age range = 1–60 years) presented adverse events related to the oral use of a toothbrush. Events could be summarized in five categories, of which ingestion was the most reported problem among the individuals (50 cases). This was followed by impaction of a toothbrush (27 cases). Reports more frequently involved females and children were more likely to have injuries compared to males and adults. Most of the cases that presented with adverse events of the oral use of a toothbrush were referred for treatment to a physician.

Based on the retrieved data, the authors conclude that the combined evidence related to serious adverse events as presented in case reports showed that the oral use of a toothbrush can be associated with ingestion, impaction, instant trauma, gingival traumatic injury and seizures.

Given the incidence of reporting, important recommendations are that a toothbrush should not be used to induce vomiting, nor should people walk or run with this device in their mouths, especially children.

Another systematic review evaluated whether tooth brushing influences the development and progression of gingival recession (Rajapakse et al. 2007).

The aim of this review was to produce the best available evidence

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and pool appropriate data to evaluate the effect of tooth brushing on the initiation and progression of non-inflammatory gingival recession (Rajapakse et al. 2007). The search identified 831 unique titles and abstracts of which 17 full papers met the eligibility criteria. Of these observational studies, two concluded that there appeared to be no relationship between tooth brushing frequency and gingival recession. Eight studies reported a positive association between tooth brushing frequency and recession. Other potential risk factors were duration of tooth brushing, brushing force, frequency of changing the toothbrush, brush (bristle) hardness and tooth brushing technique. None of the observational studies satisfied all the specified criteria for quality appraisal.

Based on these outcomes, the review authors concluded that the data to support or refute the association between tooth brushing and gingival recession are inconclusive.

Another systematic review evaluated the safety of oscillating–rotating powered brushes compared to manual toothbrushes (Van der Weijden et al. 2011).

The aim of this review was to examine the literature concerning the relative soft and/or hard tissue safety outcomes with the use of oscillating–rotating toothbrushes compared to manual toothbrushes (Van der Weijden et al. 2011). The search identified 899 unique titles and abstracts of which 35 publications met the eligibility criteria. Meta-analysis showed that the mean change in gingival recession was not significantly different among toothbrush groups in the two selected trials with safety as a primary outcome (Mdiff: 0.03, 95%CI −0.07; 0.13). Meta-analysis of trials that evaluated safety with a surrogate parameter was not possible. However, there were no significant differences between groups at the study end in any trial. A descriptive analysis of the 24 selected studies assessing safety as a secondary outcome revealed few brushing-related adverse events. The heterogeneity in objectives and methodology of the four "in vitro" trials that met the eligibility criteria precluded generalization of the results.

Based on the review outcome, the authors concluded that a large body of published research has consistently shown oscillating–rotating toothbrushes to be safe compared to manual toothbrushes, demonstrating that these power toothbrushes do not pose a clinically relevant concern to hard or soft tissues.

Toothbrush contamination

One systematic review investigated toothbrush contamination (Frazelle & Munro 2012). The aim of this review was to evaluate the cumulative state of knowledge related to toothbrush contamination, its possible role in disease transmission (Frazelle & Munro 2012). The search identified 476 unique titles and abstracts of which 10 publications met the eligibility criteria.

Seven studies were experimental and three were descriptive which identified multiple concepts related to toothbrush contamination to include contamination, methods for decontamination, storage, design and environmental factors. The sample sizes ranged from 3 to 103 with the majority of studies having a sample size under 30. The selected studies found that toothbrushes of healthy and oral diseased adults become contaminated with pathogenic bacteria from the dental plaque, design, environment, or a combination of factors. There were no studies that specifically examined toothbrush contamination and disease transmission.

