Plaque removal efficacy of the interdental toothbrush

Koichiro Jin, Koji Kawasaki, Takashi Doi, Masako Uene and Masaki Kambara

Department of Preventive and Community Dentistry, Osaka Dental University, 8-1 Kuzuahanazono-cho, Hirakata-shi, Osaka 573-1121, Japan

Daily oral care is an established part of a healthy lifestyle in Japan. Self-care by tooth brushing is the primary way of cleaning the oral cavity. However, a large amount of dental plaque remains in the proximal areas of the teeth even after brushing. As a result, the use of dental floss or an interdental brush for cleaning areas between the teeth is commonly used to complement oral cleaning.

We compared the red plaque removal efficacy of plaque disclosed with red disclosing solution by an interdental brush with that by a manual toothbrush. Oral examination and quantitative light-induced fluorescence (QLF) were performed and two parameters were analyzed from the digital images: the mean ΔR (%) and the area (mm²) of the plaque. We examined 10 subjects between 20 and 50 years of age who were students and staff members at Osaka Dental University Hospital. The digital image analysis revealed that plaque could be detected in about 33 regions (41.3%) of the 80 proximal areas measured on QLF digital images of the subjects. When using the interdental brush, the mean ΔR in the experimental group was 33% after tooth brushing had been suspended for 3 days, 26% after 7 days (representing a decrease in the mean ΔR of 20%), and 24% after 14 days (a decrease in mean ΔR of 26%). Although the downward trend in mean ΔR was not observed in the controls, it decreased significantly in the experimental group.

The mean area of red plaque after using the interdental brush in the experimental group was 0.18 mm² after 7 days (a decrease in the area of plaque of 71%), and 0.12 mm² after 14 days (a decrease in area of 80%). We found that the mean area of plaque decreased significantly in the experimental group.

These results suggest that when using an interdental toothbrush we could get about 60% more plaque removal efficacy than when only a conventional toothbrush was used. (J Osaka Dent Univ 2015; 49: 179–184)

Key words: Interdental toothbrush; Lifestyle; Oral health promotion

INTRODUCTION

Daily oral care is an established part of a healthy lifestyle in Japan. Generally, oral self-care by tooth brushing is performed for oral cleaning at home and in the workplace. However, it is difficult to remove plaque completely by daily tooth brushing alone. Considerable debris remains in the areas between teeth, especially the molars. If orthodontic appliances, prostheses or bridges are present in the oral cavity, it becomes even more difficult to remove plaque with a conventional toothbrush. Consequently, the use of dental floss or an interdental brush for cleaning between the teeth has recently been used to complement brushing. According to the last evaluation of the Healthy Japan 21 Project (fiscal year 2010), the percentage of people using dental floss or an interdental brush daily were 44.6% for those 40 years of age, and 45.7% for those 50 years old. These rates were about 5% greater than those reported 5 years earlier. The use of dental floss or an interdental brush is steadily increasing. However, the effect of interdental brushes
is only supplementary. If not used properly, their efficacy is inadequate, and there is a possibility of trauma to the interdental tissues.\textsuperscript{5}

Numerous previous studies have reported on the efficacy of plaque removal by interdental brushes.\textsuperscript{3-8} These brushes are different from dental floss because they can only be used in interdental spaces of adequate width. Many studies have reported that increased interdental space is an indication of the progression of periodontal disease. However, a detailed image analysis has not been done to evaluate the removal of plaque that remains and matures on the tooth surface if not removed with an interdental brush. The incidence of dental caries and periodontal disease can be effectively decreased by the removal of the plaque with an interdental brush along with conventional tooth brushing. Moreover, it is valuable for maintaining and promoting overall oral health.

We analyzed the efficacy of plaque removal with the combined use of an interdental brush and a conventional toothbrush. Analysis methods included oral examination and quantitative light-induced fluorescence (QLF) digital images.

**MATERIALS AND METHODS**

**Subjects**

The subjects were 10 men and women between 20 and 50 years of age who were students and staff members at the Osaka Dental University Hospital. To avoid sampling bias due to gender, the male to female ratio was 1 : 1. Subjects who regularly used antiseptic mouth rinses and those on antibiotics were excluded. The research protocol was explained in detail to all the subjects prior to the study and only those who consented to participate were included. This study was approved by the Ethics Committee of Osaka Dental University (Approval No.090501).

