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Comparison of the plaque removal efficacy of chewable, electric, and manual toothbrushes: A randomized clinical trial

Çiğnenebilir, elektrikli ve manuel diş fırçalarının plak uzaklaştırma etkinliklerinin karşılaştırılması: Randomize klinik çalışma

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ABSTRACT

Objective: A comparative evaluation of the plaque removal efficacy of manual, electric, and chewable toothbrushes.

Material-Method: Our randomized and examiner-blinded clinical study involved 90 dental students. The students were divided into three groups: manual, electric, and chewable toothbrush users. The plaque removal efficiency of the brushes was evaluated using the Turesky modification of the Quigley–Hein Index (TMQHI).

Results: Ninety participants, consisting of 32 males and 58 females, aged between 21 and 23 years (average age 22±0.47) were included in the study. The mean TMQHI score before brushing was 2.4±0.49 in the manual brushing group, 1.81±0.61 in the electric toothbrush group, and 1.93±0.6 in the chewable brush group. The mean for the manual brushing group was thus higher than that of the other two groups ($p<0.001$). The mean TMQHI score after brushing was 1.37±0.43 in the manual brushing group, 0.91±0.52 in the electric toothbrush group, and 1.31±0.67 in the chewable brush group. The effectiveness of the chewable brush in plaque removal in all regions of the mouth was lower than that of the other two ($p<0.001$). There was no statistical difference between the manual and electric toothbrushes.

Conclusion: The plaque removal efficiency of the chewable toothbrush was found to be lower than that of the electric and manual toothbrushes.

Keywords: Chewable toothbrush, dental plaque, electric toothbrush, manual toothbrush.

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ÖZ

Amaç: Manuel, elektrikli ve çiğnenebilir diş fırçalarının plak uzaklaştırma etkinliklerinin karşılaştırmalı olarak değerlendirilmesidir.

Materyal- Metot: Randomize ve araştırmacı-kör klinik çalışmamıza 90 diş hekimliği öğrencisi dahil edildi. Öğrenciler manuel, elektrikli ve çiğnenebilir diş fırçası kulananlar olarak 3 gruba ayrıldı. Fırçaların plak uzaklaştırma etkinliği, Quigley-Hein İndeksinin Turesky modifikasyonu (TMQHI) kullanılarak değerlendirildi.

Bulgular: Yaşları 21-23 arasında (ortalama yaş 22±0,47), 32 erkek ve 58 kadın olmak üzere 90 katılımcı çalışmaya dahil edildi. Fırçalama öncesi ortalama TMQHI skoru manuel diş fırçası grubunda 2,4±0,49, elektrikli diş fırçası grubunda 1,81±0,61 ve çiğnenebilir diş fırçası grubunda 1,93±0,6 olarak tespit edildi. Fırçalamadan önceki plak miktarı ortalaması, manuel diş fırçası grubunda diğer iki gruptan daha yüksekti ($p<0.001$). Fırçalama sonrası ortalama TMQHI skoru manuel diş fırçası grubunda 1,37±0,43, elektrikli diş fırçası grubunda 0,91±0,52 ve çiğnenebilir diş fırçası grubunda 1,31±0,67 olarak tespit edildi. Çiğnenebilir diş fırçasının tüm bölgelerdeki plak uzaklaştırma etkinliği diğer diş fırçalarına göre düşük bulunurken ($p<0.001$), manuel ve elektrikli diş fırçaları arasında istatistiksel olarak fark yoktur.

Sonuç: Çiğnenebilir diş fırçasının plak uzaklaştırma etkinliği elektrikli ve manuel diş fırçalarına göre daha düşük bulunmuştur.

Anahtar Kelimeler: Çiğnenebilir diş fırçası, dental plak, elektrikli diş fırçası, manuel diş fırçası

1. Introduction

The main reason for caries and periodontal diseases is the presence of a non-mineral microorganism community and its organization within the organic mucopolysaccharide matrix as dental plaque, also called dental biofilm. It is necessary to break down this organization to establish dental health. It is possible to do this by using a conventional toothbrush, although mechanical toothbrushes are also effective in removing bacteria [1,2]. Different toothbrushes have been designed with different functional and scientific benefits [3]. Several meta-analyses and Cochrane reviews have shown that electric toothbrushes have slightly higher efficacy in terms of plaque reduction and gingivitis control [4,5,6]. According to these previous studies, electric toothbrushes may be a preferable alternative due to their high level of plaque removal relative to manual toothbrushes. However, effective brushing requires both the patient's compliance and adequate brushing techniques. Precise manual dexterity is necessary for effective manual brushing, although this will vary between individuals and will improve with age [7].