Evidence profile

Table 2 shows a summary of the various factors used to rate the quality of evidence and strength of recommendations according to GRADE (Guyatt et al. 2008). There is a strong evidence in support of the efficacy of manual and power toothbrushes and the safety of power toothbrushes. Although the latter provided indirect information since it was limited to oscillating–rotating technology. With respect to safety of manual toothbrushes, there is low level of evidence based on a systematic summary of case reports (Oliveira et al. 2014) and a systematic review which only assessed the effect of tooth brushing on gingival recession (Rajapakse et al. 2007). The effect of a single oral hygiene instruction (Van der Weijden & Hioe 2002) was supported by moderate evidence and for toothbrush contamination there was a very low level of evidence and the specific impact on disease

Table 2. Estimated evidence profile (GRADE 2014) for the effect of various methods and aspects of mechanical plaque removal

Grading items	Oral hygiene instruction	Manual toothbrush	Power Toothbrush	Safety manual toothbrush	Safety power toothbrush	Toothbrush contamination
Study Designs # of included studies	Systematic review $N = 1$	Systematic review $N = 1$	Systematic review $N = 4$	Systematic review $N = 2$	Systematic review $N = 1$	Systematic review $N = 1$
Reporting and methodological estimated potential risk of bias	Substantial	Moderate	Low – Moderate	Low – Moderate	Moderate	High
Consistency	Fairly consistent	Consistent	Consistent	Inconsistent	Consistent	Consistent
Directness	Indirect	Direct	Direct	Indirect	Indirect	Direct
Precision	High	High	High	Moderate	High	Low
Publication bias	Possible	Possible	Possible	Possible	Possible	Possible
Magnitude of the effect	Small	Moderate	Moderate	Small	Small	Unclear
Body of Evidence	***Moderate***	***Strong***	***Strong***	***Low***	***Strong***	***Very Low***

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transmission was not established (Frazelle & Munro 2012).

Discussion

This meta-review summarized the available evidence as was present in the form of systematic reviews with respect to the efficacy of homecare regimens for mechanical plaque removal in managing gingivitis. Van der Weijden & Hioe (2005b) showed that a single oral hygiene instruction, describing the use of a mechanical toothbrush, in addition to a single professional "oral prophylaxis" provided at baseline, had a significant, albeit small, positive effect on the reduction of gingivitis. Slot et al. 2012 systematically collected the evidence concerning the efficacy of manual tooth brushing. The overall treatment effect of a brushing exercise was estimated as a weighted mean 42% plaque score reduction. Rosema et al. (2014a) using a similar research design concluded that a brushing exercise using a powered toothbrush provides an overall weighted mean reduction of 46%. When juxtaposed on the results from the study by Slot et al. (2012), it seems that powered toothbrushes after a brushing exercise are, at least numerically, more efficacious than manual brushes in overall weighted mean plaque score reduction (46% *versus* 42% respectively). The outcome of a recent Cochrane review by Yaacob et al. (2014) supports this presumption of which the meta-analysis comparing manual *versus* power toothbrushes corresponds to an 11% reduction in plaque in the short term and 21% reduction in the long term. With regard to gingivitis, a statistically significant benefit corresponded to a 6% and 11% reduction in gingivitis in the short and long term respectively. Another Cochrane review Deacon et al. (2010) established that there is some evidence for oscillating–rotating brushes to reduce plaque and gingivitis more than side-to-side brushes in the short term. No difference for any other mode of powered brushing has been established. Based on a systematic summary of case reports Oliveira et al. (2014) established that the oral use of a toothbrush can be associated with ingestion, impaction, instant trauma, gingival traumatic injury and seizures. Rajapakse et al. (2007) concluded that the association between tooth brushing and gingival recession to be inconclusive. Van der Weijden et al. (2011) found oscillating–rotating toothbrushes to be safe compared to manual toothbrushes. Frazelle & Munro (2012) reported that toothbrushes can become contaminated with pathogenic bacteria but the potential impact of this on disease transmission was not researched.

Appraising the quality of systematic reviews

Systematic reviews have become increasingly popular and have become the standard approach in assessing and summarizing applied health research. Unlike traditional narrative reviews, systematic reviews aim to minimize bias in locating, selecting, coding and aggregating individual studies (Shea et al. 2007a). In recent years, decision makers who were once overwhelmed by the number of individual studies have become faced by a plethora of reviews. The present synopsis is a logical and appropriate next step in applying high-quality evidence to clinical decision making (Smith et al. 2011). This systematic meta-review allows the creation of a convenient summary of the corresponding reviews in a single document and has provided succinct descriptions of selected systematic reviews related to the focused question.

