

Efficacy of inter-dental mechanical plaque control in managing gingivitis – a meta-review

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Abstract

Focused question: What is the effect of mechanical inter-dental plaque removal in addition to toothbrushing, on managing gingivitis using various formats of inter-dental self-care in adults based on evidence gathered from existing systematic reviews?

Material & Methods: Three Internet sources were searched by a strategy designed to include systematic reviews on inter-dental cleaning devices. Plaque and gingivitis scores were the primary parameters of interest. Characteristics of selected papers were extracted. The potential risk of bias was estimated and the acquired evidence was graded.

Results: Screening of 395 papers resulted in six systematic reviews. Two papers evaluated the efficacy of dental floss, two of inter-dental brushes (IDB), one of woodsticks and one of the oral irrigator. Weak evidence of unclear or small magnitude was retrieved that supported dental floss, woodsticks and the oral irrigator to reduce gingivitis in addition to toothbrushing. No concomitant evidence for an effect on plaque emerged. There is moderate evidence that IDBs in combination with toothbrushing reduce both plaque and gingivitis.

Conclusion: Evidence suggests that inter-dental cleaning with IDBs is the most effective method for inter-dental plaque removal. The majority of available studies fail to demonstrate that flossing is generally effective in plaque removal. All investigated devices for inter-dental self-care seem to support the management of gingivitis, however, to a varying extend.

Key words: dental plaque; floss; gingivitis; inter-dental brushes; Inter-dental cleaning; meta-review; systematic review

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Oral cleanliness is important for the preservation of oral health as it removes microbial plaque, preventing it from accumulating on teeth and gingivae (Choo et al. 2001). As a point of principle, it is reasonable

to state that achieving ideal plaque control by toothbrushing, 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, Lang et al. 1973). The rationale for considering inter-dental cleaning as a separate item is related to the fact that toothbrushing does not efficiently reach into the inter-dental areas between adjacent teeth resulting in parts of the teeth that remain

Conflict of interest and source of funding statement

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Ethical approval was not required.

Dörfer, Slot and Van der Weijden have formerly received either external advisor fees, lecturer fees or research grants from companies that produce interdental cleaning devices. Among these were Colgate, Dentaïd, GABA, Lactona, Oral-B, Philips, Procter & Gamble, Sara Lee, Sunstar, and Unilever.

unclean. The reason for this is that the inter-dental gingiva fills the embrasure between two teeth apical to their contact point. This is a “sheltered” area, which is difficult to access when the teeth are in their normal position. The inter-dental area, when exposed by initial inflammation of the papillae, presents local conditions, which permit the establishment and maturation of bacterial plaque. This favours periodontal disease, for which an effective inter-dental hygiene helps to reduce the extension and severity (Sicilia et al. 2002). Traditionally, self-care recommendations for inter-dental cleaning most commonly have consisted of flossing (ADA 2014), which is probably the most universally applicable method. However, the inter-dental brush was found to have an excellent effect both on the central part of the inter-dental space and on the embrasures and may remove plaque as far as 2–2.5 mm below the gingival margin (Waerhaug 1976). The choice of the type of technique must, however, be made in relation to the characteristics of the inter-dental spaces whether they are open or closed (Sicilia et al. 2003).

Today numerous inter-dental cleaning devices on the market help patients’ self-care needs. The plethora of products makes it difficult for patients to decide themselves, which is the appropriate device. But also for the dental professional, it can be challenging to give individualized recommendations to patients about the appropriate selection and use of these devices. Patient preferences and the expected likelihood of using the inter-dental cleaning product is one aspect to consider. Another is the knowledge about the evidence specific to each device and the expected results from using the device. An ideal inter-dental cleaning device should be user friendly, remove plaque effectively and have no deleterious soft-tissue or hard-tissue effects. However, not all inter-dental cleaning devices suit all patients, all types of dentitions and even not every inter-dental space. The dental professional should, therefore, navigate the patient to the optimal devices tailored to their specific needs. Good inter-dental oral hygiene requires a device that can penetrate between adjacent teeth

(Van der Weijden & Slot 2011), and thereby touching as much of the exposed surface as possible.

Dental professionals have choices and make decisions everyday as they provide care for patients (Suvan & D’Aiuto 2008). Success in delivering evidence-based health care advice 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. The model to guide a clinical decision begins with original single studies at the foundation. Evidence-based research methodologies integrate the best available evidence from original individual studies as its foundation and help synthesize evidence for the reader. The synthesis (or systematic review) is a comprehensive summary of all the research evidence related to a focused clinical question (Shea et al. 2007). By combining the results from many trials, it has more power to detect small but clinically significant effects and is a more advanced information service in the topic area of concern (Walker et al. 2008). At the next level, a synopsis summarizes the findings of systematic reviews and can often provide sufficient information to support the clinical action that matches the patient’s specific circumstances (Dicenso et al. 2009). Such a meta-review or “overview of reviews” is a systematic review that includes only systematic reviews, and is suitable whenever relevant systematic reviews are available (Sarrami-Forushani et al. 2014). Evidence-based research methodologies do not provide answers, but rather, they are a tool, a form of information and guidance based on research evidence that assists the clinician in formulating the answer appropriate for each individual patient (Suvan & D’Aiuto 2008).

The purpose of the present meta-review was to summarize and appraise the evidence emerging from systematic reviews on the efficacy of various inter-dental devices for mechanical plaque control in managing gingivitis.

Material and Methods

The protocol of this meta-review detailing the evaluation method was developed “a priori” following initial

discussion between members of the research team. This work complies with PRISMA (2014) guidelines for reporting systematic reviews.

Focused question

What is the effect of mechanical inter-dental plaque removal in addition to tooth brushing, on managing gingivitis using various formats of inter-dental self-care in adults based on evidence gathered from existing systematic reviews?

Search strategy

For the comprehensive search strategy, electronic databases were queried. 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 evidence database of the ADA Center for Evidence-based Dentistry regarding home care products in the preventive dentistry category. All three databases were searched for eligible studies up to and including August 2014. The structured search strategy was designed to include any systematic review published on inter-dental cleaning devices. For details regarding the search terms used, see Box 1. All of the reference lists of the selected studies were hand searched for additional published work that could possibly meet the eligibility criteria of the study. The PROSPERO (2014) database, an international database of prospectively registered systematic reviews, was checked for reviews in progress. Further unpublished work was not sought.

Inclusion and exclusion criteria

The *inclusion criteria* were as follows:

- Systematic reviews with or without a meta-analysis
- Papers written in the English, German, French or Dutch language
- Reviews evaluating studies conducted in humans
 - ≥18 years old
 - In good general health

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 inter-dental cleaning devices:

{[MeSH terms] (Home Care Dental Devices) OR [text words] floss OR (Dental floss) OR Flossing OR Tape OR (Dental tape) OR Superfloss OR Ultrafloss OR (Interdental cleaning devices) OR (Interproximal cleaning devices) OR (Interspace cleaning devices) OR toothpick* OR woodstick* OR woodpoint* OR (wooden interdental cleaner) OR (wedge stimulator*) OR (wooden stimulator*) OR (rubber interdental stimulator) OR (interdental stimulator) OR (gingival stimulator) OR (interproximal brushing) OR (interproximal brushes) OR (interproximal brush) OR (interproximal brush*) OR (interproximal cleaning devices) OR (interdental brushing) OR (interdental brushes) OR (interdental brush) OR (interdental brush*) OR proxabrush OR (interspace brushes) OR (interspace brush) OR (interspace brush*) OR (interspace brushing) OR proxabrush OR (dental water jet) OR (water pick) OR (water pik) OR waterpik OR (perio pik) OR (pick pocket) OR pickpocket OR (pik pocket) OR (oral irrigation) OR (oral irrigator) OR (oral irrigation jet) OR (water jet irrigator) OR (monojet oral irrigator) OR (subgingival irrigation) OR (subgingival tip) OR (dental irrigator) OR (dental irrigation) OR airfloss OR softpick OR softpik OR (power interdental cleaning) OR (electric interdental cleaning) OR (mechanical interdental cleaning); Used filter/limits: systematic review OR meta-analysis

The asterisk (*) was used as a truncation symbol.

