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ORIGINAL ARTICLES

Sham Plaque Removal Efficacy by Three F Shaped Dental Floss Products

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Conventional toothbrushes are not sufficient for removing plaque, especially at the interproximal region, however, dental floss as adjuncts to dental hygiene provides a great benefit for disrupting the oral biofilm in the interproximal areas. The objective of the present study was to compare the sham plaque removal ability of dental floss products have used a laboratory method.

Three kinds of F-shaped dental floss products used in this study. A, polyester and bundles of many thin filaments; B, Teflon and single wide tape; and C, nylon and bundles of many thin filament. A plaque-like substrate was placed in the interproximal area of the artificial teeth. The floss product to be evaluated was affixed to the flossing simulator and placed around interproximal surfaces of plaque-covered incisor and/or molar teeth extending to a 90° angle. A 200g force was applied to the floss. The flossing simulator was adjusted to provide a flossing stroke of 10 mm (incisor) and 6 mm (molar) at a rate of 10 strokes per minute for a duration of 30 seconds. The results were photographed, and the cleaning effectiveness were calculated for each picture by computer digital image analysis. This test was repeated five times for each dental floss that was evaluated. The resulting data were analyzed using ANOVA and Scheffe's test ($p<0.05$) .

As a result, floss A had significantly greater than floss B in the interproximal sham plaque removal maxillary central incisors. There were no statistically significant differences between floss A and floss C in the interproximal sham plaque removal at maxillary central incisors. There was no statistically significant difference among the three dental floss products at maxillary right second premolar. The rate of plaque removal was highest with floss A that gave a significant greater removal of the sham plaque than the other two dental floss on the maxillary right first molar.

These results suggest that dental floss A was more effective in interproximal plaque removal in this in vitro model used for determining of used three F-shaped dental floss products.

Key words : F shaped dental floss product, interproximal area of the artificial teeth, sham plaque removal

INTRODUCTION

Plaque control on interproximal surfaces is important for the prevention and control of progression of dental caries and periodontal disease, but it is impossible to completely remove plaque on the interproximal surfaces by oral cleaning using a tooth brush alone[1)]. Plaque on interproximal surfaces is considered to be removed efficiently by the concomitant use of dental floss and an interdental brush[2-5)]. Also, concerning studies in which the dental floss and interdental brush were compared, there have been reports that the

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interdental plaque removing effect was significantly greater with the interdental brush in patients with moderate to severe periodontal disease having wide interdental spaces[6] and that the plaque removal rate was higher with the interdental brush than with dental floss[7, 8]. However, in a study in which sham plaque was attached to the interproximal surfaces of artificial molars on a jaw model, third-year students at a dental hygienist school were made to perform interdental cleaning, and the plaque removal rate was evaluated. The removal rate of sham plaque was reported to be higher with floss used by winding it around the finger than with floss with a holder or interdental brush[9].

According to a questionnaire survey about the use of dental floss and interdental brush in people aged 15-89 years (494 males and 475 females), 30% of the subjects routinely used dental floss, and 28% used the interdental brush, and more than half those who practiced interdental cleaning answered that they began it on the advice of a dental clinic[10].

The shape of the threads of dental floss (filaments) varies widely, and they are roughly classified into those with a holder and those wound around the finger for use. The floss holders are either F-shaped or Y-shaped, and since the floss and the holder are integrated, it is considered to circumvent the difficulty of holding the floss with fingers and keeping it tight to facilitate its insertion into the interdental space. However, plaque cannot be removed effectively if floss is inserted into the interdental space unless it is contacted well with the dental surface. Although various types of dental floss are marketed by many companies, they are not widely used, and reports of studies that compared the plaque removal rate among products have been few. In this study, therefore, we mounted artificial teeth coated with sham plaque on a jaw model, flossed them with 3 types of commercial F-shaped dental floss with a holder using a flossing machine, and evaluated sham plaque removal from the interproximal surfaces of the artificial teeth.

