A study on the plaque removal efficiency of new and worn toothbrushes

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I. Introduction

Increased plaque accumulation is associated with gingivitis¹ and if not adequately removed may lead to periodontitis.² Poor oral hygiene status usually increases the possibility of alveolar bone loss.³ It is now widely accepted that thorough plaque control will prevent the development and recurrence of periodontitis.⁴,⁵

Toothbrushing is the most widespread mechanical means of personal plaque control in the world⁶ and is considered to be an important factor in the long-term maintenance of periodontal health.⁷ The toothbrush is still the most common and often the only cleaning device people use. Therefore, its proper use is of importance in plaque control and prevention of periodontal disease.

Many factors can influence the ability of an individual to remove plaque with a manual toothbrush. Brushing duration, brushing force and brushing technique will all either increase or decrease the amount of plaque removed and therefore, in the long term, influence gingival health. Another factor that is thought to affect brushing efficacy is toothbrush wear.⁸⁹

Dental professionals and toothbrush manufacturers generally recommend that a toothbrush be replaced every three months. This is based on the supposition that a worn toothbrush is likely to be less effective than a new one. The American Dental Association also makes this recommendation, stating that "worn brushes are not effective at removing plaque bacteria and broken bristles may injure gums."⁹⁰

Evidence supporting the hypothesis that a worn brush is less effective at removing plaque than a new brush is, however, relatively scarce. Few studies have investigated the effect of toothbrush wear and those written on the subject have produced conflicting results. Studies by Kreifeldt et al.,¹⁰ Glaze and Wade¹¹ and Warren et al.,¹² found that a worn toothbrush was significantly less effective at
removing plaque than a new brush. They concluded that plaque removal decreased with increasing toothbrush wear and recommended that toothbrushes be replaced frequently to ensure optimal plaque control. In contrast, McKendrick et al.,\textsuperscript{12} Daly et al.,\textsuperscript{13} and Sforza et al.,\textsuperscript{14} have suggested that the wear status of a toothbrush may not be critical in ensuring optimal plaque control. Daly et al., (1996) found that the plaques cores actually improved as the initially new brushes became worn, Sforza et al., (2000) confirmed the findings of Daly et al., when they found that increased toothbrush wear was not associated with worsening plaque scores. Recently, Tan E et al.,\textsuperscript{15} reported that the percentage reductions in plaque scores achieved with new brushes were not significantly different from those achieved with 3-month-old brushes. No significant differences were found for plaque score reductions with 3-month-old brushes of minor, moderate or marked wear. They concluded that the 3-month-old toothbrushes were as effective as new brushes in plaque removal.

However, Conforti et al.,\textsuperscript{16} provided data in support of the hypothesis that a worn toothbrush is less efficient with respect to plaque removal than a new brush, According to their conclusions, patients should therefore be encouraged to replace their toothbrush regularly before bristle wear becomes excessive.

Clearly, it is important that as much plaque be removed as is possible. To this purpose, manufacturers put significant effort into improving the efficiency of their toothbrushes. If the advantage gained from using new, more efficient brushes is counteracted by the effect of not replacing the toothbrush at an appropriate time, then it is suggested that worn brushes be replaced regularly.

However, patients do not always take this advice. It is very likely that they have little idea of when their toothbrush needs replacing. It was reported that the average age of a toothbrush at replacement ranges from 2.5 to 6 months.\textsuperscript{12,17,18} Most people have been shown to base their decision as to when to replace their toothbrush on the degree of splaying and bending of the bristles.

As the rate of toothbrush wear is thought to be influenced by a number of factors, including duration of use, brushing force and brushing technique, this in part explains why the average age at replacement has been shown to vary so widely. In addition, assessment of when a toothbrush is "worn-out" will vary from person to person, which will also contribute to the wide variation in the age of a toothbrush at the time of replacement.

The purpose of this study was to determine the effect of toothbrush wear on plaque removal efficiency using a single-use design. This clinical investigation was conducted to test the hypothesis that a 3-month-old toothbrush is less effective in removing plaque from a tooth surface than a new toothbrush.

\section*{II, Material and Methods}

\subsection*{1, Subjects}

A total of 42 healthy subjects were recruited. There were 27 males and 13 females with a mean age of 25.1 years (range 23-37). All participants were undergraduate students of Seoul National University’s Dental College. They were selected according to the following criteria:

1. Presence of all 6 Ramfjord teeth (16, 21, 24, 36, 41 and 44) and pocket depth \( \leq 3 \) mm on all tooth surfaces,
2. No crowns, fixed or removable prostheses or orthodontic appliances,
3. No restorations involving the surfaces of the

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teeth to be scored,
4. Healthy with no medical conditions requiring prophylactic antibiotic coverage for scaling and polishing.