- Intervention: inter-dental self-care products for controlling plaque and/or managing gingivitis.

The *exclusion criteria* were as follows:

- Orthodontic patients
- Dental implants

At the outset of this meta-review, no attempt was made to separate specific variables associated with inter-dental cleaning.

Screening and selection

Two reviewers (DES & SS) independently screened the titles and abstracts for eligible papers. If eligibility aspects were present in the title, the paper was selected for further reading. If none of the eligibility aspects were mentioned in the title, the abstract was read in detail to screen for suitability. After selection, the full-text papers were read in detail by two reviewers (DES & SS). Any disagreement between the two reviewers was resolved after additional discussion. The papers that fulfilled all of the selection criteria were processed for data extraction.

Assessment of heterogeneity

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

- Study and subject characteristics

- Methodological heterogeneity (variability in study design and risk of bias)
- Analysis performed (Descriptive or Meta-analysis).

Quality assessment

Two reviewers (DES & SS) 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 (2014) guideline for reporting systematic reviews and the (AMSTAR 2014) 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 items an overall score of 100% 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: 0–40% may represent a high risk of bias; 40–60% may represent a substantial risk of bias; 60–80% may represent a moderate risk of bias 80–100% a low risk of bias.

Data extraction

Information extracted from the studies included publication details, focused question, search results, descriptive or (weighted) mean outcomes and conclusions. Disagreements between the reviewers (DES & SS) were resolved by discussion.

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 (GRADE 2014). 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 & selection results

The searches resulted in 395 unique papers (for details, see Fig. 1) out of which six full-text articles were obtained and screened to confirm eligibility. Hand searching of the reference lists did not reveal any additional suitable systematic reviews. Neither did the PROSPERO database (2014). As a result, a final six studies were selected to be included in this meta-review, out of which two papers were identified which evaluated the efficacy of dental floss, two papers on interdental brushes, one on woodsticks and one evaluating the oral irrigator.

Assessment of heterogeneity

Considerable heterogeneity was observed in the six systematic

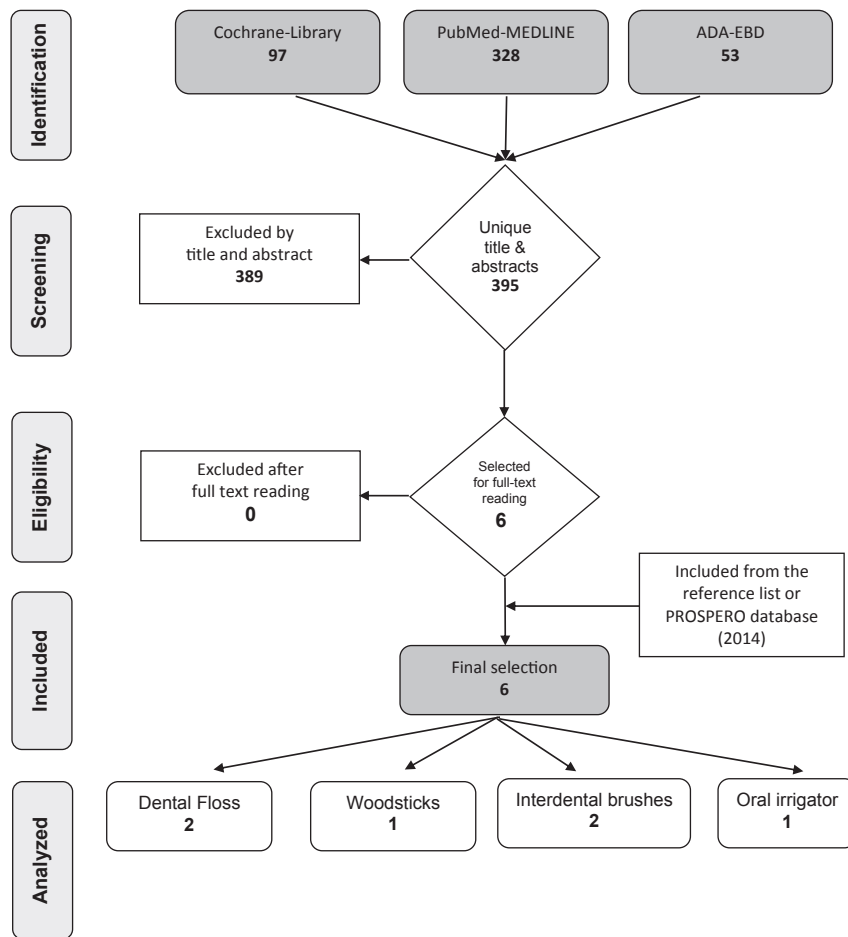


Fig. 1. Search and selection results.

reviews with respect to the databases searched, study and subject characteristics of the original individual papers description of inclusion and exclusion criteria, quality assessment scale used, reporting of effect scores, presence of meta-analysis and conclusions made. Information regarding the included papers is displayed in detail in Table 1. Various clinical indices and their modifications have been evaluated.

Quality assessment

Estimation of the risk of bias by scores related to the reporting and methodological quality of the included systematic reviews is presented in Table 2. Four reviews were considered to have a moderate estimated potential risk of bias (Berchier et al. 2008, Hoenderdos et al. 2008, Hussein et al. 2008, Slot et al. 2008). Two more recent Cochrane reviews had a low estimated risk of bias (Sambunjak et al. 2011, Poklepovic

et al. 2013). Critical items in this evaluation were found to be the development of a protocol “a priori” and its registration, searches in additional sources including non-English literature, contacting of authors of included papers for additional information, grading obtained evidence and the assessment of publication bias.

Study outcomes results

Table 1 shows the results from the data extraction. The conclusion of the original review authors and the comments of the authors of this synopsis together with a descriptive summary are presented for each inter-dental device.

Dental floss

Berchier et al. (2008) evaluated the effect of flossing as an adjunct to toothbrushing. Independent screening of titles and abstracts resulted in 11 publications that met the eligibil-

ity criteria. The majority of these studies showed that there was no benefit from floss on plaque scores (7 of 10 studies) and no effect on clinical parameters of gingivitis (8 of 8 studies). From the collective data of the studies, it appeared possible to perform a meta-analysis evaluating plaque and gingival index scores. Baseline scores were not statistically different. Comparing toothbrushing and flossing against toothbrushing only, the Quigley & Hein plaque index (Quigley & Hein 1962) weighted mean difference (WMD) was -0.04 (95% CI: -0.12 ; 0.04 , $p = 0.39$) and the Löe & Silness gingival index (Löe & Silness 1963). WMD was -0.08 (95% CI: -0.16 ; 0.00 , $p = 0.06$). End scores also showed no significant differences between those groups that flossed in comparison with those that did not floss for the Quigley & Hein plaque (WMD: -0.24 , 95% CI: -0.53 ; 0.04 , $p = 0.09$) or Löe & Silness gingival Index (WMD: -0.04 , 95% CI: -0.08 ; 0.00 , $p = 0.06$).