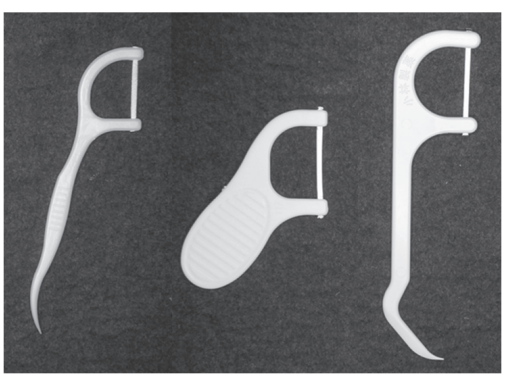
MATERIALS AND METHODS

1. Evaluation of sham plaque removal from interproximal surfaces

The following three types of F-shaped dental floss were used: polyester and bundles of many thin filaments (A), Teflon and single wide tape (B), and nylon and bundles of many thin filaments (C) (Fig. 1).

Artificial bilateral maxillary central incisors, maxillary right second premolar, and maxillary right first molar (A-PS03A, INVICTUS standard model for dentistry training, NISSIN, Kyoto, Japan) were used. Sham plaque was prepared by coating each artificial tooth with an aerosol spray for occlusal marking (Occlude, Pascal, Bellevue, WA, USA). The coated artificial teeth were set in a jaw model (INVICTUS standard model for dentistry training, NISSIN). The contact relationship was adjusted using a contact gauge to permit setting at 50 μm with resistance but not to permit setting at 110 μm. Each F-shaped dental floss was fixed on the jig of the flossing machine (Taiheikogyo, Yao, Japan) (Fig. 2).

The dental floss was inserted at an insertion angle of 90° between the interproximal surfaces between the bilateral maxillary central incisors and between the maxillary right second premolar and first molar with a load of 200 g over a flossing stroke of 10 mm in the central incisor region and 6 mm in the molar region from the top of the tooth surface to 1 mm below the gingival margin. Flossing was performed with 5 vertical strokes of pulling up the floss after bringing it into contact with the tooth neck by shifting it about 1.5 mm to the left or right at a rate of 10 strokes/minute (n=5). Thereafter, the interproximal surface of each artificial tooth was photographed using a digital microscope (VH-6200, KEYENCE, Osaka,



A B C

Fig. 1 Three kinds of F-shaped dental floss product used in this study.
(polyester and bundles of many thin filaments (A), Teflon and single wide tape (B), and nylon and bundles of many thin filament (C))

Japan) to obtain cephalometric data. The sham plaque removal area was measured from the cephalometric photograph data of the artificial teeth using image analysis software (NIH Image J) and analyzed by one-way ANOVA and a multiple comparison test (Scheffé, $p<0.05$).

2. Morphological observation of dental floss

The condition of the surface of the filaments of each dental floss was examined under a digital microscope (C-FMC 1005317, Nikon, Tokyo, Japan) and scanning electron microscope (SEM, S-4500, Hitachi, Tokyo, Japan) at a magnification of × 40 and an accelerating voltage of 5 kV.

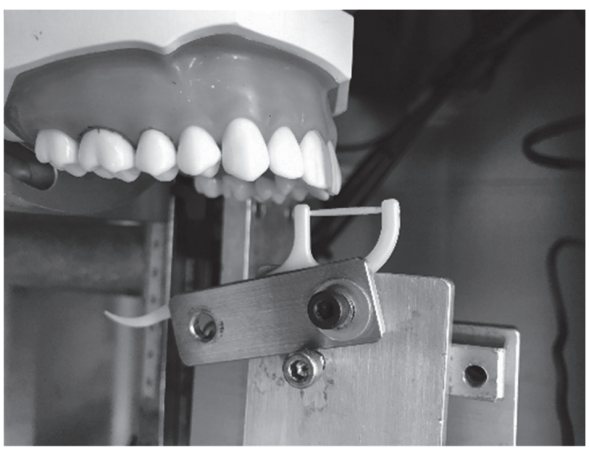


Fig. 2 Flossing machine used to measure the sham plaque removal.

RESULTS

Fig. 3 shows representative cephalometric photographs of the interproximal surfaces of each artificial tooth after flossing. Sham plaque was removed with each dental floss near the labiolingual center, which is the contact point of the interproximal surfaces, and in the region of widest contour centering around the 1/4-1/5 from the crown side in the vertical direction in both the bilateral maxillary central incisors (11, 21). In the maxillary right second premolar and maxillary right first molar (15, 16), sham plaque was removed in the area about 1/3 from the buccal side in the buccolingual direction, which was the contact point of the interproximal surfaces, and in the widest contour centering around the area 1/3-1/4 from the occlusal surface in the vertical direction.