In spite of the care with which individual systematic reviews are conducted, they may differ in quality (Shea et al. 2007b). High methodological quality is a pre-requisite for valid interpretation and application of review findings. Quality of systematic reviews can be defined as the likelihood that the design of a systematic review will generate unbiased results. Quality assessment instruments focus on either reporting quality (how well systematic reviewers have reported their methodology and findings (internal validity) or methodological quality (how well the systematic review was conducted (literature searching, pooling of data, etc.). It is possible for a systematic review with poor methodological quality to have good reporting quality. For this synopsis, the quality assessment items are based on a combination of the PRISMA checklist (2009) for assessing reporting quality and the AMSTAR (2007) tool which is a user friendly methodological quality assessment for appraisal of systematic reviews (Shea et al. 2007a, b). The outcome of the adapted checklist is presented in Table 1 which shows the estimated risk of bias in mainly low to moderate. For the next level of appraisal, that is the body of evidence which emerges from this systematic meta-review the GRADE (2011) criteria were used which indicated that there is strong evidence in support of the efficacy of toothbrushes on plaque removal. Selected systematic reviews also provide strong evidence for the efficacy of power toothbrushes on managing gingivitis.

There are, however, more aspects such as brushing methods, tooth brushing duration, filament design, tooth brushing force, etc. related to mechanical plaque control for which no systematic reviews could be identified in the comprehensive search that was performed. As will be pointed out in the paragraphs below these aspects do appear to have an effect on the efficacy of mechanical plaque. They therefore deserve discussion to place their contribution to the above systematically evaluated outcomes in the proper perspective.

Tooth brushing methods

The ideal brushing technique is the one that allows for complete plaque removal in the least possible time, without causing any damage to tissues (Hansen & Gjermo 1971). Different tooth brushing methods have been recommended over time and some have also been abandoned. Methods can be classified based on the position and motion of the brush. The most common technique used by uninstructed individuals is typically a horizontal scrub technique that engages the occlusal and free surfaces (Löe 2000). Although this method removes oral biofilm from smooth tooth surfaces, it is considered to be less effective in other areas and may cause more injury to the soft and hard tissues. To date, no particular tooth brushing method has been found to be clearly superior to the others. A

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recent study assessed methods of tooth brushing recommended for both adults and children by dental associations, toothpaste and toothbrush companies and professional sources such as in dental textbooks and by experts (Wainwright & Sheiham 2014). There appeared to be a wide diversity between recommendations on tooth brushing techniques, how often people should brush their teeth and for how long. The most common method recommended was the (Modified) Bass technique.

A recent systematic review evaluated tooth brushing methods but it focused on children (Muller-Bolla & Courson 2013). Although being outside the scope of this synopsis, the conclusion is interesting, namely, that the horizontal brushing technique as recommendation for younger children is supported by scientific evidence. The order in which the brush is used throughout the dentition has many possibilities for sequencing. The individual should be encouraged to select a sequence and to use it consistently to avoid omission of any area.

Power toothbrush users also require instruction. A publication from the *European Workshop on Mechanical Plaque Control* concluded that professional instruction and reinforcement in the use of powered toothbrushes seems important to achieve optimal results (Van der Weijden et al. 1998). These instructions vary with manufacturer and design. In general, power tooth brushing is relatively straightforward because the mechanism of action removes the need to manipulate the toothbrush so that one can focus the brush in the right position.

A better performance of a tooth brushing episode may not only rely on the technique or the product but also on the dedication of the user of the toothbrush, as well as the adherence with oral hygiene instructions (Renz et al. 2007). Powered toothbrushes have the advantage to enhance patient motivation (Hellstadius et al. 1993). No tooth brushing method can adequately clean interproximal surfaces. Inter-dental cleaning did not fall within the scope of this paper and is addressed by another reviewer of this 11th European Workshop on Periodontol-ogy (Sälzer et al. 2014-this workshop). Furthermore, the use of antimicrobial/anti-inflammatory toothpastes and mouthwashes may improve the oral biofilm and control gingival disease. This topic is addressed in this workshop by Serrano et al. (2014-this workshop) and Polak et al. (2014-this workshop).

