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The efficacy of interdental brushes on plaque and parameters of periodontal inflammation: a systematic review

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Abstract: *Aim:* The aim of the study was to asses the effect of the use of interdental brushes (IDB) in patients as an adjunct to toothbrushing compared with toothbrushing alone or other interdental oral hygiene devices on plaque and the clinical parameters of periodontal inflammation. *Material and methods:* MEDLINE–PubMed and the Cochrane Central register of controlled trials (CENTRAL) were searched through November 2007 to identify appropriate studies. Clinical parameters of periodontal inflammation such as plaque, gingivitis, bleeding and pockets were selected as outcome variables. *Results:* Independent screening of the titles and abstracts of 218 MEDLINE–PubMed and 116 Cochrane papers resulted in nine publications that met the eligibility criteria. Mean values and standard deviations were collected by data extraction. Descriptive comparisons are presented for brushing alone or brushing and woodsticks; meta-analyses were also performed for the floss comparison. *Conclusion:* As an adjunct to brushing, the IDB removes more dental plaque than brushing alone. Studies showed a positive significant difference using IDB 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 IDB compared with floss.

Key words: systematic review; interdental brush; interdental devices; interproximal brush; interspace brush

Introduction

There is an increasing public awareness of the value of personal oral hygiene. Oral cleanliness is important for the preservation of oral health, whereby microbial plaque is removed and prevented from accumulating on teeth and gingivae (1). It is well documented that plaque is the primary aetiological factor in the development of chronic inflammatory periodontal disease (2).

Periodontitis and gingivitis lesions are predominantly observed in the interproximal or interdental sites; it is these sites which are most frequently coated with plaque (3). As the interproximal areas of the dentition are also frequently affected by caries, interproximal cleaning represents an important aspect of oral self-care (4).

The primary means of plaque control is through mechanical action. The toothbrush is designed to achieve maximal plaque control. Although the toothbrush is successful in removing plaque at buccal, lingual and occlusal surfaces, it cannot completely clean the interdental surfaces (5). Good interdental oral hygiene requires something that can penetrate between adjacent teeth. Many different marketed products are designed to achieve this, including floss, woodsticks, rubber-tip simulators, interdental brushes (IDB) and single-tufted brushes.

Interdental brushes are frequently recommended by dental professionals to patients with sufficient space between their teeth. IDB are small, specially designed brushes for cleaning between the teeth; they have soft nylon filaments twisted into a fine stainless steel wire. Their shape can be conical or cylindrical. Most are round in cross-section. However, recently IDB with a more triangular cross-section were introduced into the market as suggested by Axelsson (6) and Dörfer *et al.* (7).They are available in different widths to match the interdental space, which ranges from 1.9 to 14 mm in diameter. Upon examination of extracted teeth from individuals who habitually used the IDB, Waerhaug (8) showed that the supragingival proximal surfaces (the central part of the interdental space and on the embrasures) were free of plaque and that some subgingival deposits were removed up to a depth of 2–2½ mm below the gingival margin.

Systematic reviews (SR) can be used for evidence as part of the clinical decision process (9). Recently, a Cochrane Collaboration SR addressed the question of whether IDBs provide additional benefit to the orthodontic patient. No eligible studies were identified to support the use of the IDB in addition to standard toothbrushing (10). No SR is available which has addressed the benefits of the IDB in a general patient population. The aim of the present study was to assess the effectiveness of the IDB adjunct to the use of a toothbrush in terms of plaque and clinical parameters of periodontal inflammation compared to toothbrushing alone or toothbrushing in combination with floss or woodsticks.

Materials and methods

Focused question

What is the effect of the use of IDB in patients as an adjunct to toothbrushing compared with toothbrushing alone or other interdental oral hygiene devices on plaque and the clinical parameters of periodontal inflammation?

These clinical parameters may include scores of gingival inflammation and probing pocket depth.

Search strategy

Two internet sources were selected in the search for papers satisfying the study purpose: The National Library of Medicine, Washington DC (MEDLINE–PubMed) (1965 up to November 2007) and the Cochrane Central register of controlled trials (CENTRAL) (1965 up to November 2007).

