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Original Article

A comparison of the elimination rate of artificial dental plaque between reciprocating- and rotating-interdental toothbrushes

Kun-Ok Lim

Department of Dental Hygiene, College of Health Science and Genome-based BioIT Convergence Institute, SunMoon University

Corresponding Author: Kun-Ok Lim, Department of Dental Hygiene, College of Health Science and Genome-based BioIT Convergence Institute, SunMoon University, 70, Sunmoon-ro 221beon-gil, Tangjeong-myeon, Asan-si, Chungcheongnam-do, 31460, Korea. Tel : +82-41-530-2728, Fax : +82-41-530-2766, E-mail : kolim139@sunmoon.ac.kr

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ABSTRACT

Objectives: Interdental toothbrushes are made and sold in various design types and brush thicknesses. However, there is little research on which type of interdental toothbrush currently manufactured and sold on the market is the most effective in eliminating interdental plaque. Therefore, this study aims at comparing the elimination rate of artificial dental plaque between reciprocating- and rotating-types of interdental toothbrush based on the frequency of application and thickness of brush. **Methods:** This study focused on the effective management of dental plaque using interdental toothbrush, a recommended item for personal dental hygiene. The method was as follows: artificial dental plaque coloring was applied to the distal surface of artificial tooth #46 and the mesial surface of #47. The area was subject to reciprocal movement three and six times to eliminate artificial plaque. **Results:** The results showed that using a 0.7mm rotating interdental toothbrush, on the proximal surface of each molar, the elimination rates were: on the distal surface of #46, upon three applications 40.24%, upon six applications 30.41%; on the mesial surface of #47, upon three applications 44.52%, upon six applications 29.72%. **Conclusions:** These results showed that for rotating-type interdental toothbrushes, a high dental plaque elimination rate was observed even though many reciprocal movements were not performed.

Key Words: Dental plaque, Interdental brush, Oral care products, Proximal surface, Rotating-types

Introduction

In South Korea, dental caries and periodontal diseases are the most common oral diseases leading to tooth loss [1]. Periodontal disease develops from gingivitis, and the root cause of gingivitis is dental plaque [2]. The dental plaque is an aggregate of bacteria consisting more than 500 bacterial strains deposited on the surface of the natural or prosthetic teeth [3].

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In general, toothbrushes are used to remove dental plaque. A toothbrush is the most-used tool to remove dental plaque, food residue, and bacteria from the tooth surface [4]. In other words, teeth brushing is the most economical and efficient means of removing dental plaque from the oral cavity [5].

However, a tooth has mesial, distal, buccal, lingual, and occlusal surfaces. Each tooth surface is not just flat but consists of protruding and concave parts. Each tooth has a point of contact where it is attached to the adjacent tooth. Toothbrushes are not very effective in removing dental plaque from the proximal surfaces including contact points, which is a morphological part of the tooth. Dental floss and interdental toothbrushes, among other oral care products, are effective in removing dental plaque between teeth [5]. An interdental toothbrush is small and shaped like a brush that is used to clean test tubes. It is used between the teeth to clean the interdental and proximal surfaces by a reciprocating motion from the buccal to lingual surfaces.

The experiment was conducted using a reciprocating device capable of reciprocating once per second and controlling the number of reciprocating motions [5]. In general, many opinions suggest that an interdental toothbrush should only be used by the elderly with large interdental spaces; however, this is not true. Recently, interdental toothbrushes with a very small diameter of 0.7 mm, referred to as the "sss size," are available in the market. This can be used by women in their early twenties for their posterior teeth. Investigations to verify whether interdental toothbrushes could pass through the interdental areas showed that interdental toothbrushes could be used in 2,408 out of 2,608 interdental areas [6]. Since dental floss has a relatively weaker effect on the removal of dental plaque than an interdental toothbrush, an interdental toothbrush should be recommended first, except its inability to pass through the target interdental areas.

Despite the desperate need for interdental toothbrushes, many dental clinics do not advise their patients to use interdental toothbrushes. Even if they do, it is difficult to induce an actual behavioral change in patients [6].