Toothbrush filament design

Nylon toothbrushes were developed in the 1930s making them easier to manufacture and therefore more affordable. Ever since, much imagination and inventiveness has been applied to toothbrush design. Currently, there are numerous variations of manual toothbrushes available on the market. A toothbrush head contains tufts composed of nylon filaments. The number and length of filaments in a tuft, number of tufts and arrangement of tufts vary with toothbrush designs. Toothbrush stiffness is related primarily to the filament's diameter and length. Designs of the brush head have evolved, and multiple tufts of bristles, sometimes angled in different directions, are now used. The tuft arrangement has been shown to affect tooth brushing efficacy (Slot et al. 2012).

As late as 1967, most people were buying hard brushes (Fanning & Henning 1967). The shift in preference to soft brushes of specific design paralleled the change that occurred in oral health care when calculus was no longer viewed as the prime aetiological agent in periodontal disease. The concentration on plaque, especially in the cervical area and the attention to intrasulcular brushing strongly influenced the change from hard to soft filaments, primarily because of the concern with trauma to the gingival tissues (Niemi et al. 1984). However, filaments must have a degree of stiffness to create sufficient abrasion to dislodge plaque deposits. For example, a brush with very thin filaments will merely stroke across the tooth and as a result of the lack of load will no longer clean. Studies have shown that subjects clean significantly better with medium brushes than with a soft-bristled brush (Versteeg et al. 2008).

Modern toothbrushes have end-rounded filaments. Sharp edged filament tips represent a greater threat to dental tissues (Versteeg et al. 2008). Manual toothbrushes with cut filament ends resulted in significantly greater gingival lesions than rounded ends (Breitenmoser et al. 1979). Non-end-rounded filament turn out to be about twice as abrasive to soft tissues as rounded filament tips (Alexander et al. 1977). Danser et al. (1998) evaluated two types of end-rounding and observed that even the form to which the ends are rounded had an effect on the incidence of abrasion. A recent study observed that gingival abrasion did not explain the observed gingival recession. Gingival abrasion reflects the "instant" effect of tooth brushing on gingival tissue. Apparently, more than this is necessary to induce gingival recession (Rosema et al. 2014b). This is in support of the conclusion emerging from the systematic review by Rajapakse et al. (2007) that the association between tooth brushing and gingival recession is inconclusive.

Tooth brushing frequency and duration

There is no standard recommendation for how many times per day persons should brush their teeth. It seems reasonable to state that meticulous mechanical removal of plaque by tooth brushing, combined with the removal of inter-dental plaque once every 24 h, is adequate to prevent the onset of gingivitis and inter-dental caries (Axelsson 1994). The American Dental Association advocates to brush twice a day (ADA 2014a). Kressin et al. (2003) evaluated the effect of oral hygiene practices on tooth retention in a longitudinal study with 26 years of follow-up. They observed that consistent brushing (at least once per day) resulted in a 49% reduction of the risk of tooth loss, compared to a lack of consistent oral hygiene habits.

The recommended brushing duration often is 2 min (Van der Weijden et al. 1993), and some models of power toothbrushes have 2-min timers to encourage adherence. Although numerous studies have monitored the actual tooth brushing duration in controlled clinical settings, what actually occurs in real life may vary. Patients usually believe they spend more time than they actually do. The best estimate

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of actual manual brushing time seems to range between 30 and 60 s (Van der Weijden et al. 1993). Evidence indicates that, as brushing times increase, efficacy also increases (Van der Weijden et al. 2005a). Therefore, brushing for 2 min or longer should be encouraged, regardless of the brush used. Brushing time is also likely the most easily controlled parameter of effective everyday brushing.

Tooth brushing force (pressure)

Tooth brushing requires the application of shear forces to remove plaque from hard surfaces which concomitantly would have an impact on soft tissues. Toothbrushes are required to have some level of filament stiffness, and some force is necessary if plaque deposits are to be effectively dislodged from dental surfaces during brushing (Rosema et al. 2014b). Excessive brushing force has been mentioned as a factor that is partly responsible for the origin of toothbrush trauma (gingival abrasion) (Khocht et al. 1993). Although Danser et al. (1998) concluded in a study comparing manual and power toothbrushes that gingival abrasion is not influenced by brushing force.