This search was designed to be inclusive for any study that evaluated the effect of IDB. The following terms were used in the search strategy:

(Intervention) ([textwords] 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 interdental cleaning devices OR interspace brushing OR interspace brushes OR interspace brush OR interspace brush* OR interspace cleaning devices OR proxabrush)
AND
(Outcome) ([textwords] gingivitis OR periodontitis OR gingival pocket OR periodontal pocket OR gingival inflammation OR gingival diseas* OR periodontal diseas* OR bleeding on probing OR papillary bleeding index OR gingival bleeding OR bleeding index OR plaque removal OR plaque index OR dental plaque OR plaque OR removal OR interdental plaque OR interproximal plaque OR dental deposit* OR [MesH] Periodontal Diseases).

The eligibility criteria were:

- Randomized controlled clinical trials (RCTs);
- Controlled clinical trials;
- Subjects >18 years of age;
- Subjects in good general health (no systemic disorders);
- Intervention with IDB;
- Patients with sufficient interdental space to use an IDB;

- Evaluation parameters: plaque/bleeding/gingivitis/pocket depth and
- Conducted in humans.

Only papers written in the English language were accepted. Case reports, letters and narrative or historical reviews were not included in the search. Papers without abstracts but with titles related to the objectives of this review were selected so that the full text could be screened for eligibility.

Screening and selection

The papers were screened independently by two reviewers (DES and GAW), first by title and abstract. Then, as a second step, full-text papers were identified that fulfilled the eligibility criteria for inclusion according to the study aim. After the search, all reference lists of selected studies were screened for additional papers which might meet the eligibility criteria of the study. Any disagreement between the two reviewers was resolved after additional discussion.

Assessment of heterogeneity

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

- Study design;
- Evaluation period;
- Medical and periodontal status of subjects;
- Number of subjects;
- Mean age and age range of subjects;
- Gender;
- Oral prophylaxis at start of study period;
- Intervention type of IDB;
- Smoking and
- Industry funding.

Quality assessment

The methodological study quality was evaluated based upon the following aspects:

- Method of randomization;
- Blindness of examiners;
- Number of subjects lost to follow-up and
- Plaque indices and parameters of periodontal disease.

Data extraction

From the selection of papers that met the eligibility criteria, data were processed for analysis. Data were extracted with regard to the effectiveness of self-performed interdental plaque removal using IDB in comparison to a control treatment. Mean values and standard deviations (SD) were extracted by DES and GAW.

Data analysis

After a preliminary evaluation of the selected papers considerable heterogeneity in the study design, characteristics, outcome variables and results were present. As a summary a descriptive manner of data presentation is used. With the exception of one paper (11), only baseline data and end-trial assessments were available. Consequently, it was not possible to perform a meta-analysis of the differences because the SD of the differences was not provided and could not be calculated. Therefore, the data for baseline and end-trials were presented separately. An analysis was performed for both time points. Where appropriate, a meta-analysis was performed and weighted mean differences (WMD) were calculated by means of the Review Manager using a 'random effect' model. Review Manager (RevMan) [computer program]. Version 4.2 for windows. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2003.

Results

Search and selection results

The MEDLINE–PubMed search resulted in 222 and the Cochrane search in 122 citations (for details, see Table 1). After removing the duplicate listings of those papers that were present in both searches, 234 titles and abstracts remained to be screened. The screening of titles and abstracts initially resulted in 18 full-text articles. The reasons for exclusion are explained in Table 2. In total, five papers were excluded for failing the eligibility criteria (13–16, 21). Based on the full texts, another five articles were excluded because of insufficient data presentation on the clinical parameters (12, 17–20). Gjermo and Flötra (11) was taken as an additional paper from

Table 1. **Search and selection results**

Selection	PubMed	Cochrane	Identical
Search	222	122	110
Excluded by title and abstract	204	111	99
Selected papers for full reading	18	11	11
Excluded after full reading (Table 2)	5		
Included after full reading	13		
Excluded for insufficient data presentation (Table 2)	5		
Included from reference list (11)	1		
Final selection for data extraction	9		

Table 2. **Overview of the studies that were excluded**

References	Reason for rejection
Bergenholtz and Olsson (12)	Insufficient data presentation
Bouwsma *et al.* (13)	Histological outcome measures
Finkelstein *et al.* (14)	Interdental cleaner is Stim-U-Dent™ woodstick
Galgut (15)	Narrative review
Lissau *et al.* (16)	Longitudinal study
Mauriello *et al.* (17)	Insufficient data presentation
Nayak and Wade (18)	Insufficient data presentation
Schmage *et al.* (19)	Insufficient data presentation
Smith *et al.* (20)	Insufficient data presentation
Wolffe (21)	Interspace® is a single-tufted brush

the reference lists (8, 22–27). Consequently, nine studies were identified as eligible for inclusion in this review according to defined criteria for study design, participants, intervention and outcome. These nine trials, all experimental clinical studies, were processed for data extraction.

