

A study on toothbrush wear index and wear rate in some kindergarten children.

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Abstract

Objective: The purpose of this study is to evaluate the toothbrush wear index and wear rate in some kindergarten children in order to study proper toothbrush management method.

Methods: A toothbrush used once a day for 50 kindergarten children was collected for 1 week and 4 weeks. The mean value and standard error of toothbrush wear index (WI) and wear rate (WR) were analyzed according to the criteria. SEM analysis was performed to observe the shape of the tip of the bristles. Statistical program SPSS was used for analysis.

Results: In the wear index (WI) measurement result, there was a significant difference according to the usage period between 1 week and 4 weeks. The average wear rate was 0.840 ± 0.344 and 1.458 ± 0.390 at 1 and 4 weeks, respectively. Thereby, showing a large difference. In terms of the wear rate, the toothbrushes used by boys for 4 weeks showed a larger wear rate than that of the girls.

Conclusion: The change in the toothbrush shape varied according to the usage period. In addition, the tips of the toothbrush used for 4 weeks were cracked and many microorganisms inhabited the cracked tips. Based on this, it is possible to provide basic data for corrected toothbrush management plan during early childhood.

Keywords: Children, Toothbrush, Wear index, Wear rate.

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Introduction

In the school age of 6 to 12 years old, the intellectual ability, concentration and memory of the children improve, and their desire for learning increases. Since oral care habits, which are obtained during this time can be a lifelong basis, proper oral care habits should be formed [1]. This is a time of mixed dentition with the transition from milk teeth to permanent teeth; therefore, prevention for malalignment is necessary for the proper formation of permanent dentition through observation and proper care for the eruption process [2]. In particular, as the frequency of snack food ingestion increases, it is easy to become affected by dental caries. If the milk teeth are lost due to dental caries, it will cause malocclusion [3]. Malocclusion may result in the abnormalities of the tooth arrangement and occlusion, as well as facial abnormalities. Dental caries during this period results in psychological distress and abnormalities in the permanent dentition and whole-body development, and it increases the economic burden. As such, complete oral care is essential for a child during this time because it will serve as a basis of lifelong oral health [4].

In order to keep the mouth clean and to effectively manage the dental plaque that is a major cause of serious oral diseases, it is most important to use the right toothbrush and tooth brushing method. Tooth brushing is the most basic and effective way to prevent serious oral diseases such as dental caries and periodontal disease [5]. A toothbrush used for this is a tool for cleaning the teeth and massaging the gums and it is the most common oral hygiene product. In general, a toothbrush should be easy to use in the mouth. The head of the toothbrush must reach all the teeth surfaces, its bristles must have constant elasticity, and it should have proper durability and appearance [6].

The toothbrush is a consumable product and if used regularly, the bristles will become bent and splayed. Toothbrush bristle wear can be caused by various factors, such as the brushing method, the number of brushing, the toothbrush usage period, the type and amount of toothpaste and the strength of the hand [7]. For the evaluation of the bristle damage according to the toothbrush usage, the wear index (WI) and wear rate (WR), which have been suggested by Rawls et al., are commonly used [8]. The wear index

measures the degree of bristle splaying, while the wear rate (WR) indicates the degree of the overall damage as a score according to grade. Worn toothbrushes have less ability to manage the plaque, as compared to new toothbrushes and it is easier for the bacteria to multiply as a result of the splayed bristle tips of worn toothbrushes [9,10]. It is considered as a serious problem if the toothbrush, which is a tool used for removing bacteria and cleaning the teeth, is exposed to bacteria. Since worn toothbrushes cannot perform proper functions, it is recommended to replace the toothbrush when it begins to show wear [9,11]. Additionally, it is appropriate to specify the toothbrush replacement timing according to the characteristics of the toothbrush.

In particular, children's toothbrushes are often manufactured with fine bristles due to the nature of milk teeth, and the fine bristles are greatly affected by the number of tooth brushing and easily deformed.