In some environments, neither manual nor powered tooth brushing can be performed correctly, for example, with disabled individuals and young children [8]. A chewable toothbrush is a recent innovation in oral hygiene. The Rolly Mini chewable toothbrush meets the requirements of the Framework Regulation (EC) laws concerning food contact materials (EU2002/72/EC). The chewable toothbrush, which contains fluorine and xylitol, removes food particles and plaque accumulated between the teeth

through the mechanical cleaning effect of its bristles [9]. However, it remains unclear whether these chewable toothbrushes have any beneficial effect on the reduction of plaque.

The purpose of this clinical trial was to compare the plaque removal capacity of manual, powered, and chewable toothbrushes.

2. Material and Method

Ethical Approval

This study was approved by the Institutional Ethics Committee of the University of Usak (certificate number: 12-12-12). The informed consent of the participants was obtained before the study commenced.

Study Participants

The sample size was determined using G*Power software v. 3.1.9.2. According to a previous study by Joshi et al. [10], sample size estimation indicated that 87 patients were required to achieve a type I error (α) of 0.05 and an effect size of 0.34 at a power of 80%. Ninety participants were included in our study to allow for possible errors. Potential participants who had systemic disease, were regularly on antibiotics or other drugs, had serious periodontal disease, had oral soft tissue lesions, wore an orthodontic appliance, had crowding of the teeth, had missing teeth other than the third molar, or had more than three carious lesions were excluded from the study (Figure 1).

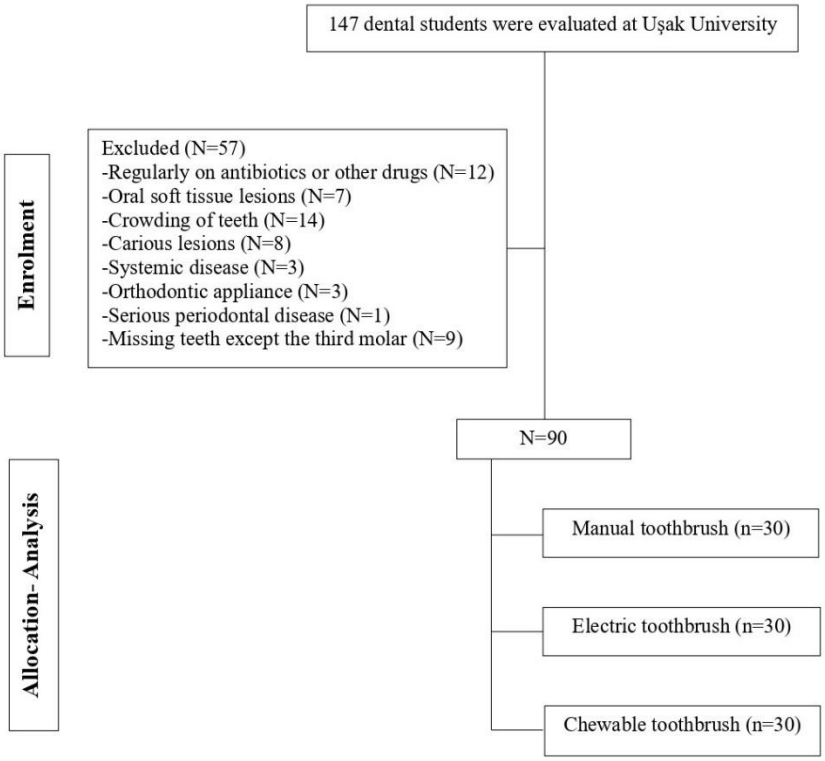

Figure 1. Flow chart of the study

Procedure

A total of 90 young people were selected and randomly categorized into three groups. A randomizing program was used to conceal their allocation (www.randomizer.org).

Group I: Using a manual toothbrush (Tepe Supreme Toothbrush) (n=30)

Group II: Using an electric toothbrush (Oral-B Electric Toothbrush) (n=30)

Group III: Using a chewable toothbrush (Rolly Mini Toothbrush) (n=30)

The participants avoided all oral hygiene procedures for 24 hours immediately prior to the study procedure, and they refrained from smoking, eating, or drinking for four hours before the procedure. The examinations were conducted after their lectures had ended (16.00–17.00 h). The participants were informed about the correct use of the various toothbrushes before they started the procedure with the help of videos and demonstrations. All groups brushed for two minutes. Group I was told to use the modified Bass technique [11] that they had observed in a demonstration. Group II was instructed to apply the electric brush head to each tooth surface, spending a few seconds on each surface. Group III was told to use the chewable toothbrush for two minutes, rolling it around their teeth using their tongue. To assess the plaque index, a basic 2% fuchsin solution was applied with a cotton swab both before and after brushing, and plaque accumulation was used to estimate the TMQHI (Turesky modification of the Quigley-Hein Index) [12]. Any excess marking material was rinsed off with water prior to brushing. For the post-brushing evaluation, the dentist was blinded to the type of toothbrush used.