Interdental toothbrushes have a variety of shapes such as a trapezoidal shape and cylindrical shape. This facilitates a reciprocating motion, and each patient can select a suitable shape. A previous study on the effectiveness of removing dental plaque in interdental areas reported that a conical-shape interdental toothbrush demonstrated a higher plaque removal rate than a cylindrical-shape toothbrush. A study also compared the removal rates of dental plaque based on the interdental toothbrush head shape, the number of usages, and use between horizontal teeth [7,8].

Interdental toothbrushes are commercially available in various designs and thicknesses. Various interdental toothbrushes manufactured to date and sold in the market include the straight and angled types; most of them have a reciprocating motion. Recently, rotating-type interdental toothbrushes were developed and made available in the market. There are no comparative studies between the existing reciprocating-type and the rotating-type interdental toothbrushes. Therefore, this study was conducted to compare the effects of interdental toothbrushes and to determine the effectiveness of the different toothbrush shapes on dental plaque removal from interdental areas.

This study aimed to compare and review the removal rates of dental plaque according to the thickness and the usage of the reciprocating- and rotating-types of interdental toothbrushes. For the effective management of oral hygiene in the interdental areas, a suitable interdental toothbrush should be recommended for each individual to effectively remove dental plaque from the interdental areas.

Methods

1. Subjects and analytical tools

In this study, artificial tooth models (#46, 47, NISSIN, Japan) and a Dentiform (D85DP-CHO.1, NISSIN, Japan), similar to natural teeth and morphologically and functionally standardized, were used. In order to maintain an average spacing and to demonstrate large spacing between teeth, the teeth with #46 distal surface and #47 mesial surface were used. General reciprocating-type (Company E) and rotating-type (Company D) interdental toothbrushes were used. As for the artificial colorant, the tooth models were sprayed with an occlusion spray (Okklean 11145-1 red, DFS, Germany). An addition rubber impression material (I-Sil putty, Spident, Germany), camera holder, rotating- and reciprocating-type interdental toothbrushes were used to calculate the removal rate of artificial dental plaque. This was done by taking pictures of the remaining artificial dental plaque under the same conditions and transferring the data to the area calculation program <Table 1>.

Table 1. Interdental toothbrush types

Type	Size	#46 Distal	#47 Mesial	N
Rotating-type interdental toothbrush	0.7 mm	20	20	40
	0.8 mm	20	20	40
	0.9 mm	20	20	40
Reciprocating-type interdental toothbrush	0.7 mm	20	20	40
	0.8 mm	20	20	40
	0.9 mm	20	20	40

In order to equalize the area of the proximal surfaces of the tooth model, a model frame was made by covering and hardening the buccal, lingual, and occlusal surfaces. The proximal surface was excluded using a rubber impression material. To keep the teeth in place and maintain an average spacing of 0.6 mm between teeth, artificial teeth #46 and #47 in the Dentiform were used.

Then, the reciprocating motion was performed with the reciprocating-type (Company E) and rotating-type (Company D) interdental toothbrushes used in the buccolingual direction three and six times, respectively. An artificial dental plaque was formed on the mesial and distal surfaces of the artificial teeth using an occlusion spray. The rotating-type interdental toothbrush removes dental plaque and foreign substance as the head of the toothbrush rotates automatically. Meanwhile, the

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interdental toothbrush passes through the interdental space. After natural drying, the reciprocating motion was performed with the reciprocating- and rotating-type interdental toothbrushes three and six times, respectively. The pictures of the remaining area of the dental plaque were taken under the same conditions, and the data were transferred to the area calculation program developed to calculate the removal rate of the dental plaque <Fig. 1>.

