

Effectiveness of sonic toothbrush in removing dental plaque in Japanese nursing undergraduates: a cross-sectional study

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Oral health adversely affects quality of life, mastication, and socialization. Periodontal disease is a risk factor for infectious and chronic diseases and is a medical and public health problem. The removal of dental plaque by tooth brushing is effective for its prevention, and sonic toothbrushes have become common. In this study, we investigated subjective changes in plaque deposition and periodontal disease symptoms before and after the short-term use of a sonic toothbrush in 25 Japanese undergraduate nursing students. Subjective changes in periodontal disease symptoms were assessed clinically by completing a self-administered questionnaire, and plaque status was assessed clinically by staining 12 teeth that could be measured by nurses. Overall, the use of the sonic toothbrush significantly reduced plaque accumulation ($p = 0.001$). The addition of an interdental brush and floss to the sonic toothbrush further reduced plaque buildup. The use of a sonic toothbrush was found to improve dental hygiene compared with the use of a hand toothbrush. In the future, it may become a tool for nurses to provide guidance on tool selection and methods of plaque removal as a method of oral health intervention.

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Introduction

Oral health refers to the subjective and objective good condition of all structures of the oral cavity and is closely related to general health. The World Health Organization (WHO) defines oral health as "the absence of chronic mouth or facial pain, oral or throat cancer, oral infections or erosions, periodontal (gum) disease, tooth decay, tooth loss, and other diseases or disorders that limit an individual's ability to chew, bite, laugh, speak, and psychosocial well-being"¹. However, the 2017 Global Burden of Disease Study reported that 3.5 billion people were affected by oral diseases in 2016,

representing approximately 50% of the global population². Oral health problems negatively impact the quality of life and oral organ functions, such as chewing, speaking, smiling, and socializing³. Plaque-related diseases are the leading cause of oral disorders. Plaque is composed of a bacterial film and may contain a variety of microbial species that directly or indirectly damage hard and soft oral tissues. Dental caries and periodontal diseases are the most common oral pathologies, and their primary prevention is based on plaque removal⁴. Dental caries is an endemic disease with demineralization of hard tissues, and a prevalence of 35% in all age groups⁵. Periodontal diseases include a variety of oral diseases that

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involve periodontal tissues. The combined effects of periodontal disease not only affect physical health, but also the economic, psychological, and social well-being of individuals, reducing their quality of life⁶. Gingivitis and periodontitis are potent pathologies that affect various age groups and pose a global public health challenge⁷. Both dental caries and periodontal disease have a multifactorial etiology but require the presence of dental plaque for their development⁴. Effective daily plaque removal maneuvers are the main method of primary prevention, and the population needs to be well informed, educated, and motivated to adopt appropriate oral hygiene behaviors⁸.

Periodontal disease is a risk factor for chronic diseases such as diabetes, rheumatoid arthritis, and cardiovascular disease. Older adults with poor oral self-care and management are at risk of aspiration of oral bacteria into the lungs and developing pneumonia⁹. Coker et al. reported on the implementation of oral care by nurses and its subsequent effect on patients' oral health literacy on the impact¹⁰. In addition, oral intervention by nurses has been shown to reduce the rate of pneumonia exacerbations and mortality, suggesting that nurses' oral care interventions may have an impact on the oral health of the elderly^{11,12}. In other words, nurses can serve as gatekeepers for the oral health of hospitalized patients. This requires skills in oral health assessment and approaches to oral care; however, there is a lack of oral hygiene assessment and skills that nurses can utilize as routine nursing interventions.

Tooth brushing is the most effective method for supragingival plaque removal, and various techniques and toothbrushes have been devised to mechanically remove bacterial plaque from the tooth surface^{13,14}. Hand toothbrushes are the most widely available, inexpensive, and popular instruments; however, they require sufficient motivation, knowledge, and dexterity to perform effective tooth brushing. In addition, toothbrushes are often used in combination with several additional tools for interdental hygiene, such as dental floss and interdental brushes, which seem to further reduce the risk of gingivitis and plaque¹⁵. Despite habitual tooth brushing, the effectiveness of plaque removal varies greatly depending on several factors, including toothbrush quality, frequency and duration of brushing, and toothbrushing technique¹⁶. In recent years, electric toothbrushes have become increasingly popular and have shown promising short- and long-term results in plaque removal and gingivitis prevention¹⁷. Their use has become widespread, particularly in developed countries, where various models have been developed. Generally, these brushes simulate manual, rotational, or oscillatory movements by moving the bristles several times, sometimes

combined with high-frequency sonic vibrations at a certain frequency¹⁷⁻¹⁹. However, not all researchers agree that sonic toothbrushes perform better than manual toothbrushes with respect to their use²⁰. Therefore, we believe that if nurses could teach a simple assessment method using 12 teeth that are easy to observe in combination with an ultrasonic toothbrush, this would help protect patients' oral hygiene and ultimately improve their health after discharge from the hospital.

