

Comparison of Four Different Types of Dental Floss in Plaque and Gingival Inflammation Reduction

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Abstract

The aim of this study was to assess whether a reference manual toothbrush alone and in conjunction with variable width of floss would have different efficacy in plaque removal or result in different amounts of reduction of gingival inflammation. The randomized, controlled, double blind examiner, two-period crossover study examined floss efficacy in 34 healthy subjects following use of a standardized manual toothbrush alone and in combination with four floss products (Oral B[®] Essential floss, Oral B[®] Satin floss, Sparkle[®] expanded floss, Paldent[®] expanded floss). The gingival index score (Löe and Silness) and Rustogi Modified Navy plaque index score were examined. The results presented that mean gingival index score reductions (baseline minus endpoint) were as follows: 0.4628, 0.5005, 0.3818, and 0.3923 for the toothbrush in combination with Oral B[®] Essential floss, Oral B[®] Satin floss, Sparkle[®] expanded floss, and Paldent[®] expanded floss, respectively. Mean plaque reductions in floss contact areas were as follows: 0.3475, 0.3096, 0.3159, and 0.198 for toothbrush in combination with Oral B[®] Essential floss, Oral B[®] Satin floss, Sparkle[®] expanded floss, and Paldent[®] expanded floss, respectively. No statistically significant differences were found between any pairs of floss. All four floss treatments showed greater ($p < 0.05$) plaque removal and reduction in gingival inflammation than toothbrush alone. In conclusion, all four floss products in combination with a manual toothbrush removed plaque significantly better than the toothbrush alone. Among floss types, there were no significant treatment differences.

Keywords: Clinical trial, Dental floss, Gingival inflammation, Plaque control

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Introduction

Present day, it has become common knowledge that the presence and persistence of dental plaque is associated with inflammatory periodontal disease.¹⁻³ Dental plaque is defined clinically as a structured, resilient, yellowish grey substance that adheres tenaciously to the intraoral hard surfaces. It is primarily composed of bacteria in a matrix of salivary glycoproteins and extracellular polysaccharides.³ Mechanical removals, more specifically tooth brushing in conjunction with flossing, remains the primary method of controlling supragingival accumulations.⁴ Tooth brushing alone does not effectively reach the interproximal areas of the dentition thus necessitate the use of dental floss to clean these areas.⁴ As interdental spaces are difficult to access, soft and/or hard deposits tend to accumulate in these areas in almost all patients. In addition, periodontal and gingival lesions are predominantly observed at these sites.^{4,5} Therefore, interproximal cleaning represents an important aspect of oral self-care and dental floss has a positive effect on the removal of plaque. Nevertheless, questions of what kind of floss would be most effective in the removal of interdental plaque or whether there is any statistically significant difference between different types of floss still remain unanswered.

There have been previous studies comparing different floss types, each using various designs and plaque indices, and these studies all demonstrated that floss had efficacy at plaque removal; however, significant difference between floss types were not found.⁶⁻⁹ Nevertheless, there is limited number of reported trials available comparing efficacy of different commercial flosses and there is a continually growing number of new interdental cleaning aids in the market. Additional research is warranted to evaluate the relative plaque removal benefits of common floss types.¹⁰ Understanding the impact of floss design (material, coating, shape, etc.) on gingival health provides evidence to help dental professionals make informed home care recommendations

to patients.

The aim of this study was to assess whether a reference manual toothbrush alone and in conjunction with variable diameters of floss would have different efficacy in plaque removal or result in different amounts of reduction of gingival inflammation.

Materials and Methods

The study proposal was approved by the Ethical Committee Board of Rangsit University (RSEC 15/2014). This randomized controlled clinical study was conducted on University students of Rangsit University, age range of 18 to 25 years. In total 34 participants with excellent health (14 male and 20 female) were randomized recruited into the study. Written informed consent was obtained from all the participants. The dentition was further screened for a minimum of 20 natural teeth with closed contacts (excluding 3rd molars) and for mild to no visible calculus accumulations. Each test site consisted of two adjacent teeth with unrestored interproximal surfaces with closed contact and without caries. However, restorations were permissible if they did not interfere with plaque as determined by examiner discretion. Probing depths at all four sites within each interproximal unit test site were less than 4 mm.

The study was based on a single examiner-blind, randomized cross over design to examine the efficacy of the four dental flosses in reduction of plaque and inflammation after a period of home use. The parameter measurements were repeated on one randomly selected participant for each five participants in order to estimate the intra-examiner reliability by calculating the intraclass correlation coefficient, which was found to be 0.84. The study was divided into two sessions, in the first session testing two flosses and in the second session testing another two by means of a randomized split mouth technique (Fig. 1). Eligible participants were determined

at the entrance visit. At the entrance visit, an oral hard and soft examination, together with a medical history review, entrance Loe and Silness Gingival Index (GI)¹¹

and Rustogi Modified Navy Plaque Index score (RMNPI)¹² (Fig. 2) were conducted and recorded.

