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

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Purpose: Previous studies have compared the use of interdental brushes and dental floss. However, none have attempted to compare their effects on subgingival plaque. Nor have smokers been excluded from previous studies, where they may have affected the assessment of gingival inflammation.

Materials and Methods: The present study compared, in untreated patients suffering from mild to moderate periodontitis, the efficacy of dental floss (DF) and interdental brushes (IDB) in the reduction of plaque, gingival inflammation and probing depth in a one-month period prior to subgingival debridement. Ten patients used DF for one side of the dentition and IDB for the other side for one month. Oral hygiene instruction was given at baseline. Measurements were made at baseline and at one month.

Results: With IDB, the mean approximal plaque score reduced supragingivally from 14.5 to 5.7 at one month, and with DF, from 12.9 to 5.3; subgingivally the score reduced from 17.3 to 6.7, and 16.7 to 8.1 respectively ($p < 0.001$). BOP and mean probing depth reduced over time for IDB sites, but not DF sites ($p < 0.01$). Overall there were no differences between the two devices. Patients preferred IDB because of its simpler method of use.

Conclusions: The use of IDB and DF resulted in similar beneficial effects on subgingival plaque and proximal gingival health.

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It has long been known that proximal plaque removal requires special attention and needs to be taught as a separate technique. The conventional toothbrush removes plaque from the buccal and lingual surfaces, but not from the proximal surfaces (Hansen and Gjermo, 1971). The role of proximal cleaning in maintaining OH (oral hygiene) is important, as gingivitis usually starts interdentally (Nayak and Wade, 1977).

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Efficacy of toothbrushing on proximal surfaces is less than that on lingual and buccal surfaces (Bergenholtz et al, 1974; Bassiouny and Grant, 1981; Mauriello et al, 1987; Kiger et al, 1991). Interproximal surfaces are least accessible to plaque control and most affected with calculus and periodontal diseases (Løvdal et al, 1958).

When the interdental brush (IDB) and dental floss (DF) are compared, IDB appears more effective in the removal of plaque in open interproximal spaces (Bergenholtz and Olsson, 1984; Kiger et al, 1991; Christou et al, 1998). In relation to other interdental cleaning aids, IDB was found to be the most efficient in proximal plaque removal (Gjermo and Fløtra, 1970; Nayak and Wade, 1977; Bassiouny and Grant, 1981). Christou et al (1998) reported that the use of IDB also resulted in a larger reduction of PD (probing depth) than the use of DF. Waerhaug (1976) reported that IDB

Table 1 Randomisation allocation for floss-usage side (IDB was then used on the other side).

Patient	Gender	Age randomisation	Floss-side	Handedness	Side flossed
1	F	53	R	R	R
2	M	47	R	R	R
3	F	56	L	R	L
4	F	30	L	R	L
5	F	48	R	R	R
6	M	40	L	R	L
7	M	45	R	R	R
8	F	45	R	R	R
9	F	33	L	L	R
10	F	39	R	R	R

had an excellent effect both in the central part of the interdental space and the embrasures.

Watts (2000) suggested, as requirements for personal plaque removal techniques, that they should be effective in the task of plaque control, have minimal adverse effects, be simple to learn, economical in time and inexpensive.

Most of the studies reported that patients prefer IDB to DF because the former is easier to use. This is important because it may help long-term compliance. Even though DF was reported to be less preferable than IDB, there are studies that show flossing is simple to learn (Terhune, 1973; Anaise, 1976; Rodrigues et al, 1996).

Only one study suggests an IDB may effectively remove subgingival plaque (Waerhaug, 1976). It might be argued that the IDB is often used loosely and that floss may generally be more effective in achieving subgingival plaque removal. Subgingival plaque has not been examined so far in randomised controlled trials of plaque control techniques. The present study was designed to compare, in untreated patients with moderate periodontitis or gingivitis, the efficacy and ease of use of IDB and DF in relation to the presence of supra- and sub-gingival plaque. Non-smoking patients also were selected so that the effect of smoking on bleeding measurements was controlled.