Outcome results

Assessment of heterogeneity

After a preliminary evaluation of the selected papers, considerable heterogeneity was observed in the study design, characteristics and outcome variables. The number, gender and age of participants varied per group and study. Information regarding the study characteristics is displayed in Table 3.

Study design, evaluation period and oral prophylaxis

In total, two studies had a cross-over design (I, VII), three a split-mouth design (II, IV and VIII) and four a parallel design (III, V, VI and IX). One study had a single-use (±1 min) design (VIII). Most studies had an evaluation period of 4 weeks (III, IV and VI) or 6 weeks (I, II and IX). The studies with the longest duration were V and VII, which lasted for 12 weeks. When repeated measures were presented, the longest evaluation term reported was used for this review.

In most studies, an oral prophylaxis at the start of the experiment was part of the protocol (I, III, V, VI, VII and IX). With the exception of VIII, all studies tested the products as complements to (non-electric) toothbrushing. All papers reported that the subjects were experienced users of the interdental devices or that they received detailed instruction on use.

Intervention type of interdental brushes and industry funding

In the identified papers, different brands of IDBs were used as test products (Curaprox (Kriens, Switserland), Barge Nilsson (Trosa, Sweden), GUM (Sunstar Americas, Chicago, USA), Johnson & Johnson (São Paulo, Brazil), Butler (Sunstar Osaka, Japan), Enta-Lactona (Bergen op Zoom, The Netherlands), Oral-B (Redwood City, USA), and Jordan (Oslo, Norway)) with different diameters and different lengths. The shape of the IDB was conical (VI, VIII) or cylindrical (I, II, III, IV, V, VIII and IX). Six studies (II, IV, V, VI, VII and IX) were financially supported by and/or study products were provided by the industry. In the remaining three studies (I, III and VIII), no such information was presented.

Subjects and smoking

Six studies (II, IV, V, VI, VII and IX) used 'good general health' as inclusion criteria for the subjects. Systemic or chronic medical diseases might have affected the outcome of the study. With respect to periodontal status, most studies had periodontal recall maintenance patients as a study population (III, VII and VIII). Studies II and V used periodontitis patients who had not previously received periodontal treatment. Only IV had patients diagnosed with gingivitis or moderate adult periodontitis. Studies I, VI and IX did not report on the periodontal status of the panelists.

Some studies (V, IX) provide information about the smoking habits of the participants; smoking was an exclusion criterion for two studies (IV, VI). Most studies (I, II, III, VIII and IX) did not mention smoking habits. None of the studies analysed the effect of smoking on the study outcome variables.

Quality assessment

Randomization, blindness and losses to follow-up

All studies randomly assigned the panelists to the different groups with test products. The method of randomization was often unclear. Only VI used block randomization. Procedures for allocation concealment were not described.

Blinding of the subject to the different interdental dental hygiene aids was not possible. Seven studies (I, II, IV, V, VII, VIII and IX) were conducted as operator- (single-) blind experiments. For the remaining papers blinding was not specified. Three studies (II, IV and VII) reported no loss of subjects to follow-up. Three (V, VI and IX) do report losses to follow-up, but only VI and VI mention that none of the withdrawals were product related. Adverse effects were not mentioned in any of the papers.

Table 3. **Overview of the studies processed for data extraction. The effectiveness of the interdental brush as an adjunct to the use of a toothbrush on the clinical parameters of periodontal inflammation compared with toothbrushing alone or toothbrushing in combination with floss or woodsticks**