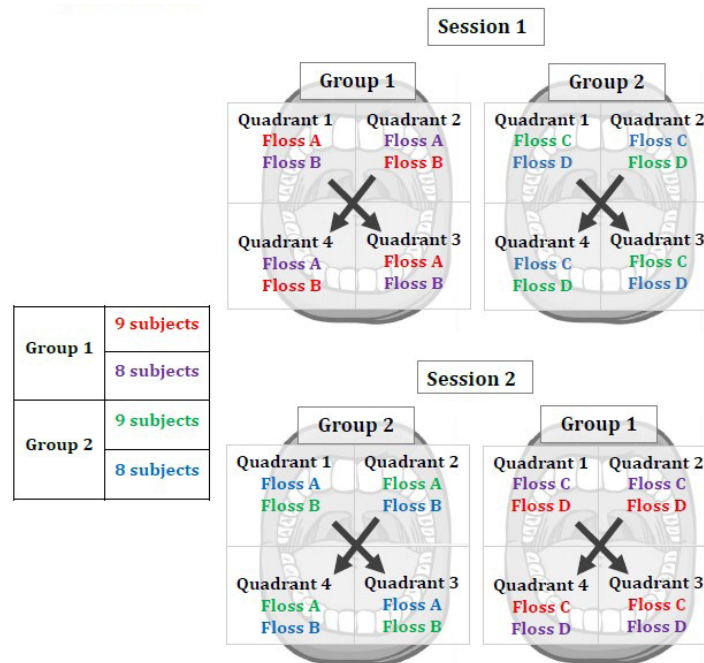


Figure 1 Split mouth design. First session: 9 participants from group 1 were asked to use dental floss A for quadrant 1, 3 and dental floss B for quadrant 2, 4. Eight participants from group 1 used dental floss A for quadrant 2, 4 and dental floss B for quadrant 1, 3. This protocol was also applied to group 2. Nine participants were asked to use dental floss C for quadrant 1, 3 and dental floss D for quadrant 2, 4. Eight participants used dental floss C for quadrant 2, 4 and dental floss D for quadrant 1, 3. After 2-week wash-out period, this shuffle protocol was conducted to second session too.

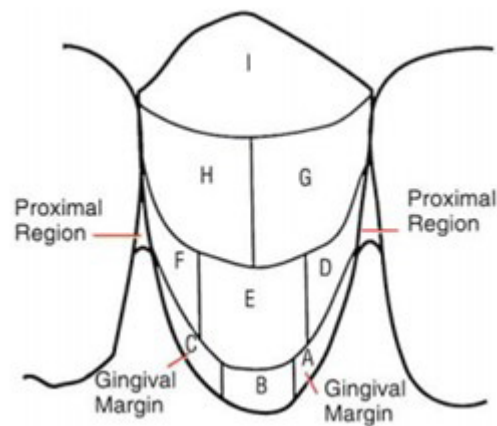


Figure 2 Rustogi Modified Navy Plaque Index (1992)¹². Plaque is assessed for each tooth area (A through I) and scoring as 0 = absent, and 1 = present. In this study, only area A, C, D and F were recorded as these are the areas contacted during proper flossing technique. (Modified from Rustogi KN et al. 1992)

At the next visit, qualified subjects were randomized into 4 groups by simple random sampling method (picking lots). They were each given a standard toothbrush and toothpaste (Colgate® Total Pro gum health) and taught the Modified Bass Technique by means of a standard video and written instruction. They were required to use only the products given twice each day and to abstain from other oral hygiene products, including flossing, for two weeks. The following studied flosses were assigned to each group:

- A: Waxed, Nylon, width 0.75 mm (Oral B® Essential Floss)
- B: Waxed, Silk, sponge and expanding width 1-5 mm (Sparkle® White Dental floss)
- C: Waxed, Nylon, width 1.6 mm (Oral B® Satin floss)
- D: Waxed, Nylon, sponge and expanding width 1-3.5 mm (Paldent® Spongy floss)

After this, a new baseline was taken. This new baseline measured their GI, and RMNPI scores. At this visit, the first two flosses were given to the participants for use for three weeks, with random designations between patients of the two flosses for two quadrants each. From this point on, the participants were required use only the previously provided toothbrush and toothpaste twice a day, the designated dental floss once a day, and to abstain from other oral hygiene products for the duration of the study. They were taught the ADA flossing technique by demonstration on a model and given written instructions.