MATERIALS AND METHODS

Two proximal OH regimens, combining the use of a manual toothbrush with the use of either IDB or DF, were compared in a split mouth design clinical trial, in which the use of IDB was randomly assigned to the left or right half of the mouth and the use of DF to the other side. For left-handed subjects, the random assignation was reversed to allow for any effect on manipulation.

To ensure allocation concealment, the allocation methods were not revealed to the examiner (TW). A statistician who was not directly involved in recruiting patients generated the randomisation sequence. Recruitment and assignment of patients to their groups was carried out by NI. Subjects were patients referred to the Periodontology Department, Guy's Hospital, London, diagnosed with gingivitis or moderate adult periodontitis and not having received periodontal treatment in the past 6 months. The subjects also fulfilled the following requirements:

1. Age 18–60 years old.
2. Some visible proximal plaque deposits present.
3. Lifetime non-smokers.
4. No gingival enlargement or overgrowth.
5. No local plaque retentive factors.
6. Not taken any drugs affecting the gums, e.g. phenytoin, cyclosporin, calcium-channel blockers, in the past 6 months.
7. No systemic disease involved which could affect the periodontal tissue, e.g. diabetes.
8. Not pregnant.
9. At least 6 teeth present in each quadrant from lateral incisor distally, with proximal contact areas in contact or not separated by more than 1 mm, and accessible by an IDB.

After selection, patients were informed about the purpose and duration of the study and gave informed consent. The study was approved by the Guy's and St Thomas' hospitals ethics committee.

A total of 10 patients (7 female, 3 male; mean age 43.6 years, range from 33 to 56 years old) finished the