Materials and Methods

Study design and selection of the participants

The study design was a cross-sectional study. This study was conducted between July 2019 and September 2019. The target population consisted of 25 first- to fourth-year students from the Department of Nursing at Nagasaki University School of Medicine and Health Sciences. Recruitment of research participants was conducted via posters directed at the students.

All procedures conformed to the Declaration of Helsinki and were approved by the Ethics Committee of the Nagasaki University Graduate School of Medicine, Dentistry, and Health Sciences (Health Sciences) (approval number: 19061309).

Inclusion criteria

The inclusion criteria were as follows:

- Aged 18 years or more
- Good general health
- The upper and lower anterior tooth (canine to canine) must be present
- No experience with electric/sonic toothbrush
- Brush teeth at least once a day

Exclusion criteria

The exclusion criteria were as follows:

- Currently undergoing orthodontic treatment
- Undergoing treatment that may affect oral health by using the sonic toothbrush
- Difficulty in using the sonic toothbrush according to the procedure

Questionnaire materials regarding demographics and oral health related items

The following information was collected via a self-administered questionnaire:

1. Age (year)
2. Sex (male/female)
3. Smoking status (Yes/No)
4. Drinking status (Yes/No)
5. Number of times brushing your teeth: two times/three times or more
6. Time required for tooth brushing: approximately 3 min, 3–5 min, 5–10 min, >10 min
7. Tools used in addition to toothbrush: dental floss, interdental brush, others

Periodontal disease score

A self-check for periodontal disease presented by the Japanese Academy of Clinical Periodontology in 2019, was used. The statements were as follows²¹:

1. My mouth feels sticky when waking up in the morning.
2. My gums bleed while brushing.
3. I am worried about halitosis.
4. My gums are itching and hurt.
5. My gums are red and swollen (healthy gums are pink and firm).
6. I find it difficult to chew hard food.
7. It seems like my teeth have become longer.
8. My front teeth have protruded, and there are gaps between my teeth where food gets stuck.

For each of the eight items, the participants were asked to answer yes or no (1 point for yes, 0 points for no). The total score of the replies was evaluated as follows: a periodontal disease score of 0–3 points meant that the patient should not be careless, 4–6 points meant that the disease may have progressed, and ≥ 7 points meant that the disease had progressed considerably.

Clinical evaluation

The following information was collected by measurement.

Teeth to be evaluated: Six upper left and right teeth (central incisors, lateral incisors, and canines) and six lower left and right teeth (central incisors, lateral incisors, and canines). In addition, the front surface of the teeth visible with the aperture was used for evaluation (Figure 1).

Participants' hygiene performance: The Patient hygiene performance (PHP) by Posdhadly and Haley index was used to assessment method evaluate the oral cleaning performance of the participants as modified PHP²². Upper and lower front teeth (central incisors, lateral incisors, and canines) were evaluated. Participants were asked to close their mouth, and the soft tissues were pushed aside using a retractor. Images

were then obtained (Figure 1). Image acquisition was performed by brushing teeth (toothbrush or sonic toothbrush) at least 30 minutes before the measurement and using a plaque removal tablet. The patient hygiene performance (modified PHP) score was determined by two researchers. For score calculation, each tooth surface was divided into five sectors (Figure 2). For each sector, a score of 1 was assigned if the sector was colored and a score of 0 if it was not. The maximum cutoff was 5 points per tooth; modified PHP scores ranged from 0 to 60 points, with higher scores indicating more advanced plaque formation. The reasons for evaluating oral cleaning ability with this modified PHP were (1) that nurses with no specialized knowledge could evaluate it in a simplified manner and (2) that only tooth surfaces that were considered assessable could be used for evaluation, so the PHP evaluation method was used as modified PHP for the front surfaces of teeth visible in 12 tooth openings, after consultation with a dental hygienist.