No.	References	Study aim	Design and evaluation period	No. of subjects, gender, age	Comparison	Conclusion
I	Bassiouny and Grant (22)	To investigate the effectiveness of a proxima brush relative to that of toothpicks on plaque removal	RCT 3 × 3 cross-over, 6 weeks (3 × 2)	19 Subjects, 8 ♀, 11♂, mean age: 24.7◇, range: 18–42	IDB Woodstick Brushing alone	The cleaning efficiency of the IDB was greater than woodsticks on the interproximal surfaces of teeth adjacent to edentulous areas
II	Christou *et al.* (5)	To compare the efficacy of dental floss and interdental brushes in the reduction of plaque, gingival inflammation and probing depth	RCT Split mouth, 6 weeks	26 Subjects, 12 ♀, 14 ♂, mean age: 37.4, range: 27–72	IDB Dental floss	In combination with a manual toothbrush, the use of IDB is more effective in removal of plaque and results in a larger reduction of probing depth than the use of dental floss
III	Gjermo and Flötra (11)	To compare the effect of different implements recommended for interdental cleaning	RCT Parallel, 28 days (4 weeks)	16 Subjects, ? ♀, ? ♂, mean age: 53, range: 27–81	IDB Dental floss Woodstick	In wide-open interproximal areas, following periodontal destruction, the IDB is most suitable to remove plaque
IV	Ishak and Watts (23)	To compare the efficacy of interdental brushes and dental floss on the presence of plaque	RCT Split mouth, 1 month	10 Subjects, 7 ♀, 3 ♂, mean age: 43.6, range: 33–56	IDB Dental floss	The use of IDB and dental floss resulted in similar beneficial effects on subgingival plaque and proximal gingival health
V	Jackson *et al.* (28)	To compare the effects of interdental brushing and flossing on clinical periodontal outcomes	RCT Parallel, 12 weeks	77 Subjects, 46 ♀, 31 ♂, mean age: ?, range: 26–75	IDB Dental floss	Interdental cleaning (particularly with IDB) in patient with chronic periodontitis was able to improve clinical periodontal outcome
VI	Jared *et al.* (24)	To compare the efficacy of interproximal cleaning devices for plaque and gingivitis reduction and decreased frequency in interproximal bleeding	RCT Parallel, 4 weeks	162 Subjects, 98 ♀, 64 ♂, mean age: 39.2◇, range: ?	IDB Dental floss Brushing alone	Daily use of IDB was effective in reducing interproximal plaque and gingivitis scores as well as interproximal bleeding on probing
VII	Kiger *et al.* (25)	To evaluate the relative effectiveness of dental floss and interdental brushes in removal of proximal plaque	RCT cross-over, 3 months (3 × 1 month)	30 Subjects, 10 ♀, 20 ♂, mean age: ?, range: ?	IDB Dental floss Brushing alone	The IDB used in combination with a toothbrush is more effective in the removal of plaque from interproximal tooth surfaces than a toothbrush used alone or in combination with dental floss

Table 3. (*Continued*)

No.	References	Study aim	Design and evaluation period	No. of subjects, gender, age	Comparison	Conclusion
VIII	Rösing *et al.* (26)	To compare the interdental plaque removal capacity of dental floss and interdental brushes	RCT Split-mouth, Single use	50 Subjects 33 ♀, 17 ♂, mean age: 44, range: 20–73	IDB Dental floss	For individuals under periodontal maintenance care, IDB, regardless of their shape (conical or cylindrical) are more efficacious in interdental supragingival plaque removal than dental floss
IX	Yost *et al.* (27)	To compare the performance of three interdental products to dental floss in the control and removal of plaque and in the reduction of gingivitis	RCT Parallel, 6 weeks	120 Subjects, 83 ♀, 37 ♂, mean age: 38.2◇, range: 18–63	IDB Dental floss	All products preformed comparably for plaque reduction and removal

◇Calculated by the author. ? unknown.

Plaque indices and clinical parameters

Plaque was scored by various indices and rubrics: Silness and Loë (29) (I, III, V and VIII), Turesky modification (30) of Quigley–Hein (31) (VI, VII), Benson modification (32) and Volpe modification (33) (II) of Quigley and Hein (31) (IX) and Wolffe (21) plaque index. In studies IV and VII, the plaque index was developed by the authors (Table 4a). For bleeding scores, the Eastman interdental bleeding index (34) (V, IX) and a measure of bleeding on marginal probing (35) (II, VI) were used. In study II, two methods to elicit bleeding were applied to assess bleeding on probing: angulated bleeding index (36), and the periodontal pocket bleeding index (37). Bleeding on probing was recorded as absent or present after 10 s by V and IV (Table 4b). Gingivitis was also assessed by different indices (see Table 4c); the gingival index of Löe and Silness (38) was used by VII and IX, and the modified gingival index of Lobene *et al.* (39) by VI. Pocket depth was assessed by II, IV and V (Table 4d).