**Experimental design**

This research was performed as a parallel-group comparison study over two weeks. The subjects were divided into two groups: one used only a conventional toothbrush (the controls) and the other used an interdental brush along with the conventional toothbrush (the experimental group). This study was performed in the following four stages.

**Stage 1**

QLF (1\textsuperscript{st} measurement) and professional mechanical tooth cleaning (PMTC) were performed in all the subjects after using only a conventional toothbrush. The subjects were then requested to refrain from brushing their teeth for three days.

**Stage 2**

The QLF digital images (2\textsuperscript{nd} measurement) of plaque disclosed with red plaque disclosing solution remaining and maturing on the tooth surfaces were taken three days after the 1\textsuperscript{st} QLF. We then explained the proper use of the interdental toothbrush to the experimental group and they cleaned their teeth with it for seven days. In contrast, the controls used only the conventional toothbrush for seven days. Further guidance and reinforcement of the tooth brushing method by a specialist was not performed in any of the subjects in this experiment.

We requested both groups to brush twice a day, after breakfast and before going to bed, for two minutes each time. They continued this for seven days. We did not restrict or specify the type or amount of toothpaste used. The subjects were requested to refrain from using a mouth rinse during the experiment. Furthermore, we instructed those in the experimental group to brush the interproximal areas using an interdental brush once a day before going to bed, but did not restrict the duration of its use. Subjects were asked to refrain from eating sugary foods or drinking soda.

**Stage 3**

After completion of the seven days of Stage 2, we took QLF digital images (3\textsuperscript{rd} measurement) of the plaque remaining on the tooth surfaces in all subjects. An interdental brush was used daily for the subsequent 7 days by all subjects in the experimental group.

**Stage 4**

Seven days after completion of Stage 3, we took the QLF digital images (4\textsuperscript{th} measurement) of the remaining plaque maturing on the tooth surfaces.
Toothbrushes used in the experiment
Conventional toothbrush
Each subject used his own toothbrush for this experiment.

Interdental brush
A soft interdental brush made by Kobayashi Pharmaceutical was used in the experimental group.

EVALUATION
QLF digital images were exposed and analyzed of the plaque in the proximal areas between the teeth in all of the subjects.

QLF digital images
We took digital images of about 8 areas between the lateral incisors and canines, and between the second premolars, and first molars from the buccal side using a QLF apparatus (Inspector Research System, Amsterdam, the Netherlands).

Analysis of QLF digital images
Two analytical parameters, the mean $\Delta R$ (%) and the area (mm$^2$) of plaque were calculated from the acquired QLF digital images using analytical software included with the QLF 2.0 System (Inspector Research System). The mean $\Delta R$ represents the mean fluorescence strength rate of the disclosed plaque, and the area represents the area of the plaque. An example of the analysis method is indicated in Fig. 1.

Statistical analysis
The t-test was performed to detect the difference in decrease of mean $\Delta R$ (%) and area (mm$^2$) between the experimental and control groups. Statistical analyses were performed using ver.18.0.0 of the SPSS$^1$ statistical analysis software (IBM, Tokyo, Japan) with a significance level of 5%.

RESULTS
Evaluation of QLF digital images of the plaque
Plaque was detected by the QLF digital images in 33 (41%) of the 80 proximal areas that were examined in the 10 subjects.

Analysis of QLF digital images of red plaque
Change in mean $\Delta R$
Changes in the mean $\Delta R$ in the experimental and control groups are shown in Fig. 2. When the interdental brush was used, the mean $\Delta R$ in the experimental group was 33% after tooth brushing was suspended for three days, 26% at 7 days and 24% at 14 days. On the other hand, a downward trend of the mean $\Delta R$ was not observed in the control group.

Decrease in mean $\Delta R$
We examined the decrease in mean $\Delta R$ based on the oral examination (2$^{nd}$ measurement) of the remaining

![Red plaque](image)

$\Delta R$: 42%, Area: 1.24 mm$^2$
Between the maxillary second premolar and first molar.