Protocol

In this study, Philips Sonicare Healthy White Professional toothbrush²³ (Figure 3) was used, which can vibrate at a high speed of 31,000 strokes/min. The duration of use was set at 14 days because this toothbrush was supposed to be effective after continuous use for at least 2 weeks twice a day.

- At baseline (T0), the subjects brushed their teeth at their usual times using their usual tools.
- At baseline (T0), Perform oral cleaning evaluation (modified PHP), periodontal disease evaluation.
- After using the sonic toothbrush (T1), the subjects brushed their teeth with a sonic toothbrush for 14 days without changing the number of times they brushed or using tools other than the toothbrush.
- After using the sonic toothbrush (T1), Perform oral cleaning evaluation (modified PHP), periodontal disease evaluation.
- All included subjects provided verbal and written informed consent before participating in the study.

Statistical analysis

Descriptive statistical analyses were performed using demographic data, periodontal disease scores, and clinical assessment data (plaque) to analyze the subjects. The normality of the data distribution was assessed using the Shapiro–Wilk test, and the Mann–Whitney test was used to compare the T0 and T1 values.

Next, the group was divided into two groups: one using only a sonic toothbrush and the other using a sonic toothbrush



Figure 1. Images of the teeth subjected to evaluation: a) right side, b) front view, and c) left-side T1.

Twelve teeth (six maxillary right and left: central incisors, lateral incisors, and canines; six mandibular right and left: central incisors, lateral incisors, and canines), the teeth to be evaluated, were stained and the front surfaces of the teeth were photographed from three different directions.

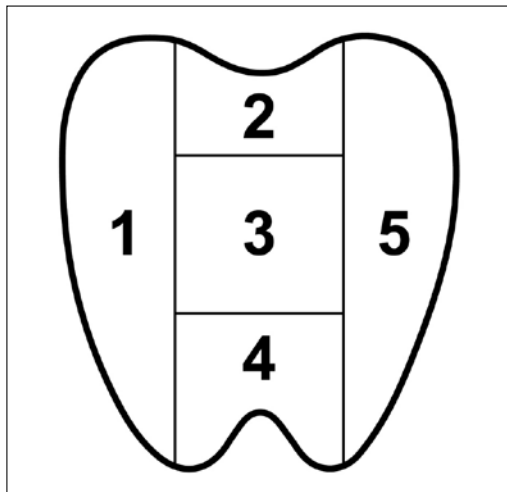


Figure 2. Sectors used in patient hygiene performance scores. To calculate the modified PHP score, each tooth surface was divided into five sectors, and any slight staining was rated as one point.



Figure 3. Philips Sonicare Healthy White Professional toothbrush.

A Philips Sonicare Healthy White Professional toothbrush, which is capable of high-speed vibration at 31,000 strokes/minute, used in this study.

with additional tools. A comparison of T1 values between the two groups was conducted, as well as a comparison of the range of decrease in T1 from T0 for both groups using the Mann–Whitney test. Statistical analysis was performed using SPSS 26.0 J for Windows with a significance level of 5%.

Results

Background of the population

A total of 25 participants were enrolled in the study. The mean age of the subjects was 20.5 ± 2.02 years. There were 22 (88%) female subjects, none of whom had a history of smoking. Fifteen (60%) subjects brushed their teeth twice a day, 10 (40%) subjects brushed their teeth three times or more a day, and 18 (72%) subjects spent 3–5 min brushing their teeth. The tools usually used for toothbrushing were dental floss ($n = 3$ [12%]), interdental brushes ($n = 3$ [12%]) in addition to manual toothbrushes (Table 1).

Periodontal disease status

Table 2 shows periodontal disease score and modified PHP score from T0 to T1. There was no significant change in the reported scores at T0 and T1 ($p = 0.196$). In particular, 17 (68%) subjects reported scores of 1–3 for T0 and 14 (56%) for T1, and none reported a score of 4 or higher. The following items were frequently selected: sticky mouth when waking up in the morning, gums bleed when brushing teeth, bad breath, and teeth seem to be getting longer.