Study outcomes

Comparison baseline – end (within groups)

Table 4 (a–d) shows the results from the data extraction. A significant improvement was observed for the groups using IDB with respect to the plaque scores in all but one study (III). In those studies that assessed bleeding scores and probing pocket depth, a significant improvement was also observed. Of the studies that assessed gingival health according to the Löe and Silness Gingival Index (38), two out of three (VI, VII and IX) showed a significant reduction, while one study (VII) showed no change.

Between groups

Table 5 summarizes differences between IDB and the intervention strategy. All three studies that compared the IDB as an adjunct to brushing alone showed a significant difference in favour of the use of the IDB on plaque. Study I shows a discrepancy between the text and the data as presented in the table with respect to mean plaque scores. Data presented in the table were assumed to be correct. The majority of the studies showed a positive significant difference on the plaque index when using the IDB when compared with floss. No differences were found for the gingival index or bleeding indices. Two out of three studies showed that the IDB, when compared with floss, has a significant positive effect on pocket reduction. The IDB removes more dental plaque than woodsticks, as shown by one of the two comparative studies.

Table 4. **Baseline–end comparisons. (a) Plaque Index, (b) Bleeding Index, (c) Gingival Index, (d) Pocket Depth**

(a) Plaque Index

			Mean (SD)		
No.	Intervention/groups	Index	Baseline	End	Difference
I		Silness and Loë (29)	⊖		
	IDB			1.38 (0.29)*	−0.5◇
	Woodstick		$\overline{X}$ 1.88 (0.25)	1.42 (0.27)*	−0.46◇
	Toothbrush only			1.48 (0.32)*	−0.4◇
III		Silness and Loë (29)	⊖		
	IDB			0.64	0.64◇
	Woodstick			0.92•	0.92◇
	Dental floss			0.95•	0.95◇
V		Silness and Loë (29)	⊖		
	IDB		1.12 (0.38)	0.72 (0.37)*	−0.40 CI (0.27, 0.53)
	Dental floss		1.13 (0.41)	0.96 (0.40)*,•	−0.17 CI (0.07, 0.27)
VIII		Silness and Loë (29)	⊖		
	Conical IDB		1.69 (0.41)	0.46 (0.20)*	−1.23◇
	Cylindrical IDB		1.66 (0.27)	0.42 (0.15)*	−1.24◇
	Dental floss		1.71 (0.25)	1.02 (0.27)*,•	−0.69◇
VI		Quigley-Hein, Turesky modification (30)	⊖		
	IDB		2.85 (0.90)	2.02 (0.77)*	−0.83◇
	Dental floss		2.86 (0.63)	2.23 (0.83)*	−0.63◇
	Toothbrush only		2.99 (0.82)	2.97 (0.81)*,•	−0.02◇
II		Quigley-Hein, Volpe modification (33)			
	IDB		3.09 (0.62)	2.15 (0.99)*	0.94 (0.81)
	Dental floss		3.10 (0.71)	2.47 (0.86)*,•	0.63 (0.65)
IX		Quigley-Hein, Benson modification (32)	⊖		
	IDB		2.30	1.29*	−1.01◇
	Dental floss		2.46	1.51*	−0.95◇
VII		Wolffe (21)	⊖		
	IDB			1.22 (0.72)*	−0.7◇
	Dental floss		$\overline{X}$ 1.92 (1.03)	1.71 (0.85)•	−0.21◇
	Toothbrush only			2.32 (0.69)•	0.40◇
IV		Ishak and Watts (23)			
	IDB		14.5 (4.79)	5.7 (2.21)*	58.46% (15.1%)
	Dental floss		12.9 (4.53)	5.3 (3.06)*	50.21% (36.75%)

(b) Bleeding Index

			Mean (SD)		
No.	Intervention/groups	Index	Baseline	End	Increment
II		Angulated bleeding index (36)			
	IDB		0.59 (0.20)	0.47 (0.20)*	0.12 (0.16)
	Dental floss		0.60 (0.22)	0.51 (0.26)*	0.08 (0.16)
		Bleeding on probing			
	IDB		0.91 (0.09)	0.83 (0.18)*	0.08 (0.15)
	Dental floss		0.90 (0.12)	0.86 (0.15)*	0.04 (0.10)
IV		Bleeding on probing			
	IDB		11.3 (4.16)	5.6 (4.79)*	44.39% (51.38%)
	Dental floss		10.3 (4.22)	8.1 (5.06)	17.24% (39.47%)