Evaluation Tools

The TMQHI index evaluates the plaque revealed on the buccal and lingual surfaces all of the teeth. The TMQHI scores were recorded as follows: 0, dental plaque was not present; 1, isolated areas of dental plaque; 2, a thin band of dental plaque ≤1 mm; 3, dental plaque covered up to 1/3 of the tooth surface; 4, dental plaque covered between 1/3 and 2/3 of the tooth surface; and 5, dental plaque covered ≥2/3 of the tooth surface. An index for the entire mouth was determined by dividing the total score by the number of surfaces examined.

Statistical Methods

The data were analyzed using IBM SPSS V23. Conformity to the normal distribution was evaluated with the Shapiro-Wilk test. One-way analysis of variance was used to compare the normal distribution of data according to the type of brush used in each group. Tukey's HSD test for multiple comparison tests was used. The analysis results are presented as means and deviations. The significance level was taken as $p<0.05$.

3. Results

This prospective study involved 90 dental students from the University of Usak, aged between 21 and 23 (average age 22±0.47 years), and it was performed between September and December 2021. Of the 90 participants included in the study, 32 were male and 58 were female (Table 1).

Table 1. Sociodemographic characteristics by groups

	Manual	Electric	Chewable	Total
Age				
mean ±sd	22±0.88	22±0.94	21±0.12	22±0.47
Sex				
n(%)				
Male	13 (%40.62)	11 (%34.37)	8 (%25)	32 (%100)
Female	17 (%29.31)	19 (%32.75)	22 (%37.93)	58 (%100)

The mean TMQHI score before brushing was 2.4±0.49 in the manual brushing group, 1.81±0.61 in the electric toothbrush group, and 1.93±0.6 in the chewable brush group. The mean for the manual brushing group was thus higher than that of the other groups (p<0.001). The mean TMQHI score after brushing was 1.37±0.43 in the manual brushing group, 0.91±0.52 in the electric toothbrush group, and 1.31±0.67 in the chewable brush group. Thus, the effectiveness of the chewable brush in removing plaque from all regions was lower than that of the other two. There was no statistical difference between the manual and electric toothbrush groups (p<0.001) (Table 2).

Table 2. Brushing effectiveness of toothbrushes by region

	Manual	**Electric**	**Chewable**	**Test statistics**	**p value**
Lower					
Pre-brushing	2,53 ± 0,54	1,93 ± 0,66	2,06 ± 0,67	7,5	
Post-brushing	1,52 ± 0,51	1 ± 0,53	1,39 ± 0,72	6,211	
Difference	1,01 ± 0,41[a]	0,93 ± 0,28[a]	0,67 ± 0,27[b]	8,971	<0,001
Upper					
Pre-brushing	2,27 ± 0,5	1,68 ± 0,62	1,81 ± 0,62	8,389	
Post-brushing	1,21 ± 0,4	0,82 ± 0,55	1,23 ± 0,69	5,019	
Difference	1,05 ± 0,38[a]	0,86 ± 0,25[b]	0,58 ± 0,25[c]	19,151	<0,001
Posterior					
Pre-brushing	2,5 ± 0,45	2,04 ± 0,64	2,11 ± 0,53	6,257	
Post-brushing	1,52 ± 0,35	1,14 ± 0,58	1,51 ± 0,64	4,757	
Difference	0,98 ± 0,37[a]	0,89 ± 0,25[a]	0,6 ± 0,25[b]	13,502	<0,001

Anterior					
Pre-brushing	2,22 ± 0,65	1,46 ± 0,59	1,65 ± 0,68	11,17	
Post-brushing	1,16 ± 0,59	0,62 ± 0,47	1,04 ± 0,78	6,226	
Difference	1,06 ± 0,44[a]	0,84 ± 0,28[b]	0,61 ± 0,29[c]	12,596	<0,001
Lingual					
Pre-brushing	2,4 ± 0,53	1,67 ± 0,54	1,84 ± 0,44	17,234	
Post-brushing	1,55 ± 0,5	0,9 ± 0,5	1,22 ± 0,57	11,552	
Difference	0,86 ± 0,35[a]	0,77 ± 0,27[ab]	0,62 ± 0,32[b]	4,423	0,015
Buccal					
Pre-brushing	2,37 ± 0,55	1,94 ± 0,74	2,02 ± 0,82	3,033	
Post-brushing	1,18 ± 0,5	0,92 ± 0,61	1,4 ± 0,83	3,905	
Difference	1,19 ± 0,48[a]	1,02 ± 0,26[a]	0,63 ± 0,22[b]	21,339	<0,001
Total					
Pre-brushing	2,4 ± 0,49[a]	1,81 ± 0,61[b]	1,93 ± 0,6[b]	8,9	<0,001
Post-brushing	1,37 ± 0,43[a]	0,91 ± 0,52[b]	1,31 ± 0,67[a]	6,149	0,003
Difference	1,03 ± 0,36[a]	0,9 ± 0,22[a]	0,62 ± 0,22[b]	16,871	<0,001