Dental Plaque status

A total of 12 teeth, 6 maxillary right and left teeth (central incisors, lateral incisors, and canines) and 6 mandibular right and left teeth (central incisors, lateral incisors, and canines)

Table 1. Participants' demographic data (n = 25).

		n (%)
Age (years) *		20.5 (2.02)
Sex	Male, Female	3 (12%), 22 (88%)
Smoking	Smoking, Not smoking	0 (0%), 25 (100%)
Drinking	Yes, No	20 (80%), 5 (20%)
Frequency of brushing	2 times, 3 times or more	15 (60%), 10 (40%)
Duration of brushing	Less than 3 min, 3 to 5 min, 5 to 10 min	4 (16%), 18 (72%), 3 (12%)
The tools usually used	Dental floss, interdental brush	3 (12%), 3 (12%)

* Mean (standard deviation) .

The subjects in this study were 88% women, and none of them smoked.

Brushing was performed twice a day for 3–5 min, and 12% of the subjects used tools other than toothbrushes.

were evaluated for dental plaque condition using the stain (table 3). The median (interquartile range) modified PHP score for all measured teeth (12 teeth) was significantly reduced at T1 using the sonic toothbrush ($p = 0.001$). This result was also true for jaw position (maxillary and mandibular: $p = 0.001$ and $p = 0.002$, respectively), lateral position (left and right: $p = 0.001$ and $p = 0.002$, respectively), and central incisor, lateral incisor, and canine ($p = 0.002$, $p = 0.003$, and $p = 0.004$). Despite the decrease in score, only the mandibular right canine tooth did not show a significant decrease in the modified PHP score ($p = 0.055$). The highest median (interquartile range) modified PHP scores among all measured teeth (12 teeth) were for the maxillary right lateral incisors (T0, 5(3.5–5) points; T1, 3(2–4) points).

Comparison of plaque condition between the single group using only the sonic toothbrush and the additional group using the sonic toothbrush with additional tools

Subjects who used the sonic toothbrush alone ($n=19$) were included in the solo group, and those who used the sonic toothbrush and additional tools ($n=6$) were included in the additional group. The modified PHP scores (T1) for the sole and additional groups that used the sonic toothbrush are presented in Table 4. The median (interquartile range) modified PHP scores for the single and additional groups were as follows: all measured teeth (12 teeth) ($p=0.019$), mandibular right central incisor, lateral incisor ($p=0.025$, $p=0.001$), mandibular left central incisor, lateral incisor ($p=0.011$, $p = 0.025$), man-

Table 2. Change in periodontal score from T0 to T1

	T0	T1	p-value
1. My mouth feels sticky when waking up in the morning.	12(48%)	9(36%)	0.180
2. My gums bleed while brushing.	3(12%)	3(12%)	1.000
3. I am worried about halitosis.	2(8%)	1(4%)	0.564
4. My gums are itching and hurt.	0(0%)	0(0%)	-
5. My gums are red and swollen (healthy gums are pink and firm).	0(0%)	0(1%)	-
6. I find it difficult to chew hard food.	5(20%)	2(8%)	0.083
7. It seems like my teeth have become longer.	0(0%)	0(0%)	-
8. My front teeth have protruded, and there are gaps between my teeth where food gets stuck.	0(0%)	1(4%)	-
Periodontal score: 1–3/ 4–6/ and 7 or higher	17 (68%) / 0 / 0	14 (56%) / 0 / 0	-
Periodontal Total score	1.0 (0–1.0)	1.0 (0–1.0)	0.196

Yes: n (%) , Median (interquartile range)

Shapiro–Wilk test.

There were no statistically significant differences in periodontal disease scores before and after sonic toothbrush use owing to subjective symptoms.

Table 3. Changes in modified PHP score from T0 to T1

Measure	T0	T1	p-value
modified PHP Total score	94 (57–110)	52 (41–71)	0.001
Maxillary right central incisor	4 (3–5)	2 (1–4)	0.006
Maxillary right lateral incisor	5 (3.5–5)	3 (2–4)	0.008
Maxillary right canine	4 (2–5)	3 (1–5)	0.031
Maxillary left central incisor	4 (3–5)	1 (1–3.5)	0.002
Maxillary left lateral incisor	4 (3–5)	2 (1–4)	0.009
Maxillary left canine	3 (1.5–4.5)	2 (1–3)	0.017
Mandibular right central incisor	4 (1–5)	2 (1–3)	0.008
Mandibular right lateral incisor	4 (1.5–5)	2 (1–4)	0.045
Mandibular right canine	4 (2–5)	2 (1.5–4)	0.055
Mandibular left central incisor	5 (2–5)	2 (0.5–3)	0.001
Mandibular left lateral incisor	4 (2–5)	2 (0.5–3)	0.002
Mandibular left canine	3 (2–5)	2 (1.5–3)	0.033
Maxillary (central incisor, lateral incisor, canine)	24 (17–27)	14 (10.5–18)	0.001
Mandibular (central incisor, lateral incisor, canine)	22 (10–28.5)	12 (6.5–18)	0.002
Right side (Maxillary, Mandibular)	24 (13–27.5)	12 (8–15.5)	0.001
Left side (Maxillary, Mandibular)	23 (16.5–28)	15 (9–21)	0.002
Central incisor	16 (9.5–19)	6 (4–11.5)	0.002
Lateral incisor	17 (11–20)	9 (7–12.5)	0.003
Canine	14 (8–18)	10 (6–13)	0.004