In response to patients who use excessive force, manual and electric toothbrush manufacturers have introduced toothbrush designs that can limit the amount of force used and thus reducing the chance of damage to soft and hard tissues. Brushing force with electric toothbrushes has consistently been shown to be lower than that with a manual toothbrush (Van der Weijden et al. 1996). This appears to be a consistent finding. There is an approximately 1.0 N difference between brushing forces when using manual and electric toothbrushes. It should be recognized that the head of a manual brush is larger than the head of an electric brush. Because the forces are given as a total of the force over the entire brush, van der Weijden et al. (1996) calculated that the unit pressure of a soft manual toothbrush was 11.32 g/mm^2 and for the power toothbrush 11.29 g/mm^2.

Most literature on force applied during tooth brushing has focused on its association with damaging soft tissue (gingival abrasion and recession), and fewer researchers have examined the effect of force on plaque reduction. An increase in efficacy was observed with raising brushing force from 1.0 N to 3.0 N (Van der Weijden et al. 1996). As shown in a manual brushing study in which efficacy was plotted against brushing force also the relationship between force and efficacy does not appear to be linear (Van der Weijden et al. 1998). Using this particular manual toothbrush, a positive correlation was identified between efficacy and force (up to 4.0 N). The greater the force used, the more effective was the plaque removal. However, efficacy decreased when forces greater than 4.0 N were used. Indeed, there appeared to be a negative correlation. The hypothesis is that this negative correlation had to do with distortion of the brushing filaments. Beyond 4.0 N, brushing was no longer performed with the tip of the filament but, due to bending, with its side, indicating that brushing force is not the sole factor that determines efficacy.

Toothbrush wear

It is generally accepted that toothbrushes should be replaced after 3 months of use. The American Dental Association advocates toothbrush replacement every 3–4 months or sooner if the bristles become frayed (ADA 2014b). Few studies have investigated the aspect of the wear of a toothbrush, as it affects the efficacy of plaque removal. Although it makes sense that a worn toothbrush would reduce toothbrush efficacy, evidence supporting this claim is inconclusive.

The effective life of a toothbrush can vary because wear is dependent on user habits, such as frequency and duration of use, brushing force and brushing technique (Dean 1991). It seems that the age itself of the toothbrush is not the critical parameter that is crucial to plaque removal efficacy. Wear rate seems to be the determining factor with regard to loss of efficacy, and thus, the replacement advice should be related more to wear than to the age of the toothbrush. It should be taken into account that in this respect, wear is considered as the visible signs of worn filaments such as bending, splaying or matting (Rosema et al. 2013).

Tongue cleansing

The dorsum of the tongue with its papillary structure and furrows harbours a great number of microorganisms (Van der Weijden & Van der Velden 1991). It forms a unique ecologic oral site with a large surface area (Danser et al. 2003). Tongue bacteria can serve as a source of bacterial dissemination to other parts of the oral cavity, for example, the tooth surfaces, and can contribute to dental plaque formation. Therefore, tongue brushing has been advocated as part of daily home oral hygiene, together with tooth brushing and flossing (Christen & Swanson 1978). Tongue cleansing reduces the number of organisms, thereby controlling oral malodor (Van der Sleen et al. 2010). It decreases the opportunity for microorganisms to translocate, improving the client's taste perception and contributing to overall oral cleanliness. A reduced gagging reflex has been observed with scrapers as compared to toothbrushes (Van der Sleen et al. 2010). A large variety of tongue cleaners are commercially available. Some studies have shown that tongue brushing, in combination with other methods of oral hygiene, is an effective method for reducing the formation of dental plaque. In contrast, Badersten et al. (1975) found no difference in "de novo" plaque accumulation between a 4-day period of tongue brushing and a 4-day period of no oral hygiene procedures. The authors suggested that the majority of the important plaque-forming bacteria might not originate from the tongue. Another reason for not finding an effect of tongue brushing on plaque formation might be that brushing the posterior part of the dorsum of the tongue is difficult due to inaccessibility and discomfort. A recent systematic review evaluated tooth brushing versus tooth brushing plus tongue cleaning. Combining tooth brushing with tongue cleaning significantly reduced tongue coating; however, there appeared to be insufficient evidence to recommend frequency, duration, or delivery method of tongue cleaning (Kuo et al. 2013).