As shown in Fig. 4, the area of sham plaque removal on the interproximal surface after flossing using each dental floss was 14.9±3.4 (mean±SD, mm^2) with floss A, 8.9±2.0 with floss B, and 10.9±3.3 with floss C in the mesial interproximal surface of the maxillary left central incisor (11), with the value being significantly greater for A compared with B. In the mesial interproximal surface of the maxillary right central incisor (21), it was 13.3±2.6 with A, 8.9±2.0 with B, and 11.8±0.6 with C, with the value being significantly greater for A compared with B. In the distal interproximal surface of the maxillary right second premolar (15), it was 14.4±2.7 with A, 11.9±

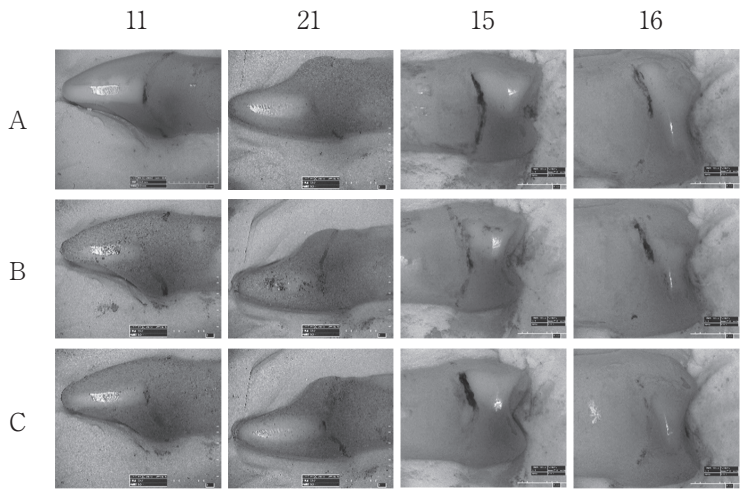
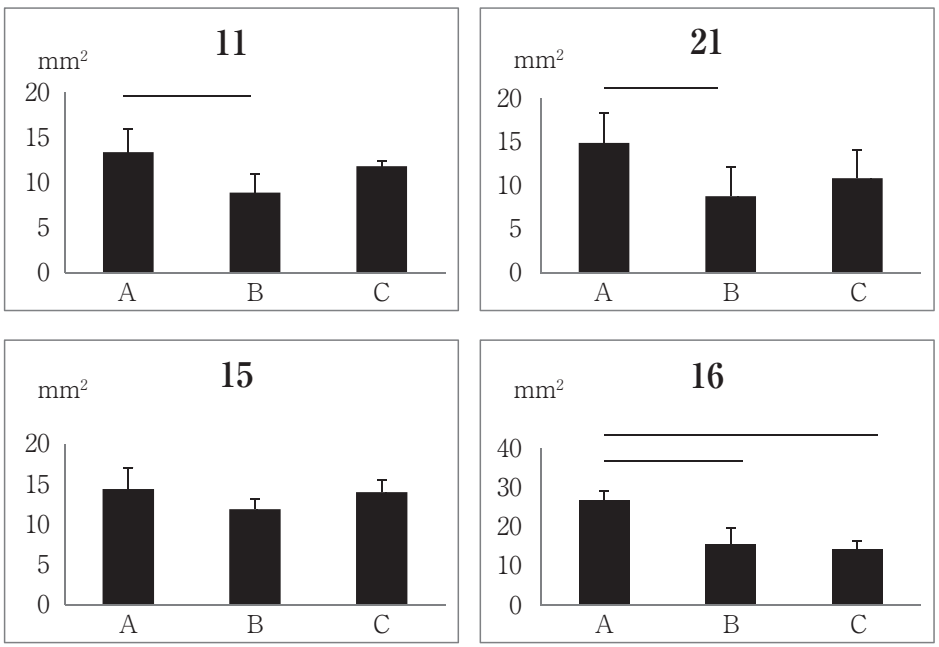


Fig. 3 The representative photographs of sham plaque removal after flossing by using three kinds of F-shaped dental floss product

1.2 with B, and 14.0±1.5 with C, with no significant difference. In the mesial interproximal surface of the maxillary right first molar (16), it was 26.6±2.5 with A, 15.5±4.2 with B, and 14.1±2.3 with C, with significant differences between A and C and between A and B, and was significantly the greatest with A (Fig. 4).