Median (interquartile range). Significant results are shown in bold font ($P < 0.05$). Shapiro–Wilk test.

The only tooth that did not show a statistically significant difference in the modified PHP score before and after sonic toothbrush use was the mandibular right canine tooth. The maxillary right lateral had the highest modified PHP score both before and after sonic toothbrush use, whereas the left side (maxillary and mandibular) had the highest modified PHP score after sonic toothbrush use.

dibular (central incisor, lateral incisor, canine) ($p=0.004$), right side (maxillary, mandibular) ($p=0.012$), and Central incisor ($p=0.018$) had significantly lower modified PHP scores in the additional group. Among all the measured teeth (12 teeth), the highest median (interquartile range) modified PHP scores were obtained for the maxillary right canine (3 (1–5) points) in the single group and for the maxillary right lateral incisor (3 (0.75–4.25) points) in the additional group. In addition, Table 5 shows the modified PHP scores of the single and additional groups for the extent of the decrease in modified PHP scores when changing from a manual toothbrush (T0) to a sonic

toothbrush (T1). The median (interquartile range) modified PHP scores for the degree of reduction in the single and additional groups were significantly greater in the maxillary left lateral incisor (2 (0–3) points) than in the additional group (-0.5 (-1.5–0.25) points) ($p = 0.007$). For all 12 teeth measured, the median modified PHP score, indicating the degree of reduction, was greater for the maxillary left lateral incisors in the single group (2 (0–3) 3 points) and for the mandibular right lateral central in the addition group (1.5 (-1.25 to 3.25) points).

Table 4. Comparisons of modified PHP scores of T1 between “sonic toothbrush alone” (single group) and “sonic toothbrush + additional tools” (additional group).

Measure	Single group (n=19)	Additional group (n=6)	P-value
Total	44 (6–90.5)	41 (18–46)	0.019
Maxillary right central incisor	2 (1–4)	0.5 (0–2.25)	0.05
Maxillary right lateral incisor	3 (2–4)	3 (0.75–4.25)	0.78
Maxillary right canine	3 (1–5)	1.5 (0–3.5)	0.246
Maxillary left central incisor	2 (1–4)	1 (0.75–1.75)	0.274
Maxillary left lateral incisor	2 (1–4)	3 (1–4.25)	0.437
Maxillary left canine	2 (1–3)	2 (0.75–3)	0.598
Mandibular right central incisor	2 (1–4)	1 (0–1.25)	0.025
Mandibular right lateral incisor	3 (2–4)	1 (0–1.25)	0.001
Mandibular right canine	3 (2–4)	1.5 (0–2.75)	0.106
Mandibular left central incisor	2 (1–3)	0.5 (0–1)	0.011
Mandibular left lateral incisor	3 (1–4)	0.5 (0–1.25)	0.025
Mandibular left canine	2 (2–4)	1.5 (0–3)	0.138
Maxillary (central incisor, lateral incisor, canine)	14 (11–20)	13.5 (3.75–15.75)	0.322
Mandibular (central incisor, lateral incisor, canine)	17 (9–20)	6 (2.5–9)	0.004
Right side (Maxillary, Mandibular)	17 (11–22)	9 (4–13.25)	0.012
Left side (Maxillary, Mandibular)	14 (10–19)	9 (5–13)	0.069
Central incisor	9 (5–14)	3 (2–5.5)	0.018
Lateral incisor	10 (7–14)	9 (2–9.5)	0.117
Canine	11 (8–14)	6 (3.75–11.5)	0.110

Median (interquartile range). Significant results are shown in bold font ($P < 0.05$).