$\Delta R$: 30%, Area: 0.31 mm$^2$
Between the mandibular second premolar and first molar.

*Fig. 1* Example of analysis of $\Delta R$ (%) and area (mm$^2$) of plaque from a QLF digital image.
plaque maturing on the tooth surfaces (Fig. 3). With use of the interdental brush in the experimental group, the decrease in mean $\Delta R$ was 20% at 7 days and 26% at 14 days. On the other hand, a downward trend in mean $\Delta R$ was not observed in the controls. We found that the decrease in mean $\Delta R$ in the experimental group was significantly greater than in the controls.

Change in area of the plaque
Changes in the area of the plaque in the experimental and control groups are shown in Fig. 4. The area tended to be small in the experimental and the control groups after using the interdental brush for 7 days (3rd measurement). After using the interdental brush, the mean area in the experimental group was 0.18 mm$^2$ after 7 days and 0.12 mm$^2$ after 14 days. On the other hand, the mean area in the controls was 0.90 mm$^2$ after 7 days and 0.85 mm$^2$ after 14 days, when only the conventional toothbrush was used. We found that the decline in area was significantly greater in the experimental group than in the controls.

Decrease in area
The decrease in area was recorded based on the oral examination (2nd measurement) of the remaining plaque maturing on the tooth surfaces (Fig. 5). After using the interdental brush in the experimental group, the decrease in area was 71% after 7 days and 80% after 14 days. The decline in area was significantly greater in the experimental group than in the controls.

Red plaque removal efficacy of the interdental brush
The analysis of QLF digital images of red plaque showed the following results: The decline in both mean $\Delta R$ and the area of plaque was significantly
greater when the interdental brush was used together with a conventional toothbrush as compared with use of the conventional toothbrush alone. We also found that the area of plaque decreased more than the mean ΔR with use of the interdental brush. There was considerable remaining plaque in the interproximal areas after brushing with only the conventional toothbrush. When using an interdental brush together with the conventional toothbrush, the plaque removal efficacy increased about 60%.

**DISCUSSION**

Bias in selection of subjects and study design
Because the subjects were students and staff members of the Dental University Hospital, we assume that they practiced daily oral self-care and had better brushing skills than the average person. The sample size was also small, with only 10 subjects. Therefore, the results obtained by this study should be extrapolated to the general population with caution. A further randomized controlled trial in a larger sample would be necessary to obtain reliable results.

Measurement areas of QLF digital images
Previous studies have reported that plaque is clearly observed between the lateral incisors and canines, and between the maxillary second premolars and first molars. Therefore, we chose these areas for measurement of red plaque by QLF digital images in this research. It is necessary to include samples from similar areas in the mouth to exclude the influence of the subjects' occlusion.

Influence of the type of interdental brush on plaque removal efficacy
Results of this study suggested that when using an interdental brush along with a conventional toothbrush, the plaque removal efficacy in the interproximal areas was increased. Setoguchi et al. reported that bristle length, bristle diameter and the number of bristles of an interdental toothbrush had no effect on plaque removal. On the other hand, Jordan et al. suggested that a straight interdental toothbrush had greater plaque removal efficacy than an angled interdental brush in interproximal areas. Thus, the influence of the type of interdental toothbrush on plaque removal efficacy cannot be ignored. In this study, we used a rubber interdental brush with high flexibility. Recently, electric interdental toothbrushes and air flossing have been developed. Further research is needed to determine the plaque removal efficacy of these new devices.

Effect of use of the interdental brush in elderly persons
Gingival recession causes an increase in the size of the interdental space in the elderly. This increases the risk of root caries. Matsumura et al. reported that when the interproximal space is wide, modifying the direction of brushing with the interdental brush improved plaque removal. When an elderly person uses an interdental brush effectively, root caries can be prevented and the teeth maintained for a lifetime. This may also help extend the healthy life expectancy. This study included subjects between 20 and 50 years of age. Further studies are needed to determine the plaque removal efficacy in elderly persons.

A summary of this paper was presented at the 21st Regular Meeting of the Society for Oral Health in Kinki, Chugoku and Shikoku on June 20, 2010 in Matsue, Shimane prefecture, Japan.

**REFERENCES**
12: 21–23.