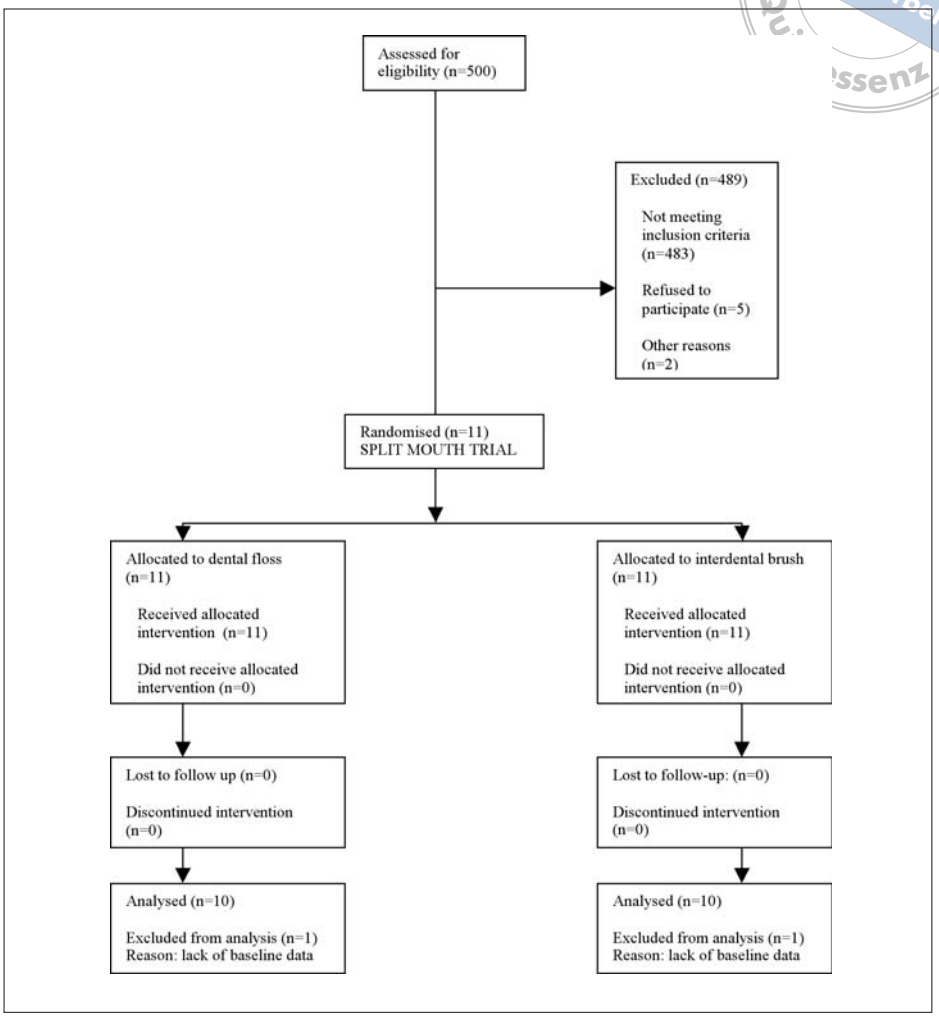

Fig 1 The CONSORT flow chart for the present study.

protocol. Table 1 shows the randomisation allocation and personal data. One participant was excluded from the analysis due to lack of baseline data (Fig 1). This was a split mouth study, so every subject had the opportunity to use both modes of cleaning interproximally.

All measurements were carried out at baseline and one month by one experienced examiner (TW), who was blinded. Ten sites in each quadrant were examined, from the distal of the lateral incisors to the mesial of the second molars, with substitution of one further tooth permitted in the event of missing teeth.

To examine the supra- and sub-gingival plaque on each proximal surface, teeth were dried and floss was taken to each proximal surface by the examiner, and first used from the gingival margin coronally, when visible plaque deposits were scored as positive. Next, floss was taken firmly subgingivally, for removal and scoring of any visible deposit there.

A 0.25N hinged constant force probe of tip diameter 0.5 mm (Borodontic™) was taken into each proximal gingival crevice from the buccal aspect, aimed apically to the contact point, and to the extent of the pocket. PD and bleeding were recorded. Recession was also measured using the same probe from the cemento-enamel junction to the gingival margin. Probing attachment level was then obtained by adding PD to recession. After an interval of 30 minutes to allow for tissue disturbance, 5% of sites were re-examined at random. Examiner reproducibility was assessed by weighted kappa statistics indicating a reasonable level (Table 2).

Subsequently, subjects received detailed instruction in the use of a manual toothbrush (Bass technique), DF (loop technique; Masters, 1969) and IDB (cylindrical bottle-brush, applied buccally) by the other researcher (NI). All materials were provided by Glaxo-

Table 2 Weighted kappa statistics for re-measurement of 5% of examined sites.

Parameter measured	Visit 1	Visit 2
PD	0.64	0.68
BOP	0.69	0.65
Recession	0.63	0.75

SmithKline UK (Sensodyne brand). Subjects were instructed to use one device for either the right side or left side, as randomly assigned, and the other device on the contralateral side. Training was accompanied by written instructions. For compliance, the subject was given a printed reminder (FLOSS – BRUSH, or BRUSH – FLOSS), to fix on the bathroom mirror, showing which instrument to use on each side of the mouth. Subjects were also given a diary sheet on which they were asked to tick off each day when they had cleaned their teeth.

After instruction, as much supragingival calculus as necessary for reasonable application of the assigned device was removed. All procedures concerning instruction and cleaning were performed in the absence of the examiner (TW), keeping the recordings blind throughout the study. After one month, the examination was repeated. A questionnaire was given to all subjects concerning their perception of ease in using the two devices. Patients were asked also whether they had any problems regarding to the usage of the two devices, and were informed which device had performed better in their mouth.

Compliance

All patients returned the diary paper on which they had marked off days as they cleaned their teeth. Nine patients had ticked all days of the study period, and one had left out one day.

Statistical analysis

The mean plaque and bleeding indices, PD and attachment level were calculated for each regimen in each patient at baseline and one month. The percentage of sites in PD categories was computed for each regimen at baseline and one month. PD was divided into 2 categories: 1–3 mm and ≥ 4 mm. An analysis was undertaken of differences in all scores at baseline between IDB and DF, differences in all scores at one month with baseline covariates by repeated measures analysis of variance, and longitudinal differences in all scores with both regimens.