Fig. 5 shows photographs showing the thickness (stereomicroscopic images) and width (SEM images) of various dental floss products. The materials of the filaments of flosses A, B, and C were polyester, polytetrafluoroethylene (commonly called Teflon R), and nylon, respectively, and the filaments were thickest in A, followed by C, and thinnest in B. The vertical width was similar in all 3 products. The



n=5, unit: mm², mean (S.D.), —: $P<0.05$

Fig. 4 The sham plaque removal at interproximal tooth surfaces of maxillary central incisor, maxillary right second premolar and first molar by using different types of F-shaped dental floss product.

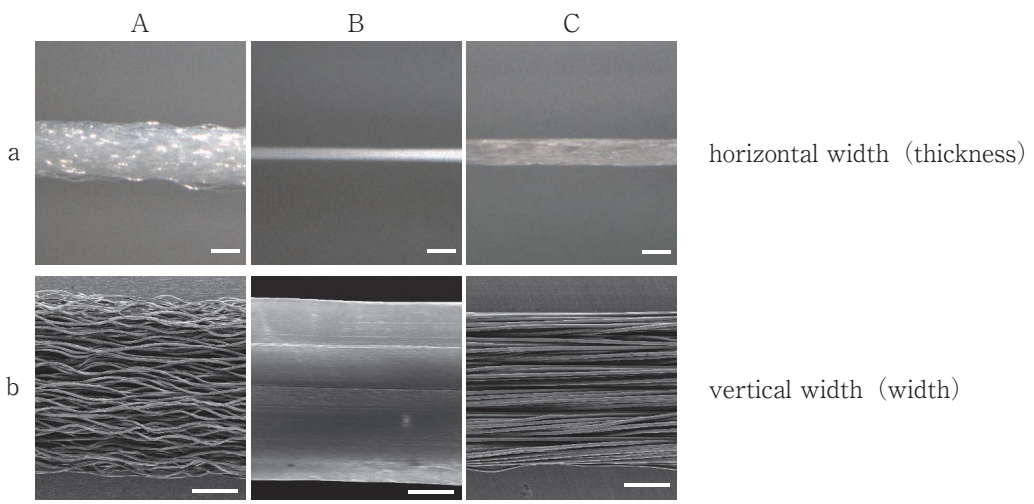


Fig. 5 Stereomicroscope (a) and scanning electron micrograph (b) images of F-shaped dental floss product. (polyester and bundles of many thin filaments (A), Teflon and single wide tape (B), and nylon and bundles of many thin filament (C).). (—: 500μm)

material of the filaments differed among the 3 products. B was a single wide tape, but A and C were bundles of many thin filaments, and the tension and flexure varied among the products.

DISCUSSION

According to the report of an *in vivo* study that compared the plaque removing effect of various types of dental floss from interproximal surfaces, Org compared 3 types of dental floss and observed that plaque was removed more efficiently on the buccal side than on the lingual side or the palatal side, and dental tape was effective[11]. Carr et al.[12] compared 4 types of dental floss and reported that there was no significant difference in the plaque removal rate. Terazhalmy et al.[13] also compared 4 types of dental floss and reported that the electric-powered floss was the most effective. However, according to the reports of *in vitro* studies that compared the plaque removal rate from interproximal surfaces, Yankell et al.[14] compared 3 types of dental floss and reported that GUM Expanding Floss, in which thin filaments spread, was excellent. Thus, the efficiency of interdental cleaning using dental floss is considered to depend on how the patient handles the floss (handling skill), morphology of the interproximal surface[15, 16], and the characteristics of the floss itself.