Table 4. **(*Continued*)**

VI		Bleeding on probing			
	IDB		100.00%	46.67%*	−53.33%◇
	Dental floss		100.00%	68.97%*	−31.03%◇
	Toothbrush only		100.00%	81.25%*	−18.75%◇
V		Bleeding on probing			
	IDB		0.54 (0.20)	0.25 (0.18)*	0.29 (0.24, 0.34)
	Dental floss		0.52 (0.24)	0.30 (0.17)*	0.23 (0.18, 0.28)
	IDB	Eastman interdental bleeding index (34)	0.43 (0.29)	0.10 (0.11)*	0.33 (0.24, 0.41)
	Dental floss		0.41 (0.31)	0.16 (0.17)*	0.24 (0.16, 0.32)
IX		Eastman interdental bleeding index (34)			
	IDB		0.64	0.14*	0.50
	Dental floss		0.58	0.23*	0.36
II		Angulated bleeding index (36)			
	IDB		0.59 (0.20)	0.47 (0.20)*	0.12 (0.16)
	Dental floss		0.60 (0.22)	0.51 (0.26)*	0.08 (0.16)

(c) Gingival Index

			Mean (SD)		
No	Intervention/groups	Index	Baseline	End	Increment
VII		Löe and Silness (38)			
	IDB			0.32 (0.22)	0.01◇
	Dental floss		$\overline{X}$ 0.31 (0.19)	0.36 (0.19)	0.05◇
	Toothbrush only			0.37 (0.19)	0.06◇
IX		Löe and Silness (38)			
	IDB		1.38	0.78*	−0.60◇
	Dental floss		1.36	0.95*	−0.41◇
	Floss in handle		1.35	0.91*	−0.44◇
VI		Lobene *et al.* (39)			
	IDB		2.30 (0.69)	1.03 (0.57)*	−1.27◇
	Dental floss		2.24 (0.66)	1.29 (0.70)*	−0.95◇
	Toothbrush only		2.09 (0.67)	1.56 (0.64)*,•	−0.53◇

(d) Pocket Depth

			Mean (SD)	
No.	Intervention/groups	Baseline	End	Increment
II		‡	‡	
	IDB	5.84 (1.27)	5.01 (1.24)*	0.83 (0.33)
	Dental floss	5.59 (1.30)	5.01 (1.26)*,•	0.58 (0.33)
IV	IDB	3.07 (0.7)	2.68 (0.53)*	11.72% (7.77%)
	Dental floss	3.43 (0.9)	2.9 (0.72)	12.23% (20.28%)
V	IDB	3.33 (0.70)	2.77 (0.77)*	0.56 CI (0.45, 0.67)
	Dental floss	3.07 (0.62)	2.76 (0.56)	0.31 CI (0.22–0.40)•

*Significant baseline end.
⊖Oral prophylaxis at baseline.
◇Calculated by the author from baseline value.
•Significant difference as compared with interdental brush.
‡Interdental scores.
CI, Confidence Interval.

Table 5. **Shows a summary of comparison and between the IDB and the intervention whether there is a significant difference in favour of the IDB**

Author(s) no.	Plaque	Gingival	Bleeding	Pocket depth	Comparison
VI	**+**	**+**	**0**	□	Brushing alone
VII	**+**	**0**	□	□	Brushing alone
I	**?**	□	□	□	Brushing alone
IX	**0**	**0**	**0**	□	Floss
V	**+**	□	**0***	**+**	Floss
VIII	**+**	□	□	□	Floss
II	**+**	□	**0***	**+**	Floss
VII	**+**	**0**	□	□	Floss
III	**+**	□	□	□	Floss
VI	**0**	**0**	**0**	□	Floss
IV	**0**	□	**0**	**0**	Floss
III	**+**	□	□	□	Woodstick
I	**?**	□	□	□	Woodstick

*Two indices, **0** = no significant difference, □ = no data available, **?** = inconclusive data, **+** = positive significant difference in favor of the test group.