More recently, also the Cochrane Oral Health group evaluated the effects of flossing in combination with toothbrushing, as compared with toothbrushing alone, in the management of periodontal diseases in adults (Sambunjak et al. 2011). Twelve trials were included in this review, with a total of 582 participants in the flossing plus toothbrushing (intervention) groups and 501 participants in toothbrushing (control) groups. All included trials reported the outcomes of plaque and gingivitis. Seven of the included trials were estimated as having an unclear risk of bias and five were considered to have a high risk of bias. 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 gingivitis, there seems to be some evidence that flossing in combination with toothbrushing provides a statistically significant benefit in reducing gingivitis compared with toothbrushing alone. To help interpret the magnitude of the effect, the data retrieved by different indices were standardized in translating them back to the most commonly reported gingivitis index. The 1-month SMD estimate back translates

Table 1. Overview of the characteristics of the included systematic reviews processed for data extraction

Device	ID Author (year)	Databases searched Up to	Number of included studies/trials # participants	Mode of analysis (methodology of meta-analysis, descriptive analysis)	Original review authors' conclusions	COMMENTS of the synopsis authors
Dental Floss	Berchier et al. 2008	PubMed-Medline Cochrane CENTRAL December 2007	11 studies 559* participants	Meta-analysis Weighted Mean Difference Descriptive analysis with vote counting	The dental professional should determine, on an individual patient basis, whether high-quality flossing is an achievable goal. In light of the results of this comprehensive literature search and critical analysis, it is concluded that a routine instruction to use floss is not supported by scientific evidence.	Two included studies reported the same experiment, however, with two different observational periods.
	Sambunjak et al. 2011	Ovid-Medline OVID-EMBASE Cochrane CENTRAL Cochrane OHG trails LILAC-BIREME CINAHL-EBSCO ZETOC Web of science mRCT clinicaltrials.gov October 2011	12 trials 1083 participants	Meta-analysis Standardized Mean Difference	There is some evidence from 12 studies that flossing in addition to toothbrushing reduces gingivitis compared to toothbrushing alone. There is weak, very unreliable evidence from 10 studies that flossing plus toothbrushing may be associated with a small reduction in plaque at 1 and 3 months. No studies reported the effectiveness of flossing plus toothbrushing for preventing dental caries.	Two studies included a control group using a 5% hydro alcohol. One study included an intervention group using a hummingbird power flosser which is not dental floss but a rubber stimulator.
Woodsticks	Hoenderdos et al. 2008	PubMed-Medline Cochrane CENTRAL February 2008	8 experiments 438* participants	Descriptive analysis with vote counting	Evidence from controlled trials, most of which were also randomized, shows that woodsticks do not have an additional effect on visible inter-dental plaque or gingival index, but do, however, provide an improvement in inter-dental gingival inflammation by reducing the bleeding tendency.	No statistical analysis could be performed. Only triangular woodstick were evaluated.

Table 1. (continued)

Device	ID Author (year)	Databases searched Up to	Number of included studies/trials # participants	Mode of analysis (methodology of meta-analysis, descriptive analysis)	Original review authors' conclusions	COMMENTS of the synopsis authors
Inter-dental Brushes	Slot et al. 2008	PubMed-Medline Cochrane CENTRAL November 2007	9 experiments 510* participants	Meta-analysis Weighted Mean Difference Descriptive analysis with vote counting	As an adjunct to brushing, the inter-dental brush removes more dental plaque than brushing alone. Studies showed a positive significant difference using inter-dental brush with respect to the plaque scores, bleeding scores and probing pocket depth. The majority of the studies presented a positive significant difference in the plaque index when using the inter-dental brush compared with floss.	No subanalysis provide based on the shape of the inter-dental brush
	Poklepovic et al. 2013	Ovid-Medline OVID-EMBASE Cochrane CENTRAL Cochrane OHG trails LILAC-BIREME CINAHL-EBSCO ZETOC Web of science mRCT clinicaltrials.gov March 2013	7 trials 354 participants	Meta-analysis Standardized Mean Difference	Only one study looked at whether toothbrushing with inter-dental brushing was better than toothbrushing alone, and there was very low-quality evidence for a reduction in gingivitis and plaque at 1 month. There is also low-quality evidence from seven studies that inter-dental brushing reduces gingivitis when compared with flossing, but these results were only found at 1 month. There was insufficient evidence to determine whether inter-dental brushing reduced or increased levels of plaque when compared to flossing.	One included study concerns brush picks, which is not an inter-dental brushes but a plastic toothpick with plastic filaments
Oral Irrigator	Husseini et al. 2008	PubMed-Medline Cochrane CENTRAL January 2008	7 experiments 590* participants	Descriptive analysis with vote counting	As an adjunct to brushing, the oral irrigator does not have a beneficial effect in reducing visible plaque. However, there is a positive trend in favour of oral irrigation improving gingival health over regular oral hygiene or toothbrushing only.	No differentiation between different oral irrigator technologies was made.

* Calculated by the review authors.

Table 2. 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)	Berchier et al. 2008	Sambunjak et al. 2011	Hoenderdos et al. 2008	Slot et al. 2008	Popklevic et al. 2013	Husseini et al. 2008
Interdental oral hygiene device		Dental Floss	Dental Floss	Woodsticks	Interdental brush	Interdental brush	Oral Irrigator
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		NA	+	NA	NA	+	NA
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		-	+	-	-	+	-
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		+	+	-	+	+	-
20) Performed a descriptive analysis		+	±	+	+	±	+
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	Weak, very unreliable	Not reported	Not reported	Very low quality	Not reported
Synopsis authors estimated quality score		62%	96%	62%	65%	96%	62%
Synopsis authors estimated risk of bias		moderate	low	moderate	moderate	low	moderate

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 (Hidding et al. 2014). NA = not applicable.

For the quality assessment score individual items with a positive rating were summed to obtain an overall percentage score.

Table 3. Estimated evidence profile (GRADE 2014) for the effect of various methods and aspects of inter-dental mechanical plaque removal

GRADE	Floss	Woodstick	Inter-dental Brushes	Oral Irrigator
Study designs	Systematic review <i>N</i> = 2	Systematic review <i>N</i> = 1	Systematic review <i>N</i> = 2	Systematic review <i>N</i> = 1
Reporting and methodological estimated potential risk of bias	Low to Moderate	Moderate	Low to Moderate	Moderate
Consistency	Inconsistent	Fairly consistent	Fairly consistent	Fairly consistent
Directness	Direct	Direct	Direct	Direct
Precision	Precise	Imprecise	Precise	Imprecise
Publication bias	Possible	Possible	Possible	Possible
Magnitude of the effect	Small	Unclear	Large	Unclear
Body of evidence	Weak	Weak	Moderate	Weak

to a 0.13-point reduction on a 0- to 3-point scale for Löe & Silness gingivitis index (1964), and the 3- and 6-month results translate to a 0.20 and 0.09 reduction respectively. Although the differences are statistically significant, the difference is minor which questions the clinical relevance even more when considering the very low level of evidence.