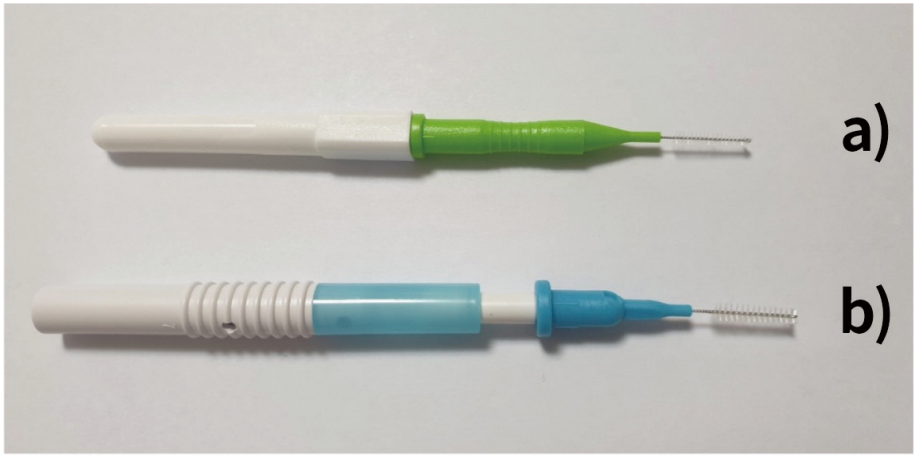

Fig. 1. Interdental toothbrush type
(a. Reciprocating-type interdental toothbrush, b. Rotating-type interdental toothbrush)

2. Data Analysis

After the first preliminary experiment, each condition was corrected to analyze the removal rate by transferring the data through equalizing of the tooth model, artificial tooth colorant, photography, and artificial dental plaque area calculation. After performing the descriptive statistics, paired sample *t*-test, ANOVA analysis according to the stroke and thickness of the interdental toothbrush using SPSS 22.0 (IBM SPSS statistics, New York, USA), Tukey's post-hoc test was performed.

Results

1. Removal rate of artificial dental plaque according to the use of interdental toothbrush

When the distal surface of #46 was brushed three times with the rotating-interdental toothbrush, the removal rate of the artificial dental plaque was the highest with a diameter of 0.7 mm (40.24%), followed by 0.8 mm (39.92%) and 0.9 mm (29.25%). When the interdental toothbrush with a diameter of 0.7 mm was used to brush three and six times, the removal rate of the artificial dental plaque was higher with the three-time brushing for the rotating-type (40.24%) and with the six-time brushing for the reciprocating-type (30.41%). The rotating-type interdental toothbrushes with a diameter of 0.7 mm and 0.8 mm demonstrated higher removal rates of artificial dental plaque than the reciprocating-type toothbrushes <Table 2>.

Table 2. Removal rate of artificial dental plaque according to the use of interdental toothbrush

Division	Type	N	Elimination rates (%)
0.7 mm three strokes	Rotating-type #46	20	40.24±7.67
	Rotating-type #47	20	42.52±11.23
	Reciprocating-type #46	20	25.30±2.78
	Reciprocating-type #47	20	25.06±5.00
0.7 mm six strokes	Rotating-type #46	20	30.41±6.08
	Rotating-type #47	20	29.72±5.50
	Reciprocating-type #46	20	28.22±4.32
	Reciprocating-type #47	20	28.52±5.22
0.8 mm three strokes	Rotating-type #46	20	39.92±6.06
	Rotating-type #47	20	38.48±7.12
	Reciprocating-type #46	20	30.54±8.86
	Reciprocating-type #47	20	31.66±5.93
0.9 mm three strokes	Rotating-type #46	20	29.25±15.00
	Rotating-type #47	20	27.22±7.15
	Reciprocating-type #46	20	33.49±8.95
	Reciprocating-type #47	20	31.51±8.57

46 is the distal surface of the first molar, # 47 is the mesial surface of the second molar

2. Removal rate of artificial dental plaque according to thickness of interdental toothbrush

This shows the average difference in the removal rate of artificial dental plaque according to the thickness of the interdental toothbrush. For both #46 and #47, the removal rate of artificial dental plaque was significantly higher with interdental toothbrushes with a diameter of 0.7 mm and 0.8 mm than 0.9 mm (#46, p=0.002; #47, p<0.001). However, there was no significant difference in the removal rate between brushes with diameters of 0.7 mm and 0.8 mm.

On the contrary, for #46, the removal rate of artificial dental plaque was significantly higher than that of interdental toothbrushes with a diameter of 0.8 mm and 0.9 mm than 0.7 mm (p<.001). For #47, no significant difference was observed <Table 3>.