Meta-analysis

From the collective data of the studies, a meta-analysis only appeared to be possible for the comparison of IDB to floss. Certain studies could not be included in the meta-analysis because of their use of different indices (I), their use of one overall baseline mean (VII), their lack of baseline data (III), or their lack of baseline and end SD (IX). Data from study VIII were used twice, once each for the separate results for conical- and cylindrical-shaped IDB use by the panellists.

Table 6 provides a summary of the outcome of the meta-analysis. In all instances, baseline scores were not statistically different. End scores only showed a significant effect with the Silness and Loë plaque index in favour of the IDB group compared with the floss group [WMD: −0.48, 95% CI (−0.65, −0.32), $P < 0.00001$; test for heterogeneity $P = 0.001$, $I^2 = 85.4\%$]. Comparisons using the other indices were not statistically significant. The heterogeneity observed with the Silness and Loë data reflects the different behaviours of the study populations to the study product, differences in study designs and all other factors that may influence the outcomes. Because of this, the reader should exercise caution when using this WMD as the exact measure of the effect.

Discussion

In the practice of evidence-based dentistry, every dental professional must make a well-considered decision on his/her advice to each patient. To make a well-informed decision, the clinical expertise, patient values, available instruments and experimental evidence must be taken into consideration (9). A SR carries weight because of its high level of evidence. It is a systematic assessment of the available literature for the effects of healthcare interventions, an assessment intended to help the professional in this process. The method of collecting information for a SR provides a solid base for clinical decision-making (40). The Cochrane Collaboration declares that reviews are needed to help ensure that healthcare decisions throughout the world can be based on informed, high-quality, timely research evidence. However, until prospective registration and complete reporting becomes a reality, clinicians using SRs to guide their practice must remain cognizant of the dangers of publication bias. For example, studies with a negative outcome are less likely to be published than studies that show apparent differences. This selective publication of study manuscripts would become visible if access to ongoing and unpublished RCTs were opened to other investigators. Trial registration

Table 6. **Meta-analyses**

Comparison	Index	Studies		WMD (random)	95% CI	Test for overall effect (*P*-value)	Test for heterogeneity (*P*-value)	Test for heterogeneity (I^2 value, %)
Floss	Plaque index; Silness and Loë (29)	V, VIII*	Base	−0.01	(−0.08, 0.06)	0.84	0.97	0
			End	−0.48	(−0.65, −0.32)	<0.00001	0.001	85.4
Floss	Plaque Index; Quigley and Hein (31)	II, VI	Base	−0.01	(−0.28, 0.26)	0.94	1.0	0
			End	−0.25	(−0.57, 0.06)	0.12	0.74	0
Floss	Bleeding on probing	II, IV, V	Base	0.01	(−0.04, 0.06)	0.62	0.86	0
			End	−0.04	(−0.10, 0.02)	0.17	0.74	0
Floss	Pocket depth	II, IV, V	Base	0.14	(−0.19, 0.47)	0.39	0.28	22.0
			End	−0.04	(−0.28, 0.21)	0.77	0.77	0

WMD, weighted mean difference; IDB, interdental brushes.
*Used twice, once each for conical- and cylindrical-shaped IDB.

through the International Standard Randomised Controlled Trial Number can provide an accurate reflection of the research activity in a particular area.

Study design

Most studies assessed in this search had an evaluation period of 4 or 6 weeks. Two lasted up to 12 weeks. Therefore, the study duration was in accordance with the American Dental Association guidelines for adjunctive dental therapies for the reduction of plaque and gingivitis (41). These guidelines state that product efficacy must be demonstrated in clinical studies with a minimum of a 4-week evaluation period. However, short-term studies do have a down side. An improvement in basic oral hygiene (toothbrushing) during the test period as a result of participation in the study (Hawthorne effect: which is known to achieve a degree of modification in subject behaviour) or as a consequence of the oral hygiene instructions may lead to an underestimation of the effect of the interdental cleaning aid (17, 28, 42). The Hawthorne effect may last as long as 6 months (43). Preferably, the test parameters or symptoms that are not attributable to the tested interdental cleaning aid are stable and constant over a period of time (44). Only then can the additional effect because of the use of interdental aids be assessed (17).

A study protocol to partly overcome these design problems should start with a phase of basic oral hygiene combined with a professional prophylaxis and oral hygiene instruction (23, 25). After this basic oral hygiene phase, balanced groups can be formed. This could minimize the effect of an improved oral hygiene regimen, thereby improving the chance of detecting the 'true' effect of the IDB. None of the studies used for this SR had such a pretrial phase.