Woodsticks

Hoenderdos et al. (2008) evaluated the effect of woodsticks in combination with toothbrushing. After screening by title and abstract 15 papers were selected for full-text reading of which 10 papers had to be excluded. Three additional papers were retrieved from the reference lists. After full-text reading, seven publications with eight clinical experiments met the eligibility criteria and provided data. No meta-analysis could be performed. In their qualitative summary in nine of 10 studies that scored plaque no significant advantage was demonstrated with respect to the use of woodsticks in combination with toothbrushing, as opposed to toothbrushing alone. However, in three of three studies reporting gingivitis data, they observed a statistically significant improvement in inter-dental gingival inflammation by a reduced tendency of bleeding upon probing by the use of triangular woodsticks.

Inter-dental brushes

The term “inter-dental brush” was used for brushes with a helical alignment of filaments fixed to a twisted central wire. The filaments may vary in lengths and, therefore, form cylin-

drical, conical or other shapes of inter-dental brushes. Synonyms used in different countries are “interproximal brush” or “mini-inter-dental brush”. There may be even more. However, single tufted brushes and inter-dental cleaning devices without a twisted wire as stem were not regarded as inter-dental brushes and not taken into account. Slot et al. (2008) evaluated the differences between inter-dental brushes and various intervention strategies in a systematic review. All three studies that evaluated inter-dental brushes as an adjunct to toothbrushing showed a significant difference in favour of the additional use of inter-dental brushes for plaque removal as compared to brushing alone. The majority (8 of 13 studies) of the studies showed a positive significant difference on the plaque index when using inter-dental brushes relative to floss. No clear benefits over toothbrushing alone with regard to the gingival index (1 of 5 studies) or bleeding indices (0 of 6 studies) were observed. Inter-dental brushes remove more dental plaque than woodsticks, as shown by one of the two comparative studies. From the collective data of the studies, a meta-analysis appeared to be possible for the comparison of inter-dental brushes to floss as adjuncts to manual toothbrushing. In all instances, there was no statistically significant difference for the baseline scores. End scores only showed a significant effect when evaluated according to the Silness & Löe plaque index (1964) in favour of the inter-dental brush group relative to the floss group (WMD: -0.48, 95% CI: -0.65; -0.32, $p < 0.00001$). Comparisons using

other indices (Quigley & Hein plaque index (1962), bleeding on probing) were not statistically significant. The heterogeneity observed with the Silness & Löe plaque index ($p = 0.001$, $I^2 = 85.4\%$) reflects the different behaviours of the study populations to the study product, differences in study designs and other factors that may have influenced the outcome. Slot et al. (2008) showed that inter-dental brushes are a useful device to complement toothbrushing. The evidence suggests that inter-dental brushing is the most effective method to interdentally remove plaque.

More recently also the Cochrane Oral Health group evaluated the effect of inter-dental brushing in addition to toothbrushing, as compared with toothbrushing alone (Poklepovic et al. 2013). Only one study with an estimated high risk of bias was retrieved that looked at this comparison. The low-quality evidence that emerged from this review, which was evaluated in a meta-analysis using a statistical approach with the standard mean difference (SMD), showed a significant reduction in plaque and gingivitis. Back translating the SMD outcome, the authors concluded that this represents a 34% reduction in gingivitis and a 32% reduction in plaque. Seven selected studies provided data on inter-dental brushing in addition to toothbrushing, as compared with toothbrushing and flossing showing a reduction in gingivitis in favour of inter-dental brushing at 1 month: This translated to a 52% reduction in gingivitis (Eastman Inter-dental Bleeding Index (Caton & Polson 1985). Although a high effect size in the

same direction was observed at 3 months, the confidence interval of the meta-analysis did not exclude the possibility of no difference. There was insufficient evidence to claim a benefit for inter-dental brushing over flossing for reducing plaque.

Oral irrigator

Husseini et al. (2008) performed a systematic review on the efficacy of oral irrigation in addition to toothbrushing. Screening of 813 titles and abstracts initially resulted in 27 full-text papers. In total, 20 studies were excluded, searching the reference lists of the selected studies resulted in no new papers. Consequently, seven studies were identified as eligible for inclusion in this review according to defined eligibility criteria. Due to their heterogeneity, the data prevented quantitative analysis, and a descriptive analysis of the selected studies was presented. Six of seven selected studies showed no differences between toothbrushing in combination with the use of an oral irrigator and toothbrushing or regular oral hygiene. One study provided inconclusive data. Three of five studies that presented data on bleeding scores showed significant reductions in the oral irrigator group compared to the control oral hygiene group. When focusing of the comparison with regular oral hygiene three of three showed a significant beneficial effect. For gingivitis, this was three of four studies. The authors concluded that as an adjunct to brushing, the oral irrigator provides a positive trend in favour of oral irrigation improving gingival health over regular oral hygiene.

Grading the "body of evidence"

The evidence which emerges from this systematic meta-review indicates that there is moderate evidence to support the efficacy of inter-dental brushes on plaque removal and reduction of gingivitis (table 3). There is weak evidence supporting the use of dental floss, woodsticks and the oral irrigator.

Discussion

The human oral cavity contains microorganisms in the form of biofilms which are matrix-enclosed

bacterial populations that adhere organisms together and adhere to surfaces or interfaces. A bacterial biofilm is the common cause of a number of human diseases. Recently, an enormous increase in knowledge about the complexity and the tenaciousness of the oral biofilm as well as on its essential role in maintaining oral health has been demonstrated (Marsh 2000). Although the biofilm appearance depends upon the conditions of the host, it also varies between specific sites. What is in common is the need for mechanical removal, however, not with the simple aim of complete removal but more a sense of cultivating and shaping the oral biofilm and supporting the bacterial haemostasis (Marsh et al. 2011). In the inter-dental space, the access to the colonized surfaces is crucial for the success of the preventive measure. One of the challenges of measuring the efficacy of inter-dental cleaning aids is that these sites are not directly visible in their full extension and – in addition to the general shortcomings of measuring intra-oral plaque removal clinically – evaluations have to rely on areas being the margin of the inter-dental space only.

Following the idea of evidence-based dentistry, the highest degree of scientific evidence is the presence of a systematic review. Emphasizing the necessity for high evidence resulted in an increasing number of systematic reviews, often on the same or similar subjects. However, the evidence of a systematic review depends on the quality of the studies, which were reviewed, a fact, which is often not discussed in systematic reviews, as the quality is primarily related to the rigidity of methodology to minimize bias. In the case of no new data to review, it is, therefore, helpful to make a synopsis of the systematic reviews already published instead of re-reviewing the same published data with the same methodology. Recently, a structured procedure, similar to the methodology of a systematic review (Sarrami-Foroushani et al. 2014), was developed to evaluate and embrace already published systematic reviews and to help the reader to understand the strengths and limitations of such publications. This next step, known as a meta-review, is necessary in the

presence of an inflationary increase of systematic reviews and gives the dental community better guidance. It is in that sense a step forward in the direction of a clinical guideline.

Toothbrushing is successful in removing plaque at buccal, lingual and occlusal surfaces, but does not reach the inter-dental areas of teeth, resulting in parts of the teeth that remain unclean. Good inter-dental oral hygiene requires a device that can penetrate between adjacent teeth (van der Weijden & Slot 2011). The current meta-review intended to evaluate various inter-dental oral hygiene products with the goal to provide guidance for clinical decision making.