2. Plaque scoring

Plaque was recorded using the patient hygiene performance (PHP) index. Plaque was disclosed with erythrosin solution (RED-COTE®, Butler, Chicago, USA) for 1 min and then plaque scores were assessed at the 6 Ramfjord teeth. The tooth surfaces, both facial and lingual, were divided into 5 sections as follows (Figure 1):

(1) Mesial third
(2) Distal third
(3) Middle third: which was further subdivided horizontally into gingival, middle and occlusal sections; a score of 1 or 0 was assigned to each subdivision depending on the presence or absence of plaque; all questionable areas were scored zero.

3. Toothbrush

A manual toothbrush with soft bristles (Oral-B Advantage®, Oral-B Laboratories, Belmont, CA, USA) was selected for the present study. Subjects were instructed to use a commercial fluoridized toothpaste (e-fresh®, Bukwang Pharm Co., Ltd, Seoul, Korea) during the experimental periods.

4. Brushing surface area

The amount of wear for 3-month-old brushes was determined by measurement of the brushing surface area. To standardize measurements, each toothbrush was placed in the same position using prefabricated acrylic resin mounter, Digital camera (FinePix S2 Pro®, Fujifilm Co., Ltd, Tokyo, Japan) was used and all images were adjusted to focus on the outer row of bristles of each toothbrush head. Standardized digital photographs of the outer row of bristles were then taken. The outline of outer row of bristles was marked and the brushing surface area was calculated (Figure 2) using image analysis software (TDI Scope Eye®, Techsan Co., Ltd, Seoul, Korea). Increases in the brushing surface area of 3-month-old brushes were then determined by comparison with the brushing surface area of new brush.

![Figure 1](image1.png)

Figure 1. Sections of tooth surface for plaque scoring by the patient hygiene performance (PHP) index

![Figure 2](image2.png)

Figure 2. Brushing surface area: A new brush (left) and a 3-month-old brush (right). The outer row of bristles of brush head was marked and the area was calculated using image analysis software.
5. Experimental design

This study was a single-center, single-examiner blind, randomized, cross-over controlled clinical trial to compare the clinical efficacy of new and worn toothbrushes. There were a total of 5 visits and 2 experimental periods. The study design is summarized in Figure 3.

At the first visit, selected subjects answered a questionnaire about their dental behaviors (frequency, duration, and methods of daily brushing, replacement interval of toothbrush, smoking, drinking, right/left handedness). They were given the same toothbrush and instructed to use it for 3 months. This 3-month-old toothbrush was used as the ‘worn’ brush for later experimental periods.

At the second visit (3 months later), all subjects were randomly assigned to one of two experimental groups (I, II). Group I subjects used a new brush at the third visit and worn brush at the fifth visit. Group II subjects used a worn brush at the third visit and new brush at the fifth visit. All plaque and calculus were professionally removed to obtain a plaque score of 0 for each subject. All subjects were then instructed not to brush their teeth 48 hours before the next visit so that plaque could accumulate.

At the third visit (2 weeks later), an examiner confirmed the 48h-periods of no oral hygiene. Following plaque scoring by the PHP index, group I subjects brushed with new brush and group II subjects brushed with a worn brush using their familiar brushing techniques. After brushing, plaque was re-scored (Figure 4). Wear extent of the 3-month-old brushes was determined by measurement of brushing surface areas.

The two experimental periods were separated by a 2-week washout period, which was designed to prevent significant carry-over effects of using respective toothbrushes at the third and fifth visits.

After this period, at the forth visit, all subjects were recruited for professional plaque control. At the final visit (2 weeks later), groups I and II brushed with
the opposite toothbrush, Plaque score was recorded before and after brushing, as performed at the third visit. All plaque scoring was carried out by a single calibrated examiner who was blinded to the type of toothbrush used in both groups.

6. Data analysis

The hypothesis was that a worn toothbrush is less effective for reducing plaque than a new brush. Plaque scores in 10 sections of each tooth were recorded and calculated for regions of interest. In this investigation, 3 sites were selected: whole, proximal, and marginal. The marginal site represents proximal plus gingival section (Figure 5).