Mann–Whitney-u test.

Comparison of the modified PHP scores of T1 between “sonic toothbrush alone” (single group) and “sonic toothbrush + additional tools” (additional group) for sonic toothbrush use. Overall, the additional group showed significantly lower modified PHP scores. By site, statistical results in the maxillary right central incisor, mandibular right central incisor, mandibular right lateral incisor, and mandibular left central incisor. The highest modified PHP scores in the additional groups were for the maxillary right lateral incisor.

Table 5. Comparison of the decrease in modified PHP scores when changing from a manual toothbrush (T0) to a sonic toothbrush (T1) for the single and additional groups.

Measure	Single group (n=19)	Additional group (n=6)	P
Total	17(6–26)	6(–9.0–24.5)	0.437
Maxillary right central incisor	1(0–3)	1.5(–0.5–2.75)	0.926
Maxillary right lateral incisor	1(0–3)	1.5(–0.5–2.0)	0.246
Maxillary right canine	1(0–3)	0.5(–0.75–2.0)	0.642
Maxillary left central incisor	2(1–3)	1(–1–2.25)	0.103
Maxillary left lateral incisor	2(0–3)	–0.5(–1.5–0.25)	0.007
Maxillary left canine	1(0–2)	0(–1.25–0.5)	0.092
Mandibular right central incisor	1(0–3)	1.5(–1.25–3.25)	0.926
Mandibular right lateral incisor	1(0–2)	0.5(–1.0–3.25)	1.0
Mandibular right canine	1(0–2)	0(–0.5–3.0)	0.975
Mandibular left central incisor	1(0–3)	1(–0.25–3.5)	0.828
Mandibular left lateral incisor	1(0–2)	0.5(0–3.25)	1.0
Mandibular left canine	1(0–2)	0.5(–0.5–1.0)	0.437
Maxillary (central incisor, lateral incisor, canine)	11(2–12)	2.5(–6.75–9.75)	0.106
Mandibular (central incisor, lateral incisor, canine)	7(1–13)	5(–3–14.75)	0.926
Right side (Maxillary, Mandibular)	5(3–11)	5.5(–5.75–10)	0.828
Left side (Maxillary, Mandibular)	8(1–15)	0.5(–3.25–10)	0.176
Central incisor	6(1–13)	2.5(–2.25–11.75)	0.514
Lateral incisor	5(3–10)	2.5(–3.75–6.75)	0.221
Canine	3(1–6)	1.5(–3.75–5.5)	0.333

Median (interquartile range). Significant results are shown in bold font ($P < 0.05$).

Mann–Whitney-u test.

Statistical significance only for the maxillary left lateral incisors with the decrease in modified PHP scores upon changing from a manual toothbrush (T0) to a sonic toothbrush (T1), for the single and additional groups.

Discussion

This study aimed to determine the changes in plaque accumulation and subjective periodontal symptoms after short-term use of a sonic toothbrush with 31,000 vibrations per minute in undergraduate nursing students.

After changing from a manual toothbrush to a sonic toothbrush and using it for 14 days, a decrease in the modified PHP score, which indicates the amount of plaque buildup, was observed in 12 teeth, which were easily observed by nurses. This result was relevant for all measured teeth (12 teeth) except for the mandibular right canine. The highest modified PHP scores before and after sonic toothbrush use

were observed for the maxillary right incisor, suggesting that more brushing was left on the maxilla than on the mandible, on the right side than on the left side, and on the lateral incisors than on the central incisors or canines. This suggests that sonic toothbrushes are effective for removing dental plaque. This is consistent with reports that electric toothbrushes, which combine ultrasonic and sound actions, have the most promising effects on oral health²⁴. Furthermore, the central incisor region on the dominant side could cause leftover brushing, which is consistent with previous reports²⁵. In addition, it is generally believed that the effectiveness of tooth brushing is related to the type of toothbrush, correct brushing method and time, and use of mouthwash and dental floss^{26–29}.