Dental floss

Based on the individual papers as retrieved in the review by Berchier et al. (2008), a trend was observed that indicated a beneficial adjunctive effect of floss on plaque levels. However, this could not be substantiated in the meta-analyses. Routine recommendation to use floss was not considered to be supported by scientific evidence. More recently, Sambunjak et al. (2011) in their Cochrane review found that in terms of reducing gingival inflammation, flossing plus toothbrushing showed a statistically significant benefit compared to toothbrushing alone. Harms and adverse effects were reported in five studies. The most frequent harm identified was soft tissue/gingival trauma, a reversible event. Most patients would avoid flossing in traumatized areas and the areas would heal. The desirable benefits of flossing in reducing gingivitis seem to outweigh the potential harms. However, grading the evidence it was determined to be of very low quality. It implies that the evidence flossing to effectively reduce gingivitis is very low and the evidence to suggest that flossing reduces plaque is unreliable (Matthews 2012). The Cochrane review agreed with the Berchier et al. (2008) findings with respect to plaque removal. However, it found a small but statistically significant benefit for flossing in reducing gingivitis. Both systematic reviews (Berchier et al. 2008, Sambunjak et al. 2011) had seven of the 12 articles in common and one study was common in the meta-analysis.

Different outcomes would be expected with different studies included (Bowen 2012). Sambunjak et al. (2011) used a broader study selection and included two studies with a control group using a 5% hydro alcohol and one study that included as intervention the hummingbird power flosser. This is, in fact, not a string of dental floss but a motorized rubber inter-dental stimulator. The differences between the two systematic reviews, therefore, may be explained by the different study selection and the more positive valuation of the more recent systematic review does not necessarily relativize the conclusion of the Berchier systematic review with respect to the use of dental floss in the more common understanding.

That dental floss has limited additional effects as adjunct to toothbrushing is apparent from more than one review. Hujuel et al. (2006) found that flossing was only effective in reducing the risk of interproximal caries when applied professionally. This absence of evidence on caries reduction was substantiated by Sambunjak et al. (2011). Although the systematic reviews did not strongly support flossing as a useful periodontal self-care adjunct, the very low evidence for the efficacy, however, does not preclude the use of floss. For instance, in inter-dental situations that only allow for the penetration of a string of dental floss, floss is the best available tool. Although floss should not be the first tool recommended for cleaning open inter-dental spaces, if the patient does not like any other tool, flossing could still be part of oral hygiene instruction. The dental professional should realize that proper instruction, sufficient motivation of the patient and a high level of dexterity are necessary to make the flossing effort worthwhile (Hujuel et al. 2006). Routine instruction in using floss is not supported by scientific evidence. The dental care professional should therefore determine, on an individual patient basis, whether high-quality flossing is an achievable goal.

Woodsticks

Woodsticks can be used effectively where sufficient inter-dental space is

available. When used on a dentition with a reduced but inflammation free periodontium, woodsticks depress the gingivae by up to 2 mm and, therefore, clean parts of the subgingival area (Morch & Waerhaug 1956). The systematic review by Høenderdos et al. (2008) focuses on the effectiveness of woodsticks as an adjunct to toothbrushing for plaque removal in adult patients. Data analysis revealed considerable heterogeneity in many aspects of the included studies and, therefore, a meta-analysis could not be carried out. Descriptive analysis indicated that hand-held triangular woodsticks do provide an improvement in inter-dental gingival inflammation by reducing the bleeding tendency. However, no evidence for a concomitant effect on visible inter-dental plaque was retrieved. Of the seven studies included for data abstraction, four were of a crossover design and four of a parallel arm. One study included both designs. The study sizes ranged from 10 to 161 subjects and control groups were toothbrushing only or either in combination with dental floss or inter-dental brush. The indices used for plaque and bleeding also differed between the studies. With the lack of correlation between the collected data, it is clear that more studies with larger numbers of subjects and study designs are needed to clarify the efficacy of woodsticks on plaque reduction and their effect on gingival inflammation. With the limited data within this review, it is difficult to draw a meaningful conclusion on the efficacy of woodsticks (Tucker 2009). The explanation suggested for reduction of bleeding scores but the lack of evidence of a concomitant effect on plaque scores is that the papillary area with the greatest inflammation corresponds to the middle of the inter-dental tissue (Walsh & Heckman 1985), which is not accessible for direct visualization. It was also suggested that bleeding following the use of woodsticks can be used to increase patient motivation and awareness of gingival health. Several studies have illustrated the clinical effectiveness of gingival self-assessment (Walsh et al. 1985). The presence of bleeding provides immediate feedback on the level of gingival health.

Inter-dental brush

The systematic review by Slot et al. (2008) highlights the effectiveness of inter-dental brushes as an adjunct to toothbrushing for plaque removal in adult patients. The evidence derived from this review supports recommendations by dental care professionals for their patients to use inter-dental brushes in addition to toothbrushing since it reduces dental plaque (Rasines 2009). The studies also presented a positive significant difference in the plaque index when using inter-dental brushes as compared to floss. Included studies, however, show that there was no difference in gingival inflammation or bleeding. Criteria for selecting adult patients varied throughout the studies. Health status was omitted in three studies, and health status was reported as "good general health" in six studies with no specific exclusion criteria. Although all studies included patients, who had inter-dental spaces that could accommodate use of an inter-dental brush, three studies did not report on the subjects' periodontal status. The diversity in selection of study subjects was considerable among these nine studies and may have affected the strength of the conclusions of the review (Gluch 2012). On the other hand, the sample size of the different trials can be considered large enough to allow identification of statistically and clinically significant differences (Rasines 2009).

More recently, in their Cochrane review, Poklepovic et al. (2013) retrieved with respect to inter-dental brushes seven studies (total 354 participants analysed). Only one of the included studies reported on the objective comparing toothbrushing with and without inter-dental brushing. The review found very low-quality evidence that inter-dental brushing plus toothbrushing is more beneficial than toothbrushing alone for gingivitis and plaque at 1 month. There was also low-quality evidence from seven studies that inter-dental brushing reduces gingivitis when compared with flossing, but these results were only found at 1 month. There was insufficient evidence to determine whether inter-dental brushing reduced or increased

levels of plaque when compared to flossing. Heterogeneity was substantial for both the gingivitis and plaque analyses probably due to methodological and clinical variability between the studies. One included study concerns brush picks which are not inter-dental brushes but a plastic toothpick with plastic filaments. The two systematic reviews on inter-dental brushes (Slot et al. 2008, Poklepovic et al. 2013) had five papers in common. The difference in selection was due to alternative inclusion criteria and it is recognized that different studies will provide different outcomes (Bowen 2012).

The result of a scanning electron microscopic study of fourteen inter-dental brushes showed that all products had an insufficient finish of bristle ends. It showed that inter-dental brushes have besides the beneficial effect a potential of a damaging the periodontal tissues which has however so far not been shown 'in vivo' (Reiter & Wetzel 1991).

A variety of IDB shapes and sizes are required in clinical practice to accommodate all inter-dental spaces. Schmage et al. (1999) assessed the relationship between the inter-dental space and the position of the teeth. Most of the inter-dental spaces in the anterior teeth are small and sized for the use of floss. Premolars and molars have larger inter-dental spaces and are accessible with inter-dental brushes. In addition, the main advantage of inter-dental brushes lies in their superiority in reaching inter-dental grooves or fissures, which can physically not be touched by any other inter-dental cleaning device. This morphological component had not been used in any of the studies published so far. This makes matching in the random assignment and a true comparison among products difficult; hence, the grouping of all inter-dental brushes into one category (Gluch 2012).

No systematic reviews were retrieved which appraised aspects that have been evaluated in individual studies such as angled or straight inter-dental brushes (Jordan et al. 2014), waist-shaped inter-dental brushes (Chongcharoen et al. 2012), hard or soft filaments (Wolff et al. 2006), durability (Hotta et al. 2004).