For each of the 2 phases of the study, changes in plaque scores of the 3 sites were computed before and after brushing. Percentage reductions in plaque scores were then calculated and compared. Individual index scores at each phase were compared using paired t-tests.

Pearson's correlation analysis was done to find the relation among the plaque scores and toothbrush wear. For all statistical analyses, two-sided values of p<0.05 were accepted as statistically significant.

III. Results

1. Dental behaviors

42 subjects initially volunteered to take part in the study. Since 2 subjects dropped out at the second visit, 40 subjects went to completion. All subjects answered a questionnaire about their dental behaviors (frequency, duration and methods of daily brushing, replacement interval of toothbrush, smoking, drinking, right/left handedness) as shown in Table 1.

2. Plaque scores

The results of the plaque scores are summarized in
Table 1. Dental behaviors of the subjects (n=40)

<table>
<thead>
<tr>
<th>Questions</th>
<th>No. of subjects</th>
<th>Questions</th>
<th>No. of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brushing Frequency</td>
<td></td>
<td>Drinking</td>
<td>23</td>
</tr>
<tr>
<td>1 time/day</td>
<td>1</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>2 times/day</td>
<td>16</td>
<td>Yes</td>
<td>17</td>
</tr>
<tr>
<td>3 times/day</td>
<td>23</td>
<td>Smoking</td>
<td></td>
</tr>
<tr>
<td>Brushing Duration</td>
<td></td>
<td>No</td>
<td>32</td>
</tr>
<tr>
<td>0-30 s</td>
<td>0</td>
<td>Yes 1-10</td>
<td>5</td>
</tr>
<tr>
<td>30-60 s</td>
<td>7</td>
<td>10-20</td>
<td>2</td>
</tr>
<tr>
<td>1-2 mins</td>
<td>16</td>
<td>20-30</td>
<td>1</td>
</tr>
<tr>
<td>2-3 mins</td>
<td>9</td>
<td>Brushing Method</td>
<td></td>
</tr>
<tr>
<td>3- mins</td>
<td>8</td>
<td>Rolling technique</td>
<td>17</td>
</tr>
<tr>
<td>Brush Replacement Interval</td>
<td></td>
<td>Bass technique</td>
<td>5</td>
</tr>
<tr>
<td>1 month</td>
<td>2</td>
<td>Modified Bass</td>
<td>10</td>
</tr>
<tr>
<td>2 months</td>
<td>6</td>
<td>Miscellaneous</td>
<td>8</td>
</tr>
<tr>
<td>3 months</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 months</td>
<td>4</td>
<td>Right-handed</td>
<td>36</td>
</tr>
<tr>
<td>5 months</td>
<td>2</td>
<td>Left-handed</td>
<td>4</td>
</tr>
<tr>
<td>6 months</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Plaque Scores of Pre- and Post-Brushing, Mean Reduction (Standard Deviations) and Percentage Difference Between Groups

<table>
<thead>
<tr>
<th>Brush sites</th>
<th>Pre-Brushing</th>
<th>Post-Brushing</th>
<th>Mean Reduction</th>
<th>% Plaque Reduction</th>
<th>Difference Between Groups*</th>
<th>Group Comparison (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole-sites</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>42.23 (3.97)</td>
<td>17.75 (6.40)</td>
<td>24.48 (6.83)*</td>
<td>57.96</td>
<td>15.1%</td>
<td>0.0001</td>
</tr>
<tr>
<td>Worn</td>
<td>41.55 (3.94)</td>
<td>23.73 (6.72)</td>
<td>17.83 (6.81)*</td>
<td>42.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>24.00 (0.00)</td>
<td>13.15 (4.26)</td>
<td>10.85 (4.26)*</td>
<td>45.21</td>
<td>20.6%</td>
<td>0.0001</td>
</tr>
<tr>
<td>Worn</td>
<td>23.95 (0.22)</td>
<td>18.05 (4.41)</td>
<td>5.90 (4.45)*</td>
<td>24.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Proximal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>18.23 (3.97)</td>
<td>4.60 (2.86)</td>
<td>13.63 (3.98)*</td>
<td>74.76</td>
<td>7.0%</td>
<td>0.071</td>
</tr>
<tr>
<td>Worn</td>
<td>17.60 (3.91)</td>
<td>5.68 (3.08)</td>
<td>11.92 (4.12)*</td>
<td>67.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>35.90 (0.63)</td>
<td>16.50 (6.01)</td>
<td>19.40 (6.04)*</td>
<td>54.04</td>
<td>16.3%</td>
<td>0.0001</td>
</tr>
<tr>
<td>Worn</td>
<td>35.75 (0.54)</td>
<td>22.50 (6.30)</td>
<td>13.50 (6.42)*</td>
<td>37.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Marginal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>6.33 (3.80)</td>
<td>1.25 (1.21)</td>
<td>5.08 (3.28)*</td>
<td>80.24</td>
<td>5.7%</td>
<td>0.317</td>
</tr>
<tr>
<td>Worn</td>
<td>5.80 (3.97)</td>
<td>1.48 (1.20)</td>
<td>4.33 (3.53)*</td>
<td>74.57</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Statistically significant difference between pre- to post-brushing, p<0.05