The fact that more than half of the study participants brushed their teeth for more than 3 min at least twice a day at the same time was considered to indicate the effectiveness of changing tools to sonic toothbrushes in reducing the amount of plaque deposits on the tooth surface. Six participants (24%) used tools other than toothbrush. Therefore, we compared the modified PHP score (T1) after sonic toothbrush use between two groups of subjects: those who used a toothbrush alone and those who habitually used dental floss or an interdental brush in addition to a toothbrush. Regarding the modified PHP score, which indicates the amount of plaque buildup on all 12 measured teeth that were easily observed by the nurse, the group that used the sonic toothbrush in combination with tools had a significantly lower PHP score. By region, the sonic toothbrush plus tool group had significantly lower PHP scores for the mandibular central incisor, lateral incisor, and right side. The results suggest that the plaque on tooth surfaces can be removed using dental floss and other toothbrushes in combination with toothbrushes rather than toothbrushes alone. In other words, it was difficult to clean interdental spaces and adjacent gingival spaces even with ultrasonic water flow, suggesting that plaque can be removed more effectively using tools that are effective in interdental spaces³⁰. To further investigate the effect of changing the toothbrush to a sonic toothbrush, we checked the modified PHP score (T0-T1), which indicates the amount of plaque change before and after sonic toothbrush use, and compared the results between the two groups. Although the change from a manual toothbrush to a sonic toothbrush decreased the modified PHP score, the maxillary left lateral incisor did not decrease in the group that added a tool to the sonic toothbrush, and the amount of change was significantly greater in the sonic toothbrush alone group. The fact that the change from a manual toothbrush to a sonic toothbrush decreased the modified PHP score and that there was no statistically significant difference in the modified PHP score compared to the group that added a tool to the toothbrush suggests that the sonic toothbrush was effective in removing dental plaque. The increase in the modified PHP score in group that added a tool to the sonic toothbrush could be due to the participants' poor use of the tool in some tooth areas.

Periodontal symptoms did not change before or after the use of the sonic toothbrush. This may be because the subjects had few subjective symptoms before using the sonic toothbrush, that they brushed their teeth regularly based on the frequency and duration of tooth brushing, or the "Hawthorne effect," in which patients who participated in a clinical study (in this case, tooth brushing) gave positive responses regarding their subjective symptom responses^{30,31}.

The limitations of this study include the small number of subjects, lack of a target group for the group using the sonic toothbrush, and the short observation time. In addition, as nursing students were the subjects of this study, they may not be an adequate representation of the general population given that they have more learning opportunities and knowledge about the importance of oral hygiene than the general population. In the future, it will be necessary to select and increase the number of subjects, set up a target group, and evaluate the performance of toothbrushes on other tooth surfaces and molars.

After considering all the possible sources of error mentioned above, we believe that the results obtained will lead to future evaluations, as even nurses were able to visually evaluate the effectiveness of toothbrushing in a simplified manner. In addition, the fact that the participants were nursing students provided an opportunity for those who would provide patient support in the future to think about evaluation methods and pay more attention to tooth brushing. Furthermore, the effect of novelty, combined with the use of a technologically innovative product, may improve patient compliance in conventional patient teaching and evaluate its effectiveness. The use of high-frequency sonic toothbrushes appears to significantly reduce the number of supragingival plaques, as shown in several studies³¹⁻³³. However, gingival indices were significantly increased in these studies. In summary, our results confirm that the use of a sonic toothbrush improves the ability of appropriately trained subjects to remove dental plaque, and that the use of additional tools can further enhance this effect.

There is an urgent need for appropriate and feasible routine oral hygiene interventions that prevent the negative outcomes associated with plaque accumulation, such as oral hygiene care, which is essential for infection prevention, including preventing the latest entry from the mouth to the lungs^{10,34}. Evidence-based oral hygiene care standards are necessary to assist nurses achieve optimal outcomes. However, specific method descriptions and education in basic nursing textbooks are insufficient. Nursing interventions for oral hygiene care must be verified, evaluated, modified, and practiced repeatedly to develop individualized interventions. In future, nurses may be able to influence oral hygiene outcomes and prevent systemic diseases by clarifying the concept of oral hygiene care as an intervention.

In conclusion, a decrease in plaque adhesion was observed after the use of sonic toothbrushes in terms of plaque removal. Therefore, we suggest that sonic toothbrushes are effective for plaque removal. In addition to sonic toothbrushes, dental floss and interdental brushes were also effective in removing plaque. However, in this study, the measurements were

performed on a limited number of teeth, on which the stained condition was relatively easy to see (12 teeth). Therefore, if the measurements were performed on other teeth, the lingual/palatal side, and the occlusal surface, the effect of the sonic toothbrush and the change in plaque adhesion before and after use would differ depending on the area.

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