At the next visit, the subjects' RMNPI, and GI scores were re-assessed. Following, there was a two-week wash-out period where they abstained from flossing. During this wash out period, subjects continued to use the provided toothbrush and toothpaste, but abstain from flossing. At the next visit, a second baseline was taken, and the remaining two flosses were given to the subjects. Likewise, a randomized split mouth technique was used. After the course of three weeks, the subjects' RMNPI, and GI scores were recorded again.

Statistical Analysis

Following data collection, Kolmogorov-Smirnov test was used to test normal distribution in all data sets. As all data sets were normally distributed, paired *t*-tests were used to compare baseline RMNPI and GI scores and endpoint RMNPI and GI scores within groups. Subsequently, analysis of variance (ANOVA) was used to compare treatment for baseline RMNPI and GI scores and endpoint RMNPI and GI scores of the four groups. The Tukey test was used as the post hoc test. All statistical tests were two-sided and used a significance level of $p < 0.05$.

Results

Tooth brushing in conjunction with flossing, regardless of the floss used, demonstrated a statistically significant decrease in plaque and gingival scores in comparison to tooth brushing alone as shown in table 1-5. However, there were no statistically significant differences between any floss group means for either GI or RMNPI as determined by one-way ANOVA (GI $p = 0.081$; RMNPI $p = 0.234$). Similarly, the proximal GI, and separated mesial and distal GI also showed no statistically significant differences between any floss groups as determined by one-way ANOVA (Proximal GI $p = 0.715$; Mesial GI $p = 0.937$; Distal GI $p = 0.752$). However, there was a statistically significant difference between floss groups for cervical RMNPI as determined by one-way ANOVA (Cervical RMNPI $p = 0.49$). Post hoc analyses were conducted given the statistically significant omnibus ANOVA F test. Specifically, Tukey tests were conducted on all possible pairwise contrasts.

Ultimately no pairs of groups were found to be significantly different. The incisal RMNPI also showed no significant difference between floss groups. Additional tests were conducted, yet all yielded the same results and demonstrated no statistically significant difference between floss groups.

Table 1 The comparison of the reduction of mean gingival index scores

Total GI	N	GI (mean ± SD)		
		Baseline Score	Endpoint Score	Difference
Floss A	34	0.691 ± 0.168	0.228 ± 0.199	-0.463**
Floss B	34	0.714 ± 0.160	0.214 ± 0.197	-0.500**
Floss C	34	0.680 ± 0.220	0.298 ± 0.142	-0.382**
Floss D	34	0.694 ± 0.189	0.302 ± 0.125	-0.392**

** means a statistically significant difference was found between the baseline and endpoint (p value = 0.001)

Table 2 The comparison of the reduction of mean Rustogi Modified Navy Plaque Index scores at contact areas A, C, D and F (mean MPI)

Total RMNPI	N	(mean ± SD)		
		Baseline Score	Endpoint Score	Difference
Floss A	34	0.753 ± 0.109	0.406 ± 0.297	-0.347**
Floss B	34	0.719 ± 0.135	0.409 ± 0.277	-0.310**
Floss C	34	0.734 ± 0.149	0.418 ± 0.258	-0.316**
Floss D	34	0.647 ± 0.158	0.449 ± 0.241	-0.198**

** means a statistically significant difference was found between the baseline and endpoint (p value = 0.001)

Table 3 The comparison of the reduction of Incisally-located RMNPI scores at contact areas (areas D and F, see in Fig 2)

Incisal MNPI	N	mean ± SD		
		Baseline Score	Endpoint Score	Difference
Floss A	34	0.778±0.106	0.452±0.326	-0.326**
Floss B	34	0.758±0.110	0.443±0.304	-0.315**
Floss C	34	0.736±0.151	0.502±0.280	-0.234**
Floss D	34	0.704±0.150	0.508±0.270	-0.196**

** means a statistically significant difference was found between the baseline and endpoint (p value = 0.001)

Table 4 The comparison of the reduction of Cervically-located RMNPI scores at contact areas (areas A and C, see in Fig 2)

Cervical RMNPI	N	mean ± SD		
		Baseline	Endpoint	Difference
Floss A	34	0.733±0.135	0.360±0.277	-0.373**
Floss B	34	0.684±0.174	0.375±0.258	-0.309**
Floss C	34	0.596±0.221	0.409±0.225	-0.187**
Floss D	34	0.590±0.189	0.385±0.216	-0.205**

** means a statistically significant difference was found between the baseline and endpoint (p value = 0.001)

Table 5 The comparison of the reduction of proximal GI scores

GI proximal	N	mean ± SD		
		Baseline	Endpoint	Difference
Floss A	34	0.708±0.242	0.238±0.210	-0.470**
Floss B	34	0.792±0.261	0.268±0.193	-0.524**
Floss C	34	0.776±0.224	0.319±0.155	-0.457**
Floss D	34	0.761±0.142	0.278±0.191	-0.483**

