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In Vivo Study on the Plaque Removal and Gingival Effect by Use of 360° Rotating Head and Sonic Vibratory Toothbrush for Adults

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Objective: This study aimed to develop a sonic vibratory-action toothbrush with 360° rotating head and examine plaque removal effect and gingival subside effect in the early-stage gingivitis in subjects using this toothbrush compared with subjects using a plane-type toothbrush.

Methods: Sixty adult volunteers aged 40-50 years were enrolled in the study participated with the compensation; they were divided into two groups, experimental group (n=30) using the sonic vibratory-action toothbrush with 360° rotating head and control group (n=30) using a plane-type bristle vibratory toothbrush, and observed for 2 weeks. Plaque was evaluated in both groups before the experiment and after 1, 2, and 4 weeks. A trained dentist and dental hygienist measured the simplified patient hygiene performance (S-PHP) index for the estimation of plaque removal effect and gingival index for the estimation of gingival health. Data were compared between experimental and control groups.

Results: On the basis of S-PHP index, dental plaque deposition was found to decrease from 2.91 to 2.08 points using the experimental toothbrush for 4 weeks and from 10.97 points (total periodontal index for 6 portions) to 7.97 points using the toothbrush for 4 weeks there was significant difference between experimental and control groups ($p<0.05$).

Conclusion: The use of a sonic vibratory-action toothbrush with 360° rotating head is recommended to improve dental plaque removal and promote gingival health.

Keywords: oral health, toothbrushing, sonic vibration, dental plaque

Introduction

Toothbrush and dentifrice are supplementary materials for teeth-cleaning and gingival massage [1]. Toothbrush is considered an industrial product [2], and dentifrice isconsidered a sanitary good or para-medical product [3]; however, both are excluded from the category of medical products in Korea. Further, there has been no standardization in toothbrushes as industrial products for any conditions and to promote oral health by law or regulations. Several types of toothbrushes have been designed and produced to promote oral health via dental plaque removal and gingival massage in various oral

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states or patient conditions [4].

The most prevalent type of toothbrush design is the plane-type head in one direction implanted with bristles with hard, medium, or soft elasticity, which is controlled by the diameter of the nylon bristle in toothbrushes with a traditional head [5]. In recent years, several types of the toothbrush head designs have been developed and marketed on the basis of the characteristics of each design for specific oral states in people [6]. For example, dentists and dental hygienists have recommended that periodontal disease patients use toothbrushes with soft bristle with one or two lanes of the bristles, patients with fixed-type of orthodontic braces use concave central-type bristle plane toothbrushes, and patients with fixed-type bridge use zigzag type bristle plane toothbrushes [7].

A special type of toothbrush head with a 360° rotating head has been developed, and its effects on plaque removal, especially in the proximal area and for orthodontic appliance dental patients, has been reported [8,9]. Recently, ultra-sonic vibratory action has been used to clean tooth surfaces using an ultra-sonic scaler during dental scaling, and this has been applied to toothbrushes to replace electric vibratory toothbrushes. This study aimed to examine the effect of sonic vibratory-action toothbrush with 360° rotating head on plaque removal and gingival health in adults.

Materials and Methods

1. Subjects

Sixty adult volunteers (aged 40-60 years, 31 men and 29 women) from the Christian believers at Daegu city were enrolled; after understanding the goals and process of the study and the obligations for the participants as per the instructions of the trained dental hygienist, the volunteers submitted a written agreement for participation in this clinical experiment. Subjects with dentures, orthodontic appliance, major bridge or implants, and severe systemic diseases were excluded from the study.

All subjects were divided into two groups, experimental and control groups, on the basis of with consideration of the first results of the plaque index as the similar value with two groups each other (Table 1).

2. Method

This study was approved by the Institutional Review Board (IRB) of the Scientific Institute of Dankook University, Korea (IRB No. DKU2018-07-017).

Volunteer subjects were enrolled with compensation using an advertisement posted in a church in Daegu city; all participants were instructed to brush using the rolling. For 4 weeks, the control group, used a manual toothbrush with routine type, and the experimental group used the sonic vibratory-action toothbrush with 360° rotating head. Oral examination was performed by a dentist and dental hygienist 4 times: before experiment, after 1, 2, and 4 weeks of brushing in both groups.