Table 2. Nineteen subjects (group I) followed the New/Worn sequence, while 21 subjects (group II) performed the Worn/New sequence. Both types of tooth-brushes demonstrated statistically significant reductions in whole mouth, proximal and marginal plaque from pre- to post-brushing for each experi-
mental period (p=0.0001, Figure 6-8). Plaque reductions for the new brush were 58.0%, 45.2% and 54.0% for whole, proximal, and marginal sites, respectively. Plaque reductions for the worn brush were 42.9%, 24.6%, and 37.8% for whole, proximal, and marginal sites, respectively. Therefore, the new toothbrush demonstrated 15.1%, 20.6%, and 16.3% greater mean plaque reduction than the worn brush for whole, proximal, and marginal sites, respectively, which was statistically significant (p=0.0001, Figure 9).

In non-proximal and non-marginal sites, both the new and worn toothbrushes also demonstrated statistically significant plaque reductions (p=0.0001, Figure 8). However, there was no statistically significant reduction between the two toothbrushes, (p=0.071 for non-proximal sites, and p=0.371 for non-marginal sites).

3. Brushing surface area

The 3-month-old toothbrushes showed a wide variation in bristle wear (Figure 10). Compared with the brushing surface areas of the new brushes used by each subject, their 3-month-old brushes exhibited increased brushing surface areas ranging from 0.2% to 112.1%. The overall mean increase (±SD) in the
Plaque score changes for marginal & non-marginal

Figure 8. Plaque score changes for marginal & non-marginal sites
*Statistically significant difference between pre- to post-brushing, p<0.05

New brush vs, Worn brush

Figure 9. Mean plaque reduction (%) of new and worn toothbrush types for different sites
*Statistically significant difference between the two brush types, p<0.05

Figure 10. The distribution of the brushing surface area increase (%) of the 3-month-old toothbrushes (n=40)
brushing surface area of the 3-month-old brushes was 50.6% (±27.8%).

4. Correlation analysis

The effect of toothbrush wear on plaque removal was investigated by assessing percentile plaque score reductions achieved with brushes exhibiting varying degrees of wear. There were linear correlations between the progressive wear of a toothbrush and plaque score reductions (r=-0.58 for whole-sites and r=-0.50 for marginal sites). However, there was no statistical significance for whole-sites (p=0.72) or marginal sites (p=0.76, Figure 11).

IV. Discussion

The aim of this study was to compare the effectiveness of new and 3-month-old toothbrushes in the removal of dental plaque. Bergstrom (1973) reported a significant correlation between the age of a brush and its wear. He revealed that the wear condition of the toothbrush deteriorated with its length of use. The relationship between the "state-of-wear" of a toothbrush and its plaque-removing effectiveness has been studied for a long time. However, these studies have yielded conflicting results.

Our present study supports the previous findings of Kreifeldt et al. (1980), Glaze and Wade (1986) and Warren et al. (2002) namely that a worn toothbrush is less effective than a new brush. This single-use study found that the new brush achieved 15.1% greater plaque reduction than the worn brush for the whole mouth, 20.6% for proximal sites and 16.3% for marginal sites.

Furthermore, our study overcomes some of the potential criticism that can be leveled at previous studies. Kreifeldt et al., and Warren et al., used mechanically worn brushes, but we used naturally worn brushes by each subject. Sforza et al. concluded the use of artificially worn toothbrush may not be considered an objective method, since it only approximates the characteristics of naturally worn toothbrushes. Even if artificially obtained bending and splaying of the bristles closely resemble the characteristics of naturally worn bristles, other factors may influence and modify the intrinsic characteristics of the bristles, such as the rubbing against the tooth surface, its interaction with food particles and bacterial plaque, abrasive characteristics of
toothpastes and natural aging of the bristles. Furthermore, if the bristles were naturally worn, the wear patterns would be varied with indivi- duals according to the different brush- ing methods.