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Contribution of dentifrices to mechanical effect

The use of a toothbrush is usually combined with a dentifrice (sold as toothpaste), with the intention of facilitating plaque removal and applying agents to the tooth surfaces for therapeutic or preventive reasons. Traditionally, it was believed that dentifrices should contain an abrasive. The addition of abrasives supposedly facilitated plaque and stain removal. As early as 1967 Bergenholtz et al. (1967) reported that brushing without dentifrice was more efficient than similar brushing with dentifrice. In a study by Creeth et al. (2009), the use of 1.5 g of dentifrice showed no additional effect after 1 min of brushing compared to brushing without dentifrice. Paraskevas et al. (2006) also studied whether dentifrice has a beneficial effect on plaque removal and whether an abrasive additive was a contributor. Their results showed that among 40 subjects using three different hydrated, silica-based dentifrices in a crossover study, the difference in abrasiveness (RDA=80 and RDA=200) did not play a role in plaque removal. Moreover, significantly more plaque (3%) was removed when the brushing procedure was performed without dentifrice. In another study by Paraskevas et al. (2007), a significant 6% difference was observed, whereby the group that used dentifrice removed less plaque compared to the group that did not use dentifrice. Furthermore, in a study by Jayakumar et al. (2010), a 9% difference in plaque removal, in favour of the non-dentifrice group, was observed. The results of a recent study by Rosema et al. (2013) showed a difference in plaque removal of 2% in favour of the non-dentifrice group. Although this difference in plaque score reduction did not reach the level of significance, it is noteworthy that the use of dentifrice did not seem to increase the amount of "instant" plaque removal (that is, the immediate effect of brushing, as opposed to prolonged effects beyond the brushing exercise), similar to the conclusions of the above-mentioned studies. These results are also supported by a report from the American Dental Association (ADA) Division of Science (ADA 2001), which accepts that "*plaque removal is minimally associated with abrasives*." The effectiveness of plaque removal during tooth brushing with dentifrice appears to be essentially a function of the access of brush filaments, rather than dentifrice abrasives (Creeth et al. 2009). Dentifrice is, however, able to carry a multitude of different chemotherapeutic ingredients. Fluoride toothpaste is the most widespread and significant form of fluoride used globally and the most rigorously evaluated vehicle for fluoride use (Benzian et al. 2012).

Limitations

With respect to manual toothbrushes, no systematically collected evidence is available with respect to gingivitis.

There are more features related to mechanical plaque control such as duration of brushing, force and dentifrice use, etc. for which no systematic reviews were identified. This should be a direction of further research.

None of the reviews reported on the relative costs of using manual or powered toothbrushes.

The outcome of this synopsis is currently limited by its reliance on review papers. In practice, this means that primary studies that may have identified outcomes beyond those reported in the review literature have not been included.

The heterogeneity found in each of these systematic reviews highlights the challenge of clinical research in this area. The conclusions are limited by quality and degree of heterogeneity in the original studies. For example, there were many ways used to measure the outcomes of plaque and gingivitis.

The impact of bacteraemia following tooth brushing as observed by Tomás et al. (2011) on general health currently is lacking.

With respect to disease transmission, the orifice of the dentifrice tube can also contribute as a source of (cross)-contamination which was not assessed in the included review.

Conclusion

This systematic meta-review has identified a substantial body of knowledge. Having carefully considered the evidence emerging from the included systematic reviews the following conclusion can be drawn from this meta-review.