Simplified patient hygiene performance (S-PHP) index was used for oral examination to evaluate plaque deposit and removal rate after painting with a disclosing agent (GARNET Disclosing; Dharma Research Inc., Miami, FL, USA) at 6 tooth surfaces (buccal or labial surface on the two upper first molars and one of the upper and lower incisor teeth and lingual surface of the two lower first molars). During oral examination, the S-PHP index was used to evaluate residual plaque deposit at 5 portions of a tooth surface: incisal, mesial, distal, cervical, and the central portions. The score was estimated as 1 point for residual plaque deposition at one portion of the tooth surface and a total of 5 points for a tooth surface. The average score of the plaque deposition for 6 teeth was calculated, and the results of every week of the experimental and control groups were compared.

Moreover, gingival index as an indication of the periodontal state was also evaluated on a 3° score range, with 0 points indicating no gingival inflammation with healthy gingiva, 1 point indicating slight gingivitis with point bleeding when probing, 2 points indicating moderate gingivitis with slightly leaner bleeding on probing with swelling, and 3 points for severe state with more than 3 mm of gingival pocket formation with bleeding when probing.

Total sum of the score was estimated for 6 teeth areas (same areas for which S-PHP index was examined), and the mean and standard deviation were calculated at each visit. The scores of experimental and control groups were compared.

Regarding statistical analysis, IBM SPSS Statistics program (ver. 19.0; IBM Corp., Armonk, NY, USA) was used for data comparison. An independent 2-sample t-test was used to compare data between experimental and control. A paired t-test for k sample parametric statistics was applied for each

Table 1. Distribution of the subjects (n=60)

	Experimental group	Control group	Total
Sex			
Male	14	17	30
Female	16	13	30
Age (yr)	44.6±10.50	42.7±11.28	43.66±10.94

Values are presented as number only or mean±standard deviation.

item of sample data changes, according to the time passing and decision level. A p-value <0.05 was considered statistically significant.

Results

1. S-PHP index

Changes in the S-PHP index over 4 weeks and the comparison of the data between the experimental and control groups is shown in Table 2.

The data revealed that the plaque deposit index gradually decreased over 4 weeks with time passing in the experimental group ($p<0.05$), but it did not decrease to that extent in the control group ($p>0.05$).

There was no significant difference in S-PHP index between the experimental and control groups before the experiment and after 1 week ($p>0.05$). However, there was a significant difference in this index after 2 and 4 weeks ($p<0.05$).

Table 2. Plaque deposit score as simplified patient hygiene performance (S-PHP) index

Period (wk)	Exp. (n=30)	Con. (n=30)	p-value
0	2.91 ± 0.41^{a}	2.69 ± 0.50^{a}	0.061
1	2.53 ± 0.29^{b}	2.63 ± 0.45^{a}	0.293
2	2.24 ± 0.29^{c}	2.56 ± 0.49^{a}	0.030*
4	2.08 ± 0.25^{d}	2.50 ± 0.39^{a}	0.001**

Values are presented as mean±standard deviation. p-value by independent two-sample t-test. Exp.: experiment group, Con.: control group. 0: before, 1: after 1 week, 2: after 2 weeks, 4: after 4 weeks. [abcd]Same letter means no statistical difference by Bonferroni's multiple comparison. *p<0.05, **p<0.01.

Table 3. Periodontal index as gingival index for 6 teeth areas

Period (wk)	Exp. (n=30)	Con. (n=30)	p-value
0	10.97 ± 2.72^{a}	11.90 ± 2.83^{a}	0.198
1	9.63 ± 2.40^{b}	11.53 ± 2.67^{ab}	0.005**
2	8.53 ± 2.10^{c}	11.00 ± 2.64^{b}	0.001**
4	7.97 ± 2.01^{c}	11.00 ± 2.42^{b}	0.001**

Values are presented as mean±standard deviation. p-value by independent two-sample t-test. Exp.: experiment group, Con.: control group. 0: before, 1: after 1 week, 2: after 2 weeks, 4: after 4 weeks. [abcd]Same letter means no statistical difference by Bonferroni's multiple comparison. **p<0.01.

2. Gingival index as periodontal index

The changes in the gingival index as a representation of the periodontal index over 4 weeks and the comparison of the data between the experimental and control groups are shown in Table 3.