Toothbrush wear was assessed in the present study by measuring the increase in the brushing surface area for each tooth- brush, Glaze & Wade\(^{11}\) first described this technique but, in their study, the brushing surface area was calculated by multiplying the greatest length by the greatest breadth of the brushing surface. However, this method has been regarded as inappropriate because the brushing surf- faces of worn toothbrushes are generally irregu- lar in outline.\(^{13}\) Our study utilized the developed method of determining and calculating toothbrush wear by using standardized digital photographs and measuring the brushing surface area with image analysis computer software.

The results from this investigation confirmed that a worn brush also removed plaque effectively after brushing and this was statistically significant. But, a worn brush was less effective than a new brush. This result differs from the conclusions reached by McKendrick et al.\(^{12}\) (1971), Daly et al.\(^{13}\) (1996), Sforza et al.\(^{14}\) (2000) and Tan E et al.\(^{15}\) (2002) and the difference may be due to a number of factors associated with the respective study design, Method of toothbrush wear, the type of toothbrush tested, and the experimental designs are all factors that may have influenced the clinical outcome of the studies, For example, Daly (1996), in his 9-week period of study design, reported the "Hawthorne effect" that sub- jects improved their oral hygiene perform- ance during a clinical trial as a result of anticipation of oral examinations.

In this study, we asked subjects to brush as they would normally, Sforza et al.\(^{14}\) (2000) and Tan E et al.\(^{15}\) (2002), however, controlled brushing method and duration. They instructed subjects to brush by the

modified Bass method for 60 seconds, Snedector et al.\(^{20}\) and Dean\(^{21}\) commented that brushing force, duration, and method may all have the potential to influence efficacy to a greater extent than toothbrush wear, thus masking the effect of wear on plaque removal. However, we thought that brushing method and duration could vary with each sub- ject because factors such as force, intensity, frequency of strokes and manual skill could not be controlled in clinical trials.

Although, the most important factor for the con- flicting results may be the plaque scoring index sys- tem, This study used the patient hygiene perfor- mance (PHP) index by Podshadley & Haley\(^{19}\) (1968) for plaque scoring. The tooth surfaces, both facial and lingual, were divided into 5 sections: mesial, distal, gingival, middle, and occlusal. Since additional plaque scores were given to proximal and gingival sites separately before brushing and a new brush could remove more plaque on the proximal and gingival sites (called together, "marginal" sites) after brushing, the significant difference of plaque reduction between new and worn brushes could be found, Glaze & Wade (1986) also used the PHP index in their study which showed similar results. Since Kreifeldt et al. (1980) focused on the gingival margin for the plaque scoring\(^{22,23}\) and Conforti et al (2003) used the Proximal Marginal Plaque index,\(^{24}\) a new brush also revealed more plaque reduction than worn brush.

However, Daly et al.\(^{16}\) and Tan E et al.\(^{20}\) used the Turesky (1970) modification\(^{25}\) of the Quigley & Hein (1962) index in which plaque scores were recorded for the facial, lingual- palatal and total, Sforza et al.\(^{14}\) (2000) used the Sillness & Løe(1964) index\(^{20}\) in which proximal and gingival sites of lingual-palatal surface were not recorded. Therefore, new brushes could not obtain additional plaque score reduction and there was no statistical
significance,

In our study, non-marginal sites revealed no statistical difference of plaque reduction between new and worn brushes while there was statistical significance in marginal sites. Therefore, we need to use a different plaque index system that gives more significance on proximal and gingival sites. Among the previous studies, the Modified Navy Plaque Index by Elliott et al.,\(^{27}\) (1972) could be an appropriate example which gives double scores to the marginal gingival area. Rustogi et al.,\(^{28}\) (1992) developed a new index based on the original Modified Navy Plaque Index, so-called the Rustogi Modified Navy Plaque Index (RMNPI). They reported that plaque removal efficiency was increased in the gumline and interproximal tooth areas using RMNPI. There are some reports using this new index system to compare plaque removal efficacy of different toothbrushes.\(^{29-31}\) Although, there is no study that compares the plaque removal efficacy of new and worn brushes using the RMNPI system. If the RMNPI had been used for this study, we would have obtained more significant data of plaque score reduction between new and worn brushes.