Therefore, this study aimed to provide basic data for proper toothbrush management during early childhood by identifying the wear index and wear rate of the children's toothbrush according to the usage period, observing the bristle tip of the worn toothbrush, and analyzing the possibility of bacterial growth.

Materials and Methods

Study Subjects

This study was conducted on 50 students at kindergartens located in the South Gyeongsang province after explaining the purpose of the study and obtaining consent from their parents and teachers. In order to identify the wear index and wear rate according to the usage period, the same toothbrushes were given to the subjects and tooth brushing education was performed by using the fones method at kindergartens. The first collection of the toothbrushes used for this study was done after tooth brushing following lunch for a week from May 15, 2017 and the second collection was done after tooth brushing for 4 weeks with the same method and at the same frequency from May 22, 2017 after distributing new toothbrushes.

Study Method

Wear index (WI)

In order to evaluate the wear index, the toothbrush wear index suggested by Rawls et al. [8] was used and the lengths of 5 parts of the bristles were measured (Figure 1). Free long length (FLL) is the extent that the bristles splay, which is the maximum width of the side of the toothbrush. Base long length (BLL) is the width of the side of the toothbrush at the part that is fixed to the plastic. Front free length (FFL) is the extent that the bristles splay, which is the maximum width of the front of the toothbrush. Base free length (BFL) is the width of the front of the toothbrush at the part fixed to the plastic. Bristles' length (BRL) is the maximum length of the toothbrush bristles. The larger the measured value, the higher the wear index.

$$WI = \frac{FLL - BLL + FFL - BFL}{BRL \times 2}$$

Wear rate (WR)

In order to evaluate the wear rate, the evaluation criteria established by Rawls et al. [8] were used, as shown in Table 1. For the wear rate, 0 to 3 points were given. For the toothbrush that was not used or did not show splaying of the bristle bundle, 0 point was given. For the toothbrush that showed splaying of some bristles in the bristle bundle, 1 point was given. For the toothbrush that showed splaying of all the bristles in the bristle bundle and many overlapping bristles, 2 points were given. For the toothbrush with most of the bristles overlapped, tangled, and seriously slanted or twisted, 3 points were given.

Scanning electron microscopy analysis

In order to observe the shape of the bristle tips and microbial characteristics according to the usage period, the scanning electron microscopy (SEM; S3500N, Hitachi Co., Japan) analysis was performed. After drying the bristles used for 1 week and 4 weeks at a drying oven at 37°C for 24 h, they were dried after pretreatment, plated with platinum, and magnified at an accelerating voltage of 15 kV for observation. The tips of the bristles used for the analysis were enlarged to be observed and photographed.

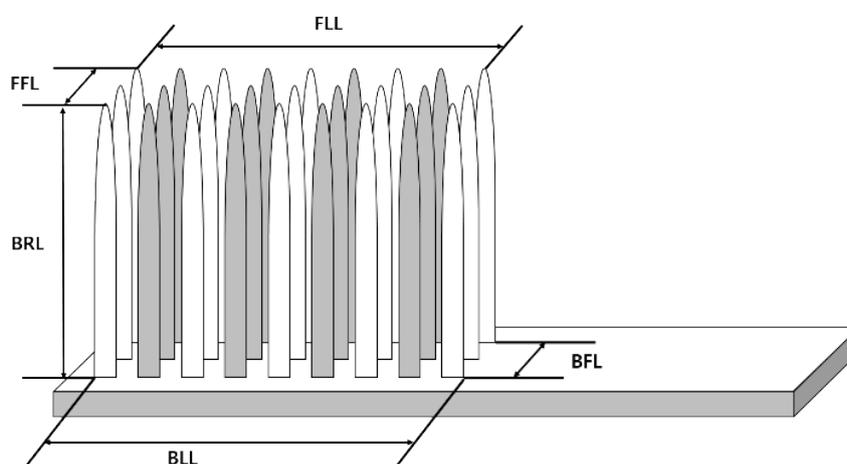


Figure 1. Schematic diagram of the measurement sites for the wear index of children's fine bristle toothbrush