Oral irrigator

The oral irrigator is one of the oral hygiene aids developed to enhance the effectiveness of plaque control and to bring benefits for gingival health. Oral irrigators are designed to disturb and remove plaque and soft debris through the mechanical action of a stream of water. There has been considerable controversy regarding the appropriate use and efficacy of this instrument (van der Weijden & Slot 2011). Hussein et al. (2008) systematically reviewed the literature on the adjunctive effect of the oral irrigator in addition to toothbrushing on controlling plaque and bleeding index gingival inflammation and pocket probing depth. Unfortunately, the selected studies could not generate sufficient data to perform a meta-analysis. Despite these limitations, descriptive analysis suggests that the oral irrigator, as an adjunct to toothbrushing, does improve gingival health more than regular oral hygiene measures or toothbrushing alone, although no evidence for a beneficial effect in reducing visible plaque was retrieved. More recently, a 4-week study indicated that when combined with manual toothbrushing the daily use of an oral irrigator is significantly more effective in reducing gingival bleeding scores than is the use of dental floss (Rosema et al. 2011).

The exact mechanisms of action accounting for these observations remain unclear. Although oral irrigation does not generate a beneficial effect by reducing visible plaque, it may flush away only loosely adhered plaque and thus interfere with maturation of the microbial biofilm every day, therefore, and to some extent modifying its components virulence factors. Another possible effect is the mechanical action of a jet stream of water and its pulsations, which might reduce the levels of inflammatory mediators in the gingival crevice/pocket, and alter the gingival response to microbial challenge, thereby contributing to improved gingival homeostasis and health (Chaves et al. 1994, Flemmig et al. 1990, Frascella et al. 2000). It is also conceivable that any benefit of the oral irrigator in reducing inter-dental plaque may be undetectable clinically. Further well-designed RCTs are warranted to

research the effectiveness of the oral irrigator as an adjunct to regular oral hygiene measures for controlling the plaque biofilm and long-term maintenance of gingival health, to explore the mechanisms involved (Jin 2009).

The included systematic review on oral irrigators did not evaluate the specially designed blunt-ended cannulae (Pik Pocket® subgingival irrigation tip - WaterPik Technologies, Fort Collins, CO, USA).

Appraisal of the evidence

A meta-review is a systematic overview of reviews, in which an attempt is made to include all available systematic reviews and to undertake rigorous appraisal on each of the systematic reviews included (Sarrami-Foroushani et al. 2014). The list of appraisal criteria was based on a combination of items described by the PRISMA (2014) guideline for reporting systematic reviews and the AMSTAR (2014) checklist for assessing the methodological quality of systematic reviews. The outcome of the adapted checklist is presented in Table 2 which shows the estimated risk of bias to be 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 (2014) criteria were used indicating that there is moderate evidence in support of the efficacy of inter-dental brushes on plaque removal and reduction of gingivitis. There is weak evidence in supporting the use of dental floss, woodsticks and the oral irrigator.

Patient compliance

There is not one aid that works for all. There is also not one aid that does not work for anyone. Best care for each patient rests neither in clinician judgement nor scientific evidence but rather in the art of combining the two through interaction with the patient to find the best option for each individual (Suvan & D'Aiuto 2008). This meta-review provides a summary of the achievable efficacy of inter-dental oral hygiene devices adjunctive to brushing under the uniform conditions of a RCT. Due to the extreme variety in morphology, accessibility, individ-

ual skills and preferences, the results have to be translated to the unique conditions in daily practice. In general, to apply any evidence to clinical practice, communication with the patient, use of clinical judgment and common sense are key steps. Clinicians should collaborate with patients to determine the best oral hygiene methods given the patients' preferences and skill level. This is even more important in this topic, where patient acceptance is a major issue to be considered when it comes to the long-term use of inter-dental cleaning devices (Warren & Chater 1996). For instance, flossing has disadvantages, in that it is an additional expense, is time consuming and thus negatively influences the ability or desire of many patients to participate in this activity (Drisko 2013). When patient preferences are evaluated comparing inter-dental brushes and dental floss, patients preferred the inter-dental brushes. The inter-dental brushes were considered to be simpler to use, despite their tendency to bend, buckle and distort (Ishak & Watts 2007).

Inter-dental plaque assessment

Plaque reduction is a prerequisite for an oral hygiene device to be considered valuable (Newman et al. 1994). The selected papers for this meta-review report for some inter-dental cleaning devices no reduction in plaque whereas a reduction of gingivitis was, observed. The mechanisms of action underlying these clinical changes in the absence of a clear effect on plaque are not fully understood. One explanation may be that the inter-dental cleaning device reduces the thickness of plaque interdentally, which may not be easily detectable using two-dimensional scoring system which primarily scores the visible surfaces. This may be the reason for an absence of an effect on plaque scores but a positive effect on gingival inflammation parameters.

New developments

New inter-dental cleaning products have become available since the systematic reviews reported in this meta-review were conducted. They comprise new developments in oral irrigation devices with respect to the

characteristics of the spray and the design of the nozzles (Sharma et al. 2012b,a), as well as an inter-dental device constructed of a plastic core with soft elastomeric fingers protruding perpendicularly (Yost et al. 2006, Abouassi et al. 2014). However, due to a limited body of published data, a detailed and systematic evaluation of the evidence for these devices is not possible. Future systematic reviews should include the evaluation of these new inter-dental cleaning devices to help guide the dental care professional in making an evidence-based decisions.

Limitations

- The available evidence as collected in the systematic review by Hoenderdos et al. (2008) with regard to woodsticks only refers to triangular shaped woodstick. No data were gathered with respect to round or square toothpicks.
- With respect to woodsticks and the oral irrigator, only few studies were available for inclusion in the reviews and therefore no meta-analyses were available.
- Evidence of practical efficiency is lacking and may continue to be limited due to the challenge of designing studies to address these areas.
- Within the evidence of the systematic review included in this analysis, there was no evidence indicating that bacteraemia following flossing is a concern. However, there is also no evidence indicating it is not (Tomas et al. 2012).
- As evidence pertaining to mechanical control in patients with implants was not in the scope of this review, it is hereby not possible to make recommendations pertaining to plaque control specific to implants. However, according to a recent systematic review, there appears to be an urgent need for studies on this topic (Louropoulou et al. 2014).

Summary and Conclusion

This meta-review summarized and appraised the available evidence from systematic reviews as was pres-

ent in the form of systematic reviews with respect to the efficacy of various inter-dental devices for mechanical plaque control in managing gingivitis. There is weak evidence that flossing plus toothbrushing compared to toothbrushing alone has a small but significant effect on gingivitis. However, there is a lack of evidence for a concomitant reduction in plaque scores. The evidence for woodsticks and toothbrushing as compared to toothbrushing alone was weak and showed that there is a benefit of unclear magnitude with respect to bleeding scores but lacking evidence for a concomitant reduction of plaque. Moderate evidence was available for the efficacy of interdental brushes in addition to toothbrushing as compared with toothbrushing alone. This corresponded to a 34% reduction in gingivitis and a 32% reduction in plaque scores, when standardizing the results retrieved from the use of different indices. There is weak evidence that the oral irrigator plus toothbrushing compared to regular oral hygiene has an effect on gingivitis. The magnitude remained unclear and it also lacked evidence on a concomitant reduction of plaque scores. In all there is consistent evidence that suggests that inter-dental brushes are the most effective devices to remove inter-dental plaque. In addition, they are appreciated best by the patients.