There were linear correlations between the progressive wear of a toothbrush and plaque score reduction, which means that the brushing efficiency of the 3-month-old brushes tends to decrease with progressive wear increase. However, these correlations were not statistically significant. This is because plaque reduction may be influenced and changed by several factors such as different frequency, duration, force, and method of daily brushing of each subject as well as toothbrush wear differences. To determine the effect of increased toothbrush wear on plaque reductions, other factors stated above should be excluded. If toothbrushing with all different worn brush were performed by one subject, better results could be obtained.

This study was performed on the gingivitis model, if subjects suffered periodontitis, the study design should be changed. A new index system may be used in order to record plaque on the root surface area near the marginal gingiva. Furthermore, some variables such as brushing method and duration may influence the results, since root surface is a more three-dimensional structure. Therefore, a more careful design of plaque index may be needed to evaluate the patient hygiene performance. The importance of regular oral hygiene monitoring and professional cleaning has been well documented in maintaining low plaque scores.\(^{4,32,33}\)

V. Conclusions

Within the limits of the present study, it is concluded as follows:

1. The single-use clinical study shows that a worn toothbrush is less effective than a new brush for plaque removal.
2. Since toothbrush wear is a potentially important factor in personal oral hygiene, it is obviously recommended that worn brushes be replaced regularly.
3. Further study regarding the plaque index system that focuses on proximal and gingival sites is needed for more careful evaluation of the patients’ hygiene performance.

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새 칫솔과 마모된 칫솔의 치태제거효율에 관한 비교연구

남재진1, 양병근1, 김태일1, 설양조1, 이용무1, 구영1, 류인철1, 백대일2, 정종평1, 한수부1

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3개월 동안 사용한 마모된 칫솔의 마모 정도와 양상을 관찰하고, 새 칫솔과 마모된 칫솔의 잉슬질 전·후 치태제거효율을 single-use design으로 비교·평가하여 3개월 주기의 칫솔 교체 주기의 근거를 임상적으로 확인해보고자 하였다.

치주적으로 건강한 치과 대학생 42명을 대상으로 설문지를 통해 잉슬질 습관을 조사하고, 3개월간 동일한 칫솔과 치약을 사용하게 하였다. 3개월 후 피험자들을 무작위로 두 군(I, II)으로 나누고, 치석제거기를 시행한 뒤 2주 후에 내원하도록 하였으며 내원 전 48시간동안은 잉슬질을 하지 않도록 지시하였다. 2주후 I군은 새 칫솔을, II군은 마모된 칫솔을 사용하도록 하였으며 잉슬질 전·후에 각각 구강 내를 erythrosin으로 염색한 후 6개월로 Ramfjord 치아의 plaque score를 Patient Hygiene Performance (PHP) index로 측정하였다. 2주간의 washout period 후에 다시 치석제거기를 시행한 뒤, I군이 마모된 칫솔을, II군은 새 칫솔을 사용하게 하여 동일한 방법으로 PHP index를 각각 측정하였다. 마모된 칫솔은 수거하여 brushing surface area의 면적으로 마모도를 평가하였다. 결과는 paired t-test와 Pearson's correlation analysis로 통계처리 하였다.

2명이 탈락하였고 잉슬질 전·후에 대한 전체 부위, 치간 부위, 변연치는 부위의 plaque score는 두 칫솔 모두 통계학적 유의성 있게 감소하였으며 (p<0.0001), 두 칫솔을 비교한 경우에는 새 칫솔이 마모된 칫솔보다 치태 감소량이 통계학적으로 유의성 있게 많았다 (p<0.0001). 칫솔의 마모도는 평균 50.6% 증가하였으며, 마모도 증가에 따른 치태 감소량에는 직선적인 상관관계가 있었으나 통계학적 유의성은 없었다. (전체 부위 r=-0.58, p=0.72 / 변연치는 부위 r=-0.50, p=0.76).

Single-use design에서 3개월 동안 마모된 칫솔은 치태제거 능력에 있어서 새 칫솔보다 덜 효율적이었다. 칫솔의 마모도는 구강 위생 관리에 영향을 미치는 중요한 요인이며, 마모된 칫솔은 정기적인 교체가 요구된다. 또한, 치간 부위를 포함한 변연치는 부위의 치태를 정확하게 평가할 수 있는 치태지수에 대한 연구가 필요하였다.

주요어: 새 칫솔, 마모된 칫솔, 마모도, 치태제거효율, 구강 위생, 치태지수