There is moderate evidence that a single oral hygiene instruction describing the use of a mechanical toothbrush in addition to a single professional "prophylaxis" had a small positive effect on the reduction of gingivitis. With respect to manual toothbrushes, no systematically collected evidence is available with respect to gingivitis. With respect to plaque scores, there is strong evidence that the overall treatment effect of a manual brushing exercise was estimated as a weighted mean difference of ±42% between pre- and post brushing. Similarly, there was also strong evidence for power toothbrushes where the estimated effect as a weighted mean difference of approximately 46% plaque reduction following a brushing exercise. In the comparison manual *versus* power toothbrushes, there is strong evidence that powered toothbrushes reduce plaque and gingivitis more than manual tooth brushing both in the short and long term. At present, there is limited evidence that oscillating–rotating brushes reduce plaque and gingivitis more than side-to-side brushes in the short term. The superiority of any other mode of powered brushing has not been established. Further research is required before evidence-based advice concerning the relative performance of the different powered toothbrushes can be given by health care professionals to the public.

There is circumstantial evidence that the oral use of a toothbrush can lead to adverse events, such as gingival traumatic injury and seizures, as well as to serious adverse events, such as ingestion, impaction and instant trauma. Given the large number of toothbrushes that are used worldwide, the occurrence of these events can be classified as incidental. There is strong but inconclusive evidence to support or refute the association between tooth brushing and gingival recession.

Comparing manual versus power toothbrushes, there was no apparent relationship with toothbrush use and soft tissue trauma. There is limited although strong evidence that

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gingival recession was not significantly different between manual and oscillating–rotating toothbrush groups with safety as a primary outcome. A large body of published research providing indirect although strong evidence with safety as secondary outcome has consistently shown oscillating–rotating toothbrushes to be safe compared to manual toothbrushes, demonstrating that these power toothbrushes do not pose a clinically relevant concern to hard or soft tissues. There is a limited level of evidence that toothbrushes of healthy and oral diseased adults become contaminated with pathogenic bacteria from the dental plaque, design, environment or a combination of factors. However, the impact of this observation on disease transmission remains unclear. There are also various aspect of mechanical plaque control that affect efficacy which have currently not been systematically evaluated.

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Clinical relevance

Scientific rationale for the study: Removing dental plaque is important for maintaining oral health. Tooth brushing is generally accepted as the most efficient oral hygiene method of cleaning one's teeth. For this purpose, manual and power toothbrushes are available. From a professional perspective dental care professionals need to assist their patient in long-term maintenance of their oral health and therefore need to advise them (evidence based) whether certain efforts or specific products are worthy of their investment. Over the last two decades, various systematic reviews have been published in relation to oral hygiene interventions which provide a comprehensive summary of all primary evidence that could be retrieved from individual studies relevant to a particular focused question. A synopsis of synthesis summarizes these findings and implications of these systematic reviews in a meta-review.

Principle findings: This meta-review identified a substantial body of know-
ledge related to mechanical plaque control. Tooth brushing instruction has a small but significant effect on

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plaque scores and oral health. The overall treatment effect of a brushing exercise is estimated as a 42% and 46% reduction in plaque index scores from baseline for manual and power brushing respectively. Power toothbrushes reduce plaque and gingivitis more than manual toothbrushes. The greatest body of evidence is available for oscillating–rotating power toothbrushes. Whether the brush has a replaceable battery or rechargeable power source may also be important. The use of a toothbrush may cause adverse/side effects which on average are localized and transient. The relationship of tooth brushing and gingival recession remains unclear.

Practical Implications: In adults with gingivitis, the quality of self-performed mechanical plaque removal is not sufficiently effective and could be improved. In addition, there is room for improvement in the efficacy of toothbrushes in their capability of reducing plaque score during a brushing exercise. Power toothbrushes provide a benefit over manual toothbrushes. The value of this for long-term dental health remains unclear.

Limitation: Because of heterogeneity of the included systematic reviews, such as their aims and methods of recording and reporting a sophisticated level of data combination and analysis was neither possible nor indicated. A meta-analysis was therefore not undertaken.

Further research: A systematic evaluation considering the effect of tooth brushing on oral health currently is lacking. More aspects of mechanical plaque control which affect efficacy deserve to be systematically evaluated. The impact of toothbrush contamination on disease transmission needs to be studied.

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