Table 3. Removal rate of artificial dental plaque according to thickness of interdental toothbrush

Unit : Mean±SD (N=20)

Type		7 mm	8 mm	9 mm	F	p^*
Rotating-type	#46	40.24±7.67[a]	39.92±6.06[a]	29.25±15.00[b]	7.325	0.002
	#47	42.52±11.23[a]	38.48±7.12[a]	27.22±7.15[b]	16.540	<0.001
Reciprocating-type	#46	25.41±3.16[b]	31.66±5.93[a]	33.49±8.95[a]	8.602	<0.001
	#47	25.06±5.00	30.54±8.86	27.51±7.55	2.816	0.068

*by one-way ANOVA

[a,b]Same letters indicate statistically indifferent by Tukey's multiple comparison.

46 is the distal surface of the first molar, # 47 is the mesial surface of the second molar

3. Removal rate of artificial dental plaque according to the number of uses of the 0.7-mm reciprocating- and rotating-type interdental toothbrushes

Using the 0.7-mm rotating-type interdental toothbrush on the proximal surface of each molar, the removal rate was 40.24% after brushing three times and 30.41% after brushing six times for #46 distal, and 42.52% after brushing three times, and 29.72% after brushing six times for #47 mesial. With the rotating-type interdental toothbrush, the removal rate of dental plaque decreased with an increase in the number of reciprocating motions. Using the 0.7-mm reciprocating-type interdental toothbrush on the proximal surface of each molar, the removal rate was 25.30% after brushing three times and 28.22% after brushing six times for #46 distal, and 25.06% after brushing three times and 28.52% after brushing six times for #47 mesial. With the reciprocating-type interdental toothbrush, the removal rate of artificial dental plaque increased with an increase in the number of reciprocating motions (p<0.05) <Table 4>.

Table 4. Removal rate of artificial dental plaque according to the number of uses of the 0.7-mm reciprocating- and rotating-type interdental toothbrushes

Type		Size	Number of times	N	Elimination rates (%)	t	p^*
Rotating interdental toothbrush	#46 Distal	0.7 mm	3	20	40.24±7.67	-5.208	<0.001
		0.7 mm	6	20	30.41±6.08		
	#47 Mesial	0.7 mm	3	20	42.52±11.23	-5.080	0.001
		0.7 mm	6	20	29.72±5.50		
Reciprocating interdental toothbrush	#46 Distal	0.7 mm	3	20	25.30±3.16	2.054	0.037
		0.7 mm	6	20	28.22±4.32		
	#47 Mesial	0.7 mm	3	20	25.06±5.00	2.255	0.036
		0.7 mm	6	20	28.52±5.22		

*by paired sample t-test

Discussion

Dental plague management is important for reducing the negative effects of periodontal disease and dental caries, the major oral diseases in South Korean adults [9]. Since prevention of oral diseases by only toothbrush use is difficult, supplementary use of oral hygiene products suitable for each individual is required. The use of oral hygiene products suitable for the oral condition of each individual can enhance the effects of dental plaque management, interdental hygiene, and gingival massage [10,11]. Particularly, tooth brushing combined with the use of an interdental toothbrush is highly effective in removing dental plaque [12]. Oral hygiene products effectively remove dental plaque while promoting blood circulation in the gingiva and the keratinization of epithelial cells [13].

In order to maintain and promote the oral health of South Koreans, in addition to tooth brushing, the use of various oral care products suitable for the environment of each individual should be encouraged [14]. Currently, toothbrushes, reciprocating-type interdental toothbrushes, and dental

floss are widely used for oral hygiene. However, these oral care products are not sufficiently used due to the inconveniences that come with their usage. Therefore, oral care products that are convenient to use and effectively removes dental plaque are needed.