When the teeth in the mandible, posterior, and buccal regions were examined, the manual and electric toothbrushes were found to be more effective in plaque removal than the chewable brushes ($p<0.001$). In the upper jaw and anterior region, the manual brush was most efficient in removing plaque (1.05±0.38; 1.06±0.44), followed by the electric toothbrush (0.86±0.25; 0.84±0, respectively), and finally, the chewable brush (0.58±0.25; 0.61±0.29) ($p<0.001$). In the lingual region, the most effective brushing method was manual brushing (0.86±0.35), while the chewable brush removed only a small amount of plaque ($p=0.015$) (Table 2).

4. Discussion and Conclusion

Tooth brushing is the most important factor in maintaining oral and dental health. However, due to individual inadequacies, today's fast lifestyle, and intense work schedules, tooth brushing is pushed into the background, and oral hygiene is often not provided. In such cases, chewable toothbrushes have attracted attention because they do not require the use of water and toothpaste and are easy to use. However, in our study, it was evident that the brushing efficiency of chewable toothbrushes was less than that of either manual or electric toothbrushes.

Many factors, such as tooth brushing frequency, duration, technique, skill, and motivation, can affect the results of tooth brushing. Our study was conducted with dentistry students. The study aimed to evaluate the brushing effectiveness of the different materials by excluding individual factors and by ensuring the accurate application of the correct technique during tooth brushing. Additionally, the TMQHI plaque index was used with all teeth to measure brushing efficiency more accurately.

In a study comparing the effectiveness of manual and chewable toothbrushes among dentistry students, Mladenovic et al. [13] found that the manual toothbrush removed a significantly greater amount of plaque in the upper jaw only, in comparison to the chewable toothbrush. Unlike the results of our study, no significant differences were found between plaque removal efficiencies in the other regions or in the entire jaw. However, this result may have been associated with an insufficient number of participants.

In another study comparing manual and chewable toothbrushes in children aged 8-10 years, a chewable toothbrush was found to remove plaque more effectively after one week of use [14]. The success of the chewable toothbrush, especially on the lingual surfaces, was associated with the children's brief and ineffective use of manual toothbrushes. In another study conducted with children, Bezgin et al. [15] found that chewable toothbrushes were more effective on lingual surfaces, while manual toothbrushes were more effective on buccal surfaces. In another study conducted with children between the ages of 9 and 13, no statistical difference was found between the results for chewable and manual toothbrushes [10]. The results suggest that chewable toothbrushes increase children's motivation to chew. However, in our study, the fact that the participants were dental students who were able to use the manual toothbrush more professionally is assumed to have increased the effectiveness of manual tooth brushing. It is also thought that these results may be due to the Hawthorne effect with chewable brushes. In pilot studies conducted by Jeong et al. [16], in which the plaque removal efficiencies of the rolling and non-rolling techniques with the manual brush and chewable brushes were compared, the manual toothbrush method used with the rolling technique was found to be more effective than the chewable brush. However, no statistical difference was observed between the non-rolling technique and the chewable toothbrush. This study therefore showed the importance of using the correct brushing technique when using the manual method.

In a study by Aravind et al. [17], which compared three toothbrushes similar to those in our study, it was shown that electric toothbrushes were more effective than either manual or chewable toothbrushes in children, while the manual and chewable toothbrushes showed similar results. In this study, with children, the vibrating, oscillating, or rotating operation of the electric toothbrush depended less on individual competence than either the manual or chewable toothbrush.

A possible limitation of our study is that the initial difference in the amount of plaque between the groups was statistically significant. In our study, the preference of a brushing method with high plaque removal efficiency in manual tooth brushing may have increased the success of manual brushing. However, the preferred brushing method is a difficult technique and cannot be performed ideally in the whole population. Therefore, evaluation of manual brushing using different methods may provide more generalizable results. A positive aspect of our study is that the researcher evaluating the plaque index was blind to the particular brush used.

In our study, the plaque removal efficiency of the manual and electric toothbrushes to be superior, it was observed that the chewable toothbrushes also significantly reduced the plaque scores. An added advantage is that disposable toothbrushes, such as these, prevent microbial contamination. It is thought that chewable toothbrushes could be used as an alternative, especially for individuals who do not have the right brushing technique, or in children who are unable to perform toothbrushing effectively.

Declaration of Ethical Code

In this study, we undertake that all the rules required to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with, and that none of the actions stated under the heading "Actions Against Scientific Research and Publication Ethics" are not carried out.

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