** means a statistically significant difference was found between the baseline and endpoint (p value = 0.001)

Discussion

The use of dental floss has been general accepted as an effective method for interdental plaque removal.¹³⁻¹⁴ In the current market, dental flosses come in a variety of shapes and materials. Based on dental floss material, dental floss may be composed of nylon, Teflon, or silk. Furthermore, these flosses may be waxed or unwaxed.¹⁵ Waxed flosses have a light wax coating which helps makes it less likely to break but may make it harder to use in tight spots. Unwaxed flosses better fit into tight spaces; however, they are more prone to shedding or breaking. Nylon is defined as a fiber forming substance of a long-chain synthetic polyamide. It is made of about 35 strands twisted together. Teflon is the trade name of a polymer of polytetrafluoroethylene (PTFE). The polymer is melted into a paste and stretched into a long, thin strand. The polymer is then expanded into one or more directions. Silk is a natural protein fiber that has soft texture with very low abrasion. Other types of floss include is expanding floss and super floss. They tend to be composed of texturized yarn. A textured yarn is comprised of long, parallel filaments, which are lightly twisted or interlaced to give coherence. This technology was adapted in the production expanding dental floss, which uses interlaced filaments to increase the bulk of floss. Initially, as the floss is coated with wax, it will have a smaller diameter, similar to that of typical floss. However, contact with saliva will cause the floss to expand. Additionally, friction caused by

running the floss between teeth can also cause this type of floss to expand. This expansion is believed to produce better results and more effective flossing, as expanding flosses are thought to clean more surfaces and wider spaces more thoroughly than other types of floss. Super flosses are also made from yarn-like material but have stiffer sections on each end that can be used to clean around braces or dental bridges.

The finding of this study concurred with those of previous studies in that there was a significant difference between toothbrushing alone and toothbrushing in conjunction with flossing.^{12,16-20} It is evident that plaque control by tooth brushing alone is not sufficient in maintaining gingival health and that it needs to be used in conjunction with dental aids. Interdental cleansing aids such as flosses, interproximal brushes, etc. are recommended for routine oral hygiene practice (WHO).²¹ Previous clinical studies have compared the difference in plaque removal between waxed and unwaxed floss by Lamberts *et al*¹⁷, the effectiveness of variable diameters with unwaxed floss⁸, waxed floss, dental tape, and Superfloss¹⁶, nylon waxed and expanded polytetrafluoroethylene-type floss by Ciancio *et al*⁶, toothpicks, single-tufted brush, and dental floss¹⁹, traditional floss and a flossette and a pick by Cronin & Conforti²⁰, plaque removal efficacy between unwaxed, woven, shred-resistant floss, and a powered flosser by Terezhalmay *et al*⁹ presented no statistically significant

differences were found between groups. The study by Gjeremo & Flotra¹⁹ concluded that there was a significant difference between dental floss and toothpicks, with dental floss achieving the superior outcome. It was also found that dental floss and interdental brushes proved to be appropriate for different scenarios. Interdental brushes being well-suited to wide interdental spaces. Accordingly, case evaluation is imperative for recommendation of the most appropriate interdental appliance. In the study by Terezhalmay *et al*⁹, reported no significant difference was found between the conventional floss groups. However a statistically significant difference was found between the powered flosser and conventional flosses. The powered flosser may prove to be an interesting option in future recommendations for patients; however, its availability and price may prove to be an obstacle and limitation.

Findings from this clinical study contribute to the current literature on interdental cleaning aids, a body of research that is relatively sparse compared to reports on toothbrushes and other plaque-control products. With the growing number of innovations in dental floss products, evaluations of their comparative effectiveness are needed to assist dental professionals in making evidenced-based recommendations. However, additional research is needed to establish a clear relationship for specific flossing aids. Based on the research available, it can be concluded that when giving advice for dental care for interdental areas, it is adequate to allow the patient to use any floss of their preference, to allow ease of use and mouth comfort. Nonetheless, the importance of patient compliance cannot be reiterated enough as flossing frequency, duration, technique, and consistency are recognized to affect “real world” results. Thus, the role of oral hygiene instruction is vital in the maintenance of periodontal health and prevention of interproximal caries. It is important to note that the conventional dental floss may not be the ideal interdental aid for every interproximal site and scenario. Each patient and interproximal scenario should be evaluated

separately and recommendations should be made accordingly.

Conclusion

All four floss products in a variety of shape, used after brushing with a manual toothbrush, resulted in a significantly greater reduction of plaque and gingival inflammation in comparison to the toothbrush alone. However, no significant differences were found between four floss types.

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