Power of the trial

A calculation based on the data of this trial gave the probability of type 2 error (β) as 20% for a difference of 20%. The power of the trial (1-β) was therefore 80%.

RESULTS

Plaque scores were reduced, both supra- and sub-gingivally, in both groups as the study progressed (Table 3). At baseline, for instance, the mean supragingival plaque score for the sites where IDB were used (IDB sites) was 14.5, and at one month, this was 5.7. Table 3 also shows mean differences in the same parameters from first to second visits. For instance, the mean difference for supragingival plaque between visit 1 (at baseline) and visit 2 (at one month) was 58.43 for IDB sites and 50.21 for DF sites, whereas for subgingival plaque, the mean difference between visit 1 and visit 2 was 57.91 for IDB sites and 50.18 for DF sites. Results of statistical tests are also given for the data in Table 3. For instance, with both OH regimens, supra- and sub-gingival plaque scores at one month were significantly lower than at baseline ($p < 0.001$). There was, however, no significant difference between supra- and sub-gingival plaque scores at visit 2 ($p = 0.77$, and $p = 0.37$).

Most of the IDB changes between visits reached statistical significance, but most of those with DF did not. There were no significant differences between techniques, although the recession difference approached this ($p = 0.054$).

Patient questionnaire

On a four-point scale, 1 patient found IDB to be very easy to use, 8 considered it easy, 1 considered it difficult, and none considered it very difficult. Respective scores for DF were 1, 5, 4 and 0. Comparing IDB and DF, 7 patients preferred the former, 2 the latter, and one had no preference.

The problems listed for use of IDB in response to an open question were that it tended to bend, buckle and distort, while for DF, some patients suggested it sometimes stuck between teeth, and might cause soreness, but sometimes was easier to use on anterior teeth.

Table 3 Mean ± standard deviation (SD) for all variables measured at both visits, and mean percentage differences between visits.

Parameter measured	Visit 1		Visit 2		% Difference	
	IDB	DF	IDB	DF	IDB	DF
Supragingival plaque	14.5 ± 4.79	12.9 ± 4.53	5.7*** ± 2.21	5.3*** ± 3.06	58.43 ± 15.1	50.21 ± 36.75
Subgingival plaque	17.3 ± 4.08	16.7 ± 3.59	6.7*** ± 2.36	8.1*** ± 3.84	57.91 ± 23.57	50.18 ± 24.59
BOP	11.3 ± 4.16	10.3 ± 4.22	5.6** ± 4.79	8.1 ± 5.06	44.39 ± 51.38	17.24 ± 39.47
Mean PD	3.07 ± 0.7	3.43 ± 0.9	2.68** ± 0.53	2.9 ± 0.72	11.72 ± 7.77	12.23 ± 20.28
% Sites >3 mm PD	26 ± 20.38	29.5 ± 22.78	13* ± 16.7	21 ± 26.33	61.78 ± 40.03	35 ± 46.1
Mean recession	-1.24 ± 0.34	-1.3 ± 0.42	-1.13 ± 0.47	-1.32 ± 0.61	11.36 ± 19.13	1.1 ± 25.7
Mean probing attachment level	1.77 ± 0.38	1.84 ± 0.33	1.54 ± 0.35	1.48* ± 0.44	10.64 ± 22.75	19.42 ± 21.68

** p < 0.05*
*** p < 0.01*
**** p < 0.001*

DISCUSSION

The present study has shown no difference between DF and IDB used as proximal tooth cleaning aids, even when subgingival plaque is considered. It confirms previous studies on supragingival plaque (Bergenholtz and Olsson, 1984; Christou et al, 1998; Kiger et al, 1991), as well as the study by Waerhaug (1976), which showed a potential for these brushes to clean subgingivally.

This short-term study was designed to investigate whether the use of IDB can be more or less effective than the use of DF during the hygienic phase of periodontal therapy. In order to eliminate bias, the present study compared the use of DF with that of IDB in untreated patients prior to subgingival debridement. Most previous studies gave subjects subgingival debridement prior to the investigation. It has been suggested that the effect of mechanical debridement may mask small beneficial effects when adjunctive treatments are tested as a part of therapy (Timmerman et al, 1996).