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References

- Abouassi, T., Woelber, J. P., Holst, K., Stampf, S., Doerfer, C. E., Hellwig, E. & Ratka-Kruger, P. (2014) Clinical efficacy and patients' acceptance of a rubber interdental bristle. A randomized controlled trial. *Clinical Oral Investigations* **18**, 1873–1880.
- ADA (2014) Mouth health - Adults 40–60. URL <http://www.mouthhealthy.org/en/adults-40-60/> [accessed on 23 September 2014]

- AMSTAR (2014) AMSTAR - Checklist. URL http://amstar.ca/Amstar_Checklist.php [accessed on 09 March 2014]
- Axelsson, P. (1994) *Mechanical plaque control*, p. 219–243. London: Quintessence.
- ♦Berchier, C. E., Slot, D. E., Haps, S. & Van der Weijden, G. A. (2008) The efficacy of dental floss in addition to a toothbrush on plaque and parameters of gingival inflammation: a systematic review. *International Journal of Dental Hygiene* **6**, 265–279.
- Bowen, D. M. (2012) Flossing or alternative interdental aids? *Journal of Dental Hygiene* **86**, 58–62.
- Caton, J. G. & Polson, A. M. (1985) The interdental bleeding index: a simplified procedure for monitoring gingival health. *Compendium of Continuing Education in Dentistry* **6**, 88, 90–92.
- Chaves, E. S., Kornman, K. S., Manwell, M. A., Jones, A. A., Newbold, D. A. & Wood, R. C. (1994) Mechanism of irrigation effects on gingivitis. *Journal of Periodontology* **65**, 1016–1021.
- Chongcharoen, N., Lulic, M. & Lang, N. P. (2012) Effectiveness of different interdental brushes on cleaning the interproximal surfaces of teeth and implants: a randomized controlled, double-blind cross-over study. *Clinical Oral Implants Research* **23**, 635–640.
- Choo, A., Delac, D. M. & Messer, L. B. (2001) Oral hygiene measures and promotion: review and considerations. *Australian Dental Journal* **46**, 166–173.
- Dicenso, A., Bayley, L. & Haynes, R. B. (2009) Accessing pre-appraised evidence: fine-tuning the 5S model into a 6S model. *Evidence Based Nursing* **12**, 99–101.
- Drisko, C. L. (2013) Periodontal self-care: evidence-based support. *Periodontology 2000* **62**, 243–255.
- Flemmig, T. F., Newman, M. G., Doherty, F. M., Grossman, E., Meckel, A. H. & Bakdash, M. B. (1990) Supragingival irrigation with 0.06% chlorhexidine in naturally occurring gingivitis. I. 6 month clinical observations. *Journal of Periodontology* **61**, 112–117.
- Frascella, J. A., Fernandez, P., Gilbert, R. D. & Cugini, M. (2000) A randomized, clinical evaluation of the safety and efficacy of a novel oral irrigator. *American Journal of Dentistry* **13**, 55–58.
- Gluch, J. I. (2012) As an adjunct to tooth brushing, interdental brushes (IDBs) are more effective in removing plaque as compared with brushing alone or the combination use of tooth brushing and dental floss. *Journal of Evidence Based Dental Practice* **12**, 81–83.
- GRADE (2014) Grading of recommendations assessment, development and evaluation. URL <http://www.gradeworkinggroup.org/index.htm> [accessed on 03 September 2014]
- Hidding, J. T., Beurskens, C. H., Van der Wees, P. J., van Laarhoven, H. W. & Nijhuis-Van der Sanden, M. W. (2014) Treatment related impairments in arm and shoulder in patients with breast cancer: a systematic review. *PLoS One* **9**, e96748.
- ♦Hoenderdos, N. L., Slot, D. E., Paraskevas, S. & Van der Weijden, G. A. (2008) The efficacy of woodsticks on plaque and gingival inflammation: a systematic review. *International Journal of Dental Hygiene* **6**, 280–289.
- Hotta, M., Imade, S., Sano, A., Nakajima, H. & Yamamoto, K. (2004) Stem durability testing of interdental brush. *Dental Materials Journal* **23**, 604–608.
- Hujoel, P. P., Cunha-Cruz, J., Banting, D. W. & Loesche, W. J. (2006) Dental flossing and interproximal caries: a systematic review. *Journal of Dental Research* **85**, 298–305.
- ♦Husseini, A., Slot, D. E. & Van der Weijden, G. A. (2008) The efficacy of oral irrigation in addition to a toothbrush on plaque and the clinical parameters of periodontal inflammation: a systematic review. *International Journal of Dental Hygiene* **6**, 304–314.
- Ishak, N. & Watts, T. L. (2007) A comparison of the efficacy and ease of use of dental floss and interproximal brushes in a randomised split mouth trial incorporating an assessment of subgingival plaque. *Oral Health and Preventive Dentistry* **5**, 13–18.
- Jin, L. (2009) Is oral irrigation beneficial to gingival health as an adjunct to toothbrushing? *Evidence Based Dentistry* **10**, 40–41.
- Jordan, R. A., Hong, H. M., Lucaci, A. & Zimmer, S. (2014) Efficacy of straight versus angled interdental brushes on interproximal tooth cleaning: a randomized controlled trial. *International Journal of Dental Hygiene* **12**, 152–157.
- Lang, N. P., Cumming, B. R. & Loe, H. (1973) Toothbrushing frequency as it relates to plaque development and gingival health. *Journal of Periodontology* **44**, 396–405.
- Löe, H. & Silness, J. (1963) Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontologica Scandinavica* **21**, 533–551.
- Louropoulou, A., Slot, D. E. & Van der Weijden, F. (2014) Mechanical self-performed oral hygiene of implant supported restorations: a systematic review. *Journal of Evidence Based Dental Practice* **14**(Suppl), 60–69. e61.
- Marsh, P. D. (2000) Role of the oral microflora in health. *Microbial Ecology in Health and Disease* **12**, 130–137.
- Marsh, P. D., Moter, A. & Devine, D. A. (2011) Dental plaque biofilms: communities, conflict and control. *Periodontology 2000* **55**, 16–35.
- Matthews, D. (2012) Weak, unreliable evidence suggests flossing plus toothbrushing may be associated with a small reduction in plaque. *Evidence Based Dentistry* **13**, 5–6.
- Morch, T. & Waerhaug, J. (1956) Quantitative evaluation of the effect of toothbrushing and toothpicking. *Journal of Clinical Periodontology* **27**, 183–190.
- Newman, M. G., Cattabriga, M., Etienne, D., Flemmig, T., Sanz, M., Kornman, K. S., Doherty, F., Moore, D. J. & Ross, C. (1994) Effectiveness of adjunctive irrigation in early periodontitis: multi-center evaluation. *Journal of Periodontology* **65**, 224–229.
- ♦Poklepovic, T., Worthington, H. V., Johnson, T. M., Sambunjak, D., Imai, P., Clarkson, J. E. & Tugwell, P. (2013) Interdental brushing for the prevention and control of periodontal diseases and dental caries in adults. *Cochrane Database Systematic Review* **12**, CD009857.
- PRISMA (2014) Statement. URL <http://www.prisma-statement.org> [accessed on 03 September 2014]
- PROSPERO (2014) International prospective register of systematic reviews. URL <http://www.crd.york.ac.uk/PROSPERO/> [accessed on 03 September 2014]
- Quigley, G. A. & Hein, J. W. (1962) Comparative cleansing efficiency of manual and power brushing. *Journal of the American Dental Association* **65**, 26–29.
- Rasines, G. (2009) The use of interdental brushes along with toothbrushing removes most plaque. *Evidence Based Dentistry* **10**, 74.
- Reiter, C. & Wetzel, W. E. (1991) The finishing of the bristle ends in interdental brushes. *Schweiz Monatsschr Zahnmed* **101**, 431–437.
- Rosema, N. A., Hennequin-Hoenderdos, N. L., Berchier, C. E., Slot, D. E., Lyle, D. M. & Van der Weijden, G. A. (2011) The effect of different interdental cleaning devices on gingival bleeding. *Journal of the International Academy of Periodontology* **13**, 2–10.
- ♦Sambunjak, D., Nickerson, J. W., Poklepovic, T., Johnson, T. M., Imai, P., Tugwell, P. & Worthington, H. V. (2011) Flossing for the management of periodontal diseases and dental caries in adults. *Cochrane Database Systematic Review* **12**, CD008829.
- Sarrami-Foroushani, P., Travaglia, J., Debono, D., Clay-Williams, R. & Braithwaite, J. (2014) Scoping meta-review: introducing a new methodology. *Clinical and Translational Science* **0**, 1–5. doi:10.1111/cts.12188.
- Schmage, P., Platzer, U. & Nergiz, I. (1999) Comparison between manual and mechanical methods of interproximal hygiene. *Quintessence International* **30**, 535–539.
- Sharma, N. C., Lyle, D. M., Qaqish, J. G. & Schuller, R. (2012a) Comparison of two power interdental cleaning devices on plaque removal. *The Journal of Clinical Dentistry* **23**, 17–21.
- Sharma, N. C., Lyle, D. M., Qaqish, J. G. & Schuller, R. (2012b) Comparison of two power interdental cleaning devices on the reduction of gingivitis. *The Journal of Clinical Dentistry* **23**, 22–26.
- Shea, B. J., Grimshaw, J. M., Wells, G. A., Boers, M., Andersson, N., Hamel, C., Porter, A. C., Tugwell, P., Moher, D. & Bouter, L. M. (2007) Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC Medical Research Methodology* **7**, 10.
- Sicilia, A., Arregui, I., Gallego, M., Cabezas, B. & Cuesta, S. (2002) A systematic review of powered vs manual toothbrushes in periodontal cause-related therapy. *Journal of Clinical Periodontology* **29**(Suppl. 3), 39–54. discussion 90–31.
- Sicilia, A., Arregui, I., Gallego, M., Cabezas, B. & Cuesta, S. (2003) Home oral hygiene revisited. Options and evidence. *Oral Health and Preventive Dentistry* **1**(Suppl. 1), 407–422. discussion 423–405.
- Silness, J. & Löe, H. (1964) Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontologica Scandinavica* **22**, 121–135.
- ♦Slot, D. E., Dörfer, C. E. & Van der Weijden, G. A. (2008) The efficacy of interdental brushes on plaque and parameters of periodontal inflammation: a systematic review. *International Journal of Dental Hygiene* **6**, 253–264.
- Suvan, J. E. & D’Aiuto, F. (2008) Progressive, paralyzed, protected, perplexed? What are we doing? *International Journal of Dental Hygiene* **6**, 251–252.
- Tomas, I., Diz, P., Tobias, A., Scully, C. & Donos, N. (2012) Periodontal health status and bacteraemia from daily oral activities: systematic review/meta-analysis. *Journal of Clinical Periodontology* **39**, 213–228.
- Tucker, R. (2009) Do woodsticks work? *Evidence Based Dentistry* **10**, 43.
- Waerhaug, J. (1976) The interdental brush and its place in operative and crown and bridge dentistry. *Journal of Oral Rehabilitation* **3**, 107–113.
- Walker, E., Hernandez, A. V. & Kattan, M. W. (2008) Meta-analysis: its strengths and limitations. *Cleveland Clinic Journal of Medicine* **75**, 431–439.
- Walsh, M. M., Heckman, B. H. & Moreau-Diettinger, R. (1985) Use of gingival bleeding