Table 1. Evaluation criteria of toothbrush wear rate

Score	Standard
0	Not used, There is no spreading in the bristles
1	Some bristles spread in bristles
2	Entire bristle spreads in a bundle of bristles, Multiple overlaps with each other
3	Most bristles are tangled and tilted

Table 2. Evaluation of the wear index (WI) and wear rate (WR) according to the usage period

Division	M ± SD		F-value	P-value
	1 week	4 weeks		
WI	0.072 ± 0.072	0.180 ± 0.103	2.705	0.038*
WR	0.840 ± 0.344	1.458 ± 0.390	1.204	0.005*

*p<0.05

Analysis Method

The collected data were analyzed by using the SPSS 21.0 program. The mean and standard deviation of the wear index and wear rate were calculated, and t-test analysis was performed in order to identify the difference between the gender and the toothbrush usage period.

Results

Evaluation of the Wear Index (WI) and Wear Rate (WR) According to the Usage Period

In the wear index (WI) measurement result, the 1-week mean WI was 0.072 ± 0.072 and the 4 week mean was 0.180 ± 0.103, thereby showing a significant difference according to the usage period. In the evaluation of the wear rate (WR), the 1 week mean and the 4 weeks mean were 0.840 ± 0.344 and 1.458 ± 0.390, respectively, thereby showing a large difference (Table 2).

Evaluation of the Wear Index (WI) and Wear Rate (WR) According to the Gender

The evaluation results of the wear index (WI) and wear rate (WR) according to the gender were as follows. In terms of the WI, there was no significant difference between the male and female subjects in both 1-week and 4-week means (Table 3). In terms of the WR, the mean WR of the toothbrushes used by boys for 4 weeks was larger than that of the girls (Table 4).

Change in Bristle Shape

The SEM measurement result for the surface to observe the shape of the fine bristle tip of children's toothbrush is presented in Figure 2. The fine bristle tips used for 1 week were not split, while the fine bristle tips used for 4 weeks were noticeably split and many bacteria were observed between the gaps.

Discussion

Tooth brushing is known to be the most important and fundamental method in oral care. The first step towards proper tooth brushing is to choose the right toothbrush, and for the children's toothbrush, it has been reported that the bristles must be soft, the toothbrush head must be small and

Table 3. Evaluation of the wear index (WI) by gender

Gender	WI (M ± SD)	
	1 week	4 weeks
Male	0.073 ± 0.066	0.252 ± 0.117
Female	0.071 ± 0.080	0.129 ± 0.881
F-value	0.046	0.256
P-value	0.983	0.152

*p<0.05

Table 4. Evaluation of the wear rate (WR) by gender

Gender	WI(M ± SD)	
	1 week	4 weeks
Male	0.910 ± 0.350	1.900 ± 0.369
Female	0.786 ± 0.350	1.143 ± 0.331
F-value	0.146	0.075
P-value	0.666	0.015*

*p<0.05

the handle can be comfortably held [12]. Moreover, many studies have shown that soft bristles are more effective on removing plaque and rounded tips of the bristles can protect the gingiva [13-15]. It has been emphasized that it is important to choose the right toothbrush because it is difficult for children to remove plaque completely and it is easy to damage the gingiva [16-18]. In order to identify and manage the characteristics of the toothbrush, this study investigated the wear index and wear rate in children.

Based on the wear index measurement result of the subjects' toothbrushes, the 1 week mean was 0.072 ± 0.072 and the 4 weeks mean was 0.180 ± 0.103, thereby showing a significant difference in the wear index according to the usage period. Based on the previous studies, the wear index was 0.280 ± 0.256 after 1 week use and 0.442 ± 0.358 after 4 weeks use in the study of Shin et al. [19], thereby showing a similar or a slightly higher score, as compared to the result of this study. In the present study, the mean wear rate was 0.840 ± 0.344 after 1 week use and 1.458 ± 0.390 after 4 weeks use, thereby showing a large difference. In the study of Shin et al. [19], the wear rate was 0.333 ± 0.492 after 1 week use and 1.273 ± 0.467 after 4 weeks use, thereby showing a similar or a slightly lower score, as compared to the result of this study. However,