In addition, the present study included subgingival plaque score as a measured parameter. The assessment of subgingival plaque is not a usual part of clinical examination, and it was decided to use DF to assess this. There is a limitation, in that floss will not enter subgingival tooth concavities. However, most of the teeth examined in this study had minimal attachment loss (Table 3) and no concavities were detected while probing. Subgingival plaque was detected more frequently than supragingival plaque (Table 3), which suggests that concavities played a minimal part in this study.

Smokers were excluded from the present study. There is evidence that smokers have less, or delayed, gingival bleeding when compared with non-smokers (Newbrun, 1996). Past smokers were also excluded (Dietrich et al, 2004). This was in contrast to all previous studies where authors presented results of the use of the devices without taking into account the effect of smoking on BOP (bleeding on probing).

In the present study, comparisons have been made between baseline and one-month measurements. Statistically significant, but small, changes occurred in supra- and sub-gingival plaque scores in both OH regimens, while statistically significant changes in PD and BOP occurred only in IDB sites (Table 3). This may be the result of subject selection and study design. Only one visit of professional OHI (oral hygiene instruction) was scheduled, which may not be sufficient to obtain an adequate level of OH. In the present study, the supragingival plaque score was reduced from 14.5 to 5.7 for IDB sites, and from 12.9 to 5.3 for DF. At the same time, the subgingival plaque score was reduced from 17.3 to 6.7 for IDB sites and from 16.7 to 8.1 for DF sites (Table 3).

In the present study, the use of IDB resulted in significant reduction of bleeding and PD but DF did not. There is a well-established correlation between reduction of inflammation and reduction of PD. It is possible that when using IDB, a mechanical depression of the interdental papilla is induced, which may cause recession of the marginal gingiva (Badersten et al, 1984). However, there was no significant difference between the effects of the two techniques.

The mean probing attachment level gave an opposite difference. There was no significant difference in mean probing attachment level over 1 month when IDB was used, but the difference with DF was statistically significant (Table 3). One might expect that since

the use of IDB had resulted in significant reduction of BOP and mean PD, there should be more recession on IDB sites and more reduction in probing attachment level. However, the results obtained in the present study proved otherwise.

An attempt to compare results of the most representative studies on effects of OHI before instrumentation (Christou et al, 1998) is problematic because of differences in the design of these studies (length of the experimental period, different frequency of OHI and patient motivation, no standardised use of interdental cleaning devices) and differences in use of indices. However, it seems clear on the basis of these trials and the present study that there is little to choose between DF and IDB for interproximal cleaning. Any choice can therefore be made on other grounds, such as patient preference.

In the present study not only efficacy was investigated, but also the simplicity of the two devices was evaluated. Patient acceptance is a major issue to be considered when it comes to the long-term use of interdental cleaning devices. Subjects reported easier use of IDB than DF, even though some patients claimed that the handles of the IDB were too weak and often bent. Subjects also found that the use of DF was more difficult and technically demanding. No statistical analysis was performed on patients' replies to the open question, because it cannot be known whether they might have agreed or disagreed with each other's comments, but the results were not unexpected.

Taken with the objective results, these patient-centred findings suggest that IDB is more likely to be used efficiently than DF, and highlight ways in which IDB may be improved for patients' benefit. The returned compliance check data suggested that patients were cooperating well with trial procedure, and the results can be trusted.

When the power of the trial to show a 20% difference in plaque scores between methods was calculated on the basis of the 10 patients in this trial, it was found to be 80%. This is an acceptable level for the power of clinical trials, and gives a probability for type 2 error (i.e. wrongly accepting the null hypothesis of no difference between treatments) of 20%. A 20% difference in plaque is a reasonable clinical difference for considering one interproximal cleaning method better or worse than another.

CONCLUSIONS

There was no statistically significant difference in terms of effectiveness between IDB and DF. Most patients preferred IDB as a simpler technique.

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