- for reinforcement of oral home care behavior. *Community Dentistry and Oral Epidemiology* **13**, 133–135.
- Walsh, M. M. & Heckman, B. L. (1985) Interproximal subgingival cleaning by dental floss and the toothpick. *Dental Hygiene* **59**, 464–467.
- Warren, P. R. & Chater, B. V. (1996) An overview of established interdental cleaning methods. *The Journal of Clinical Dentistry* **7**, 65–69.
- Van der Weijde, F. & Slot, D. E. (2011) Oral hygiene in the prevention of periodontal diseases: the evidence. *Periodontology* **2000** **55**, 104–123.

- Wolff, D., Joerss, D. & Dorfer, C. E. (2006) In vitro-cleaning efficacy of interdental brushes with different stiffness and different diameter. *Oral Health and Preventive Dentistry* **4**, 279–285.
- Yost, K. G., Mallatt, M. E. & Liebman, J. (2006) Interproximal gingivitis and plaque reduction by four interdental products. *The Journal of Clinical Dentistry* **17**, 79–83.

◆Studies selected for this meta-review.

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Clinical Relevance

Scientific rationale for the study: Maintenance of effective plaque control is the cornerstone of any attempt to prevent and control periodontal diseases. To be controlled, plaque must be removed frequently by mechanical self-care methods. Over the last two decades, more and more systematic reviews have been published in relation to various oral hygiene interventions and devices. Systematic reviews provide a synthesis that embraces rigorously all primary research evidence that could be found relevant to a particular focused question. A meta-review summarizes the findings and implications of these systematic reviews.

Principle findings: In the absence of a concomitant effect on plaque scores, there is weak evidence that dental floss, woodsticks and the oral irrigator reduce gingivitis in addition to toothbrushing. Compared to toothbrushing alone interdental brushes in combination with toothbrushing provide a significant reduction of both plaque and gingivitis scores.

Practical Implications: Good interdental oral hygiene requires a device that can penetrate between adjacent teeth. The choice must be made in relation to the characteristics of the inter-dental spaces and whether they are accessible or not for the particular device by the respective patient. In patients with accessible interdental spaces the inter-dental brush is the most effective inter-dental cleaning device in reducing plaque and gingivitis. The use of floss, woodsticks and the oral irrigator may be effective in controlling gingivitis. Based on the selected systematic reviews, it would appear that if the patient or the clinician prefers to limit the number of inter-dental cleaning devices, inter-dental brushes of the appropriate size should be the first choice providing inter-dental spaces are accessible.

Limitation: A caution to the reader is that the strength of systematic reviews relies on the quality of the original research and the methodology of the review. Systematic reviews may fail to provide strong guidance on the topic explored, and are sometimes biased or contain an insufficient

number of published articles to provide a clear understanding of the topic under review. With respect to woodsticks and the oral irrigator, no meta-analyses were available. The available evidence as collected in the systematic review with regard to woodsticks only refers to triangular-shaped woodstick. No data were gathered with respect to other shapes of woodsticks.

Further research: New developments in inter-dental cleaning such as rubber inter-dental cleaners and new technologies in oral irrigators need to be systematically evaluated. The efficacy and safety of extra small inter-dental brushes in patients with intact papillae is an item of interest. Furthermore, the investigation of optimized self-performed inter-dental oral hygiene around dental implants deserves investigation. Patient preference is an aspect that needs to be assessed in relation to motivation of the patient so that adding inter-dental devices to daily oral cleaning does not become a stumbling block.