The rotating-type interdental toothbrush from Company D has taken a step forward from the conventional interdental toothbrush by using a form that enables the head of the toothbrush to rotate automatically while moving between teeth to remove foreign substances and dental plaque from the interdental areas. The core technology of this product does not require a battery or a motor, and its compact and lightweight design allows easy carrying and storage. Therefore, this study investigated the effect of removing dental plaque using rotating- and reciprocating-type interdental toothbrushes which demonstrate different motions. When removing dental plaque with a rotating- and reciprocating-type interdental toothbrushes according to the prescribed number of movements and measuring each area of dental plaque removed, with the reciprocating-type interdental toothbrush, the removal rate was 25.30% after brushing three times and 28.22% after brushing six times for #46 distal, and 25.06% after brushing three times and 28.52% after brushing six times for #47 mesial. With the reciprocating-type interdental toothbrush, the removal rate of dental plaque increased with an increase in the number of reciprocating motions (p<0.05), which was in line with the results of the studies by Wolff et al. [7] and Sim et al. [8], who reported a higher removal rate with an increase in the number of motions.

In terms of the removal rate of artificial dental plaque based on toothbrush shape, the trapezoid shape demonstrated a higher removal rate than the cylindrical shape. In a survey of preference by the consumer network, 60.84% preferred the angled body while 30.25% preferred the straight body, indicating a higher preference for angled interdental toothbrushes in general. Regarding the handle pattern, a higher preference for a straight shape was observed [6-8,15]. Currently, various interdental toothbrushes with different shapes and sizes are available, but the difference in the removal rate of artificial dental plaque according to the method of use has not been examined. Comparing the effects of the methods of motion on the removal rate of artificial dental plaque, the rotating-type interdental toothbrush was more effective in removing dental plaque with the reciprocating motion repeated only three times, while the removal rate for the reciprocating-type interdental toothbrush increased with an increase in the number of motions. Excessive brushing may result in tooth wear. Since the areas brushed with the interdental toothbrush are the proximal tooth surfaces and interdental areas, wear in these areas may result in toothache. The reciprocating-type interdental toothbrush demonstrated a higher plaque removal rate with an increase in the number of motions; however, it is considered to have a lower efficiency of dental plaque removal. Therefore, rotating-type interdental toothbrushes are more effective than the reciprocating-type in removing dental plaque.

Dental hygienists should inform and educate people to make appropriate decisions in choosing oral hygiene products [16].

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This study has some limitations. First, there could have been an error in measuring the force strength because plaque removal was manual. The removal rate was calculated based on the number of times the dental plaque was removed. The artificial dental plaque used in this study is not the same as actual dental plaque when the occlusion spray was used. Second, there was a limitation in standardizing the overall removal rate based on the results obtained from only a small portion of an artificial molar. In the future, studies on the removal rate of dental plaque using interdental toothbrushes in patients who visit dental clinics should be conducted to promote effective selection and use of oral hygiene products.

Conclusions

In this study, in order to seek efficient management of dental plaque using an interdental toothbrush recommended for personal oral hygiene, an artificial tooth colorant was applied to the distal surface of artificial teeth #46 and the mesial surface of #47. The artificial dental plaque was removed by performing a reciprocating motion three and six times with rotating- and reciprocating-type interdental toothbrushes. Close-up shots of the remaining dental plaque were taken with a digital camera; after image analysis, the remaining areas were measured to calculate the removal rates of artificial dental plaque. The results obtained by using the rotating- and reciprocating-type interdental toothbrushes were compared to draw the following conclusions:

1. Regarding the removal rate of artificial dental plaque from the proximal surface of the molar according to the thickness of the interdental toothbrush, the removal rate of the artificial dental plaque was higher with the rotating-type interdental toothbrush than the reciprocating-type interdental toothbrush for diameters of 0.7 mm and 0.8 mm (p<0.001).

2. When using the 0.7-mm rotating-type interdental toothbrush on the proximal surface of each molar, the removal rate was 40.24% after brushing three times and 30.41% after brushing six times for #46 distal, and 42.52% after brushing three times and 29.72% after brushing six times for #47 mesial, demonstrating a high removal rate of artificial dental plaque with fewer reciprocating motions (p<0.001).

3. When the 0.7-mm reciprocating-type interdental toothbrush was used on the proximal surface of each molar, the removal rate was 25.30% after brushing three times and 28.22% after brushing six times for #46 distal, and 25.06% after brushing three times, and 28.52% after brushing six times for #47 mesial. With the reciprocating-type interdental toothbrush, the removal rate of artificial dental plaque increased with an increase in the number of reciprocating motions (p<0.05).

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Conflicts of Interest

The author declared no conflict of interest.

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