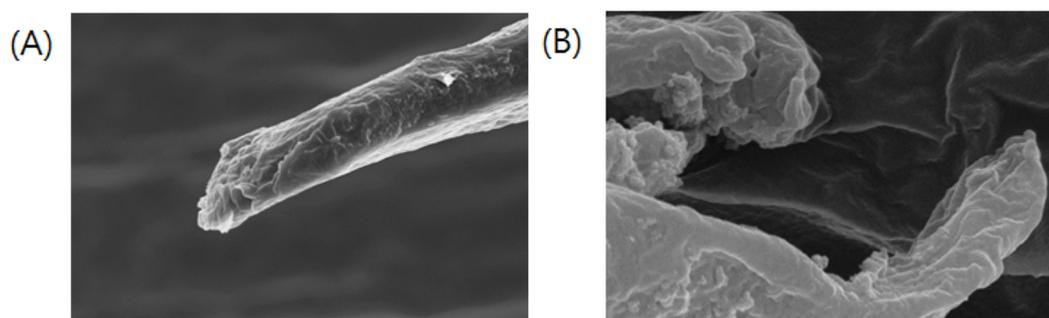


Figure 2. Observation the shape of the fine bristle tip of children's toothbrush (a) 1 week (b) 4 weeks

since the study of Shin et al. [19] was conducted on adults, the shape of the bristles and toothbrush use habits of adults were completely different from those of the children. Moreover, in the study of Shin et al. [19], the toothbrush was used three times a day, but in this present study, the toothbrush was used only once a day while the children were staying in kindergartens, which resulted in the difference in the figures. The toothbrushes used in this study were children's fine bristles toothbrushes.

In the evaluation results regarding the wear index and wear rate according to gender, there were no significant differences in the wear index after the 1 week use and after the 4 weeks use (Table 3). In terms of the wear rate, the toothbrushes used by boys for 4 weeks showed a larger wear rate than that of the girls. In the study of Kim [20] conducted on kindergarteners for approximately 2 months, the mean wear index was 0.421 ± 0.239 , which was twice higher than the mean wear index of the toothbrushes used by boys for 4 weeks in this present study. This is viewed as a result of the difference in the usage period. The mean wear rate was 1.936 ± 0.848 , which was similar to that of the toothbrushes used by boys for 4 weeks in this present study (1.900 ± 0.368). The result of this study suggests that careful attention should be paid to the management of toothbrushes of boys in their early childhood because greater deformation may occur in their toothbrushes. In terms of the change in the bristle shape, there were clear differences in the comparison between 1 week and 4 weeks use. The bristle tips of the toothbrush used for 4 weeks were cracked, and many microorganisms inhabited the cracked bristle tips. In this study, analysis on microbial species was not performed, but according to the study of Kim et al. [21], general bacteria and coliform group were detected and it was confirmed that diarrheal toxin genes were contained as a result of analysis on the characteristics of specific bacteria. It is reasonable that hygiene management should be thoroughly done to prevent the toothbrush from becoming exposed to bacteria because the oral cavity is the first point of entry for all food intake and furthermore, it is an important passageway into the intestine for microorganisms [22].

The limitation of this study is that unlike adults with tooth brushing habits, children brush their teeth in various ways, which may cause inconsistent results. For this reason, an

experimental tool that standardized the tooth brushing method for children needs to be designed. In addition, if studies on the effects of the wear index, wear rate and change in the bristle shape on tooth brushing efficiency are conducted, the explanatory power of this study will be improved.

Conclusion

This study attempted to compare the wear index and wear rate after implementing tooth brushing once a day in order to establish an appropriate management plan for toothbrushes in early childhood for children in kindergartens. As a result, the bristles used for 4 weeks were deformed and especially, bristle tip cracking and microbial hatching were observed. Since infants have a weak immunity, it should be recommended that toothbrushes be kept in a dry place with low humidity so as to prevent microbial hatching, and children's toothbrushes characterized by fine bristles be replaced sooner than 3 months, the known average replacement interval.

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