The data revealed that gingival index gradually decreased over 4 weeks in the experimental group ($p<0.05$), but it did not decrease to that extent in the control group ($p>0.05$).

There was no significant difference in S-PHP index between the experimental group and control groups before experiment ($p>0.05$). However, there was a difference in this index after 1, 2, and 4 weeks ($p<0.05$).

Discussion

Several types and shapes of toothbrushes have been designed and developed for effective teeth-cleaning and gingival massage. The most commonly recommended type of toothbrush is the plane-type of the bristle plane with moderate hardness and straight toothbrush handle [10]. However, sonic power with vibratory action has already been proven to be more effective in dental plaque removal [11]. This study used a combined design of sonic vibratory-action toothbrush with 360° rotating head for dental plaque removal and to promote

Table 4. Estimation of the decreasing rate of simplified patient hygiene performance (S-PHP) index by time passing

Period (wk)	Experimental group		Control group	
	S-PHP score	Decreasing rate (%)	S-PHP score	Decreasing rate (%)
0	2.91	0	2.69	0
1	2.53	13.1	2.63	2.2
2	2.24	23.0	2.56	4.8
4	2.08	28.5	2.50	7.0

0: before, 1: after 1 week, 2: after 2 weeks, 4: after 4 weeks.

Table 5. Estimation of the decreasing rate for of gingival index by time passing

Period (wk)	Experimental group		Control group	
	Gigival score	Decreasing rate (%)	Gigival score	Decreasing rate (%)
0	10.97	0	11.90	0
1	9.63	12.2	11.53	3.1
2	8.53	22.2	11.00	7.6
4	7.97	27.3	11.00	7.6

0: before, 1: after 1 week, 2: after 2 weeks, 4: after 4 weeks.

gingival health through the massage effect that enhances blood circulation and stimulation of epithelial cell keratinization in the early stages of gingival inflammation [12].

The decreasing rate of S-PHP index and gingival index for the use of each toothbrush was over time, as shown in Table 4 and 5; these decreasing rates were calculated on the base of the data collected before experiment. The experimental group showed less decrease in S-PHP index as 13.1% at 1 week, 23.0% after 2 weeks, and 28.5% after 4 weeks, whereas the control group showed less decrease in S-PHP index as 2.2% at 1 week, 4.8% after 2 weeks, and 7.0% after 4 weeks.

The decreasing rates of the gingival index were calculated on the base of the data at before experiment. The experimental group showed decrease in the gingival index as 12.2% at 1 week, 22.2% after 2 weeks, and 27.3% after 4 weeks, whereas the control group showed less decrease in the gingival index as 3.1% at 1 week, 7.6% after 2 weeks, and 7.6% after 4 weeks. Therefore, it was concluded that the use of the sonic vibratory-action toothbrush with 360° rotating head will be effective to clinically promote gingival health by time passing.

Together, these data suggest that as the sonic vibratory-action toothbrush with 360° rotating head will help to effectively move dental plaque and promote gingival health.

Conclusion

We examined plaque deposit and gingival state in 60 adult volunteers, who were equally divided into experimental groups for using (sonic vibratory-action toothbrush with 360° rotating head and control groups (plane-type manual toothbrush) and observed for 4 weeks, to compare plaque removal effect and gingival effect between the groups before the experiment and after 1, 2, and 4 weeks of brushing using the S-PHP index and gingival index, as determined by a dentist and or dental hygienist. The results are as follows:

1. The plaque deposit index gradually decreased after 4 weeks by time passing in the experimental group ($p<0.05$), but it did not decrease to that extent so decreased in the control group ($p>0.05$).

2. There was no significant difference in S-PHP index between the experimental and control groups before the experiment and a week after the experiment ($p>0.05$). However, S-PHP was significantly different after 2 and 4 weeks during the experiment ($p<0.05$).

3. The gingival index decreased after 4 weeks in the experimental group ($p<0.05$), but it did decrease to that extent not in the control group ($p>0.05$).

4. There was no significant difference in S-PHP index between experimental and control groups before the experiment ($p>0.05$). However, S-PHP was significantly different after 1, 2, and 4 weeks ($p<0.05$).

5. We recommend the use of a sonic vibratory-action toothbrush with 360° rotating head to effectively promote gingival health in adults.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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