IDB size

In young individuals in whom the papillae fill out the interdental spaces, dental floss is the only tool which can reach into this area. When the interdental papilla recedes, the space increases. The size of the IDB should fit snugly in this interdental space. Therefore, patients need IDBs of various sizes. Schmage *et al.* (19) assessed the relationship between the interdental space and the position of teeth. Most interproximal spaces at anterior teeth were small and sized for the use of floss. Premolars and molars have larger interproximal spaces and are accessible for the IDB. Most studies do not discuss the different IDB sizes nor do they indicate if the IDB was used in all available approximal sites. This need to account for different sizes of the interdental space makes a 'true' random assignment of IDBs in clinical trials difficult.

Guidance for use

The general advice for IDB use is to move the brush from the buccal to the lingual aspect of the interdental area and then back out again, depressing the interdental papilla to allow the bristles to reach subgingivally (28). Only studies V and IV provide specifics about the instructions to the subjects with respect to this. In the other selected studies, no information about the brushing procedure is mentioned, but one may assume that the subjects used the IDB from the buccal aspect of the dentition. One study (IX) differentiates between the effect on buccal and lingual sites. Plaque removal from the buccal surfaces of the interproximal sites was more effective than from the lingual surfaces. Also, Nayak and Wade (18) showed a significant difference in gingival scores for buccal when compared with lingual sites (18). A benefit is that IDB can also be used from the lingual site, as it can be bent and adjusted. A suggestion for further research would therefore be to set up a clinical trial which evaluates both buccal and lingual use.

Patient preference

When assessing the effectiveness of any interdental cleaning method, there are two issues to consider. First, the theoretical efficacy based on clinical evidence, and second, the practical efficacy, which is largely governed by the acceptability of the method to the patient and the degree of compliance achieved. This latter factor is particularly important, as most current methods of interdental cleaning are limited in their effectiveness by the ability and motivation of the patient, rather than by the method itself (45).

Many interdental cleaning aids are available for our patients. Often, a toothbrush and dental floss are not sufficient to clean interdental spaces adequately, so it is extremely important to find an interdental device that the patient likes and will use (9). Patient acceptance is a major issue to be considered when it comes to the long-term use of interdental cleaning devices (45). Patient preferences were evaluated in three studies (II, IV and VII). Comparing IDB and dental floss, patients preferred the IDB. The IDB was considered to be a simpler method, despite the fact that its tendency to bend, buckle and distort (IV) made the procedure somewhat complicated at times. IDB were considered to be less time-consuming and were felt to be more efficacious than floss for interdental plaque removal (II), which is consistent with previous work (12).

Gingival depression

The three studies that assessed probing pocket depth (II, IV and V) all showed that reduction was more pronounced with the IDB than with floss (Table 4d). A possible reason that the meta-analysis does not support the individual observations is the large difference at baseline between the IDB and floss groups in these studies. To overcome this imbalance, an elegant approach would be to use the difference between baseline and end as the measure of the effect. However, only one study (II) provides this information. Jackson *et al.* (28) propose that the reduced pocket depth may have been related to the reduction of swelling with concomitant recession. However, with a lack of effect on signs of gingival inflammation (see meta-analysis, Table 6), the reason for the effect on pocket depth cannot readily be explained by a reduction in the level of gingival inflammation. As an explanation for the observed effect, the proposition by Badersten *et al.* (46) seems conceivable. They suggested that a mechanical depression of the interdental papilla is induced with the IDB, which causes recession of the marginal gingival. This, together with good plaque removal (Table 6), could be the origin of the improved reduction in pocket depth.

Conclusions

Within the limitations of the search and selection strategy of this review, it may be concluded that:

- As an adjunct to toothbrushing, the IDB removes more dental plaque than brushing alone.
- Inconclusive evidence is available for the effect on gingival inflammation.
- The IDB removes more dental plaque than dental floss or woodsticks.
- There is no difference in the effect of IDB on parameters of gingival inflammation as compared to floss.
- The reduction of pocket depth after the use of the IDB is more pronounced than with floss.

A suggestion for further research can be to design new IDB with a more appropriate form for better adaptation to the interdental space. This could for instance be a triangular form which is commonly used for woodsticks and has proven for this oral hygiene product to be the most effective.

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