Therefore, in this study, 3 types of F-shaped dental floss were operated mechanically using a flossing machine to minimize the effects of the handling skill and morphology of the interproximal surface, and the plaque removing effect on interproximal surfaces was compared using artificial teeth, the interproximal surfaces of which were covered with sham plaque, mounted on a jaw model. Clinically, F-shaped dental floss is suited for removing plaque from the interproximal surfaces of front teeth, and Y-shaped dental floss is suited for removing plaque from the interproximal surfaces of the molar region, but F-shaped dental floss was used for both frontal and molar teeth because of the use of fixing a dental floss to the flossing machine. The sham plaque removal area with the 3 types of dental floss examined showed no significant difference between A and C in either the right or left maxillary central incisor but was significantly higher with A than with B. The plaque removal area showed no significant difference among the 3 types of dental floss in the maxillary right second premolar but was greatest with A, with significant differences compared with B and C, in the maxillary right first molars. Thus, the plaque removing effect from the interproximal surfaces was considered to have been high with A compared with B and C, because A passed through the contact point more smoothly, fitted the tooth surface better because of the flexure of many fine filaments, and was easier to manipulate along the tooth surface. Therefore, the interproximal surface cleaning effect of dental floss is considered to depend on the material, tension, and flexure of the filaments of dental floss itself. For the future, we will compare the *in vivo* plaque removing effect of these 3 types of dental floss from interproximal surfaces and report the results.

CONCLUSION

The plaque removing effect of dental floss on the interproximal surfaces was compared in artificial teeth covered with sham plaque and mounted on a jaw model by mechanically manipulating dental floss using a flossing machine. Judging from the sham plaque removal area with 3 types of F-shaped dental floss, product A showed the best plaque removing effect.

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The authors declare no conflicts of interest associated with this manuscript.

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REFFERENCES

1) Bergeholy A, Gustafsson LB, Segerlund N, Hagberg C and Ostby N. Role of brushing technique and toothbrush design in plaque removal. *Scand J Dent Res*. 1984; 92: 344-351.
2) Reitman WR, Whitely RT and Robertson PB. Proximal surface cleaning by dental floss. *Clin Pre Dent*. 1980; 2: 7-10.
3) Kinane DF, Jenkins WM and Paterson AJ. Comparative efficacy of the standard flossing procedure and a new floss application in reducing interproximal bleeding: a short-term study. *J Periodontal*. 1992; 63: 757-760.
4) Christou V, Timmerman MF, Van der Veiden U and Van der Weijden FA. Comparison of different approaches of interdental oral hygiene: interdental brush versus dental

floss. *J Periodontol*. 1998; 69: 759–764.
5) Biesbrock A, Corby PMA, Bartizek R, Corby AL, Coelho M, Costa S, Bretz WAG and Bretz WA. Assessment of treatment responses to dental flossing in twins. *J Periodontol*. 2006; 77: 1386–1391.
6) Jin K, Kawasaki K, Doi T, Uene M and Kanbara M. Plaque removal efficacy of the interdental toothbrush. *J Osaka Dent Univ*. 2015; 49: 179–184.
7) Jackson MA, Kellett M, Worthington HV and Clerehugh V. Comparison of interdental cleaning methods: a randomized controlled trial. *J Periodontol*. 2006; 77: 1421–1429.
8) Sarner B, Birkhed D, Andersson P and Lingstrom P. Recommendations by dental staff and use of toothpicks, dental floss and interdental brushes for approximal cleaning in an adult Swedish population. *Oral Health Prev Dent*. 2010; 8: 185–194.
9) Shinya A, Sato T, Nomoto S and Yotsuya M. Plaque-removing effects of interdental instruments in molar region. *Bull Tokyo Dent Coll*. 2020; 61: 21–26.
10) Kitasako Y, Takagaki T, Ikeda M and Tagami J. Frequency of use of dental floss and interdental brushes among Japanese adults of different ages. *Jpn J Conserv Dent*. 2017; 60: 282–288.
11) Org G. The effective of 3 types of dental floss for interdental plaque removal. *J Clini Periodontol* 1990; 17: 463–466.
12) Carr MP, Rice GL and Horton JE. Evaluation of floss types for interproximal plaque removal. *Am J Dent*. 2000; 13: 212–214.
13) Terezhalmy GT, Bartizek RD and Biesbrock AR. Plaque-removal efficacy of four types of dental floss. *J Periodontol*. 2008; 79: 245–251.
14) Yankell SL, Shi X, Spirgel CM, Gonzalez LA and Cwik J. Laboratory plaque reduction by three floss products. *Am J Dent*. 2019; 32: 267–270.
15) Bergenholtz A and Olsson A. Efficacy of plaque-removal using interdental brushes and waxed dental floss. *Scand J Dent Res*. 1984; 92: 198–203.
16) Smuckler H, Nager MC and Tolmie PC. Interproximal tooth morphology and its effect on plaque removal. *Quintessence Int*. 1989; 20: 249–255.