ORIGINAL ARTICLE

Plaque Removal Efficacy of Different Toothbrushes: A Comparative Study

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Abstract

Aim and objective: This study aimed to compare the plaque removal efficacy of different toothbrushes and to ascertain the most efficient mechanical mean for daily plaque removal so as to maintain oral health in a preeminent way.

Study design: It was a randomized controlled clinical trial consisting of 60 subjects divided into three groups (group I ultrasonic and sonic toothbrush, group II multidirectional toothbrush, and group III manual toothbrush) with 20 in each group. Prebrushing and postbrushing plaque scores were recorded at weekly intervals for four weeks using Turesky modification of Quigley and Hein plaque index.

Results: Statistically significant differences ($p < 0.001$) existed in mean percent reduction of pre-day 1 to pre-day 28 mean percent reduction in plaque values of the ultrasonic toothbrush group (111.92 $\pm$ 25.20), the multidirectional toothbrush group (189.06 $\pm$ 52.70), and the manual toothbrush group (42.34 $\pm$ 14.77). Similar results were found in post-day 1 to post-day 28 mean percent reduction in plaque values.

Conclusion: Group II (i.e., multidirectional toothbrush) showed maximum mean percent reduction in prebrushing and postbrushing plaque scores at the end of four weeks when compared with the baseline values followed by ultrasonic toothbrush and manual toothbrush.

Keywords: Multidirectional toothbrush, Plaque, Plaque removal, Plaque scores, Ultrasonic toothbrush.

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Introduction

Dental plaque is a direct cause of gingival and periodontal diseases. Plaque is capable of reducing the pH at enamel surface to the levels that causes dissolution of the hydroxyapatite crystals and initiates caries. A number of oral hygiene measures have been used since before history. The first true bristled toothbrush originated in China at around 1600 AD. The first recent toothbrush was reinvented in late 18th and early 19th centuries.[1]

Different designs of manual and powered toothbrushes were introduced over the past 40 years. In recent literature, four main types of powered toothbrushes are available, based on their mechanism of action: side to side, counter-oscillation, rotation oscillation, circular, sonic, and ultrasonic.

The powered toothbrush using sonic energy operates at a frequency of 260 Hz. Its brush head oscillation produces a bristle tip velocity that, when inserted in a fluid/air environment, creates turbulent fluid and bubble activity and associated shear forces. Another powered toothbrushes include ultrasonic toothbrushes. Ultrasound can also be used in the removal of plaque bacteria. Ultrasound converts the dentifrice bubbles into localized active cleaning agents with the help of acoustic microstreaming and enhances cleaning from its interaction with bubbles.[2]

Later, toothbrushes were created using the combination of sonic and ultrasound processes. Research confirmed that they could synergistically remove *S. mutans* biofilm. Sonic brush head motion generates bubbles in a dentifrice, and the ultrasound projected into that slurry causes the expansion of the bubbles and contract lead to dislodgement of the plaque bacteria adhering to the tooth surfaces.[3] SMILEX ultrasonic toothbrush that has been used in this study uses a combination of both the technologies. It removes the plaque from teeth and to destroy the insoluble glucan caked with teeth.

Recently, a novel multi-directional power brush has been developed. It is characterized by its unique, multi-directional movement owing to three distinct brush. Each zone helps provide improved plaque removal in three different intraoral regions.[4] There are several studies comparing the efficacy of different powered toothbrushes, but there are a limited data comparing ultrasonic and sonic toothbrush with the multidirectional toothbrush for which this study was planned.

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Materials and Methods

A total sample size of 60 subjects was taken and the study was carried out for 4 weeks. The subjects participated in the study were given verbal information regarding the study. A human subject ethics review committee assessed and approved the subject consent form and study protocol prior to the study inception.

The selected sampling was done taking into consideration following criteria:

Inclusion Criteria

- Children aged between 9 years and 16 years.
- Good general health.

- Minimum of 24 natural teeth.
- Subjects reported brushing at least once daily.
- Subjects never used a power toothbrush before.
- Using no other means of oral hygiene except tooth brushing.

Exclusion Criteria

- Caries, periodontal diseases, or oral lesions.
- A history of rheumatic fever, AIDS, leukemia, cirrhosis, sarcoidosis, diabetes mellitus, hepatitis, or any medical condition requiring consultation or drug therapy.
- Any physical condition that limits manual dexterity required for tooth brushing.
- A present history of medications that are likely to affect oral health.
- Antibiotic usage during the two months preceding the study.
- Fixed orthodontic appliances.
- Removable dentures or extended fixed prosthesis.

After informed consent, all the participants were divided randomly into three groups of 20 each.

Group I

Subjects were guided daily to brush with ultrasonic and sonic toothbrush (smilex ultrasonic toothbrush) (Fig. 1) as per the manufacturer's instructions.

Group II

Subjects were guided daily to brush with multidirectional (Oral-B Professional Deep Sweep Triclean 5000) toothbrush (Fig. 2) as per the manufacturer's instructions.

Group III

Subjects were guided daily to brush with the manual toothbrush (Oral-B cross action) (Fig. 3) using the modified Bass technique.

Selected subjects were then informed and monitored about the daily-guided 2-minutes tooth brushing with ADA-approved pea-sized toothpaste for 4 weeks. Participants were asked to cease tooth brushing 23–25 hours prior to the baseline visit, 7th day, 14th day, 21st day, and 28th day visits, i.e. when plaque scoring was to be done and the subjects were also asked to discontinue eating and drinking 4 hours prior to the earlier-mentioned visits.

Figs 1A and B: Group I (Smilex ultrasonic toothbrush)

Dental plaque was disclosed using the ivoclar vivadent plaque test. The teeth were isolated with the cotton rolls and the plaque-disclosing agent was applied with the applicator tip. The plaque appeared fluorescent yellow under polymerization light after the disclosing agent was applied (Fig. 4). Prebrushing and postbrushing plaque scores using Turesky modification of the Quigley and Hein analysis were recorded on the 1st day, 7th day, 14th day, 21st day, and 28th day, respectively.

Clinical Evaluation

A blind pedodontist evaluated the amount of plaque at 7th, 14th, 21st, 28th days, respectively. Evaluation involved disclosing with ivoclar vivadent plaque test and scoring with Turesky modification of Quigley and Hein plaque index. The six sites (mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual, and distolingual) per tooth were examined, and these sites were scored as shown below:
Score 0: No plaque.
Score 1: Separate flecks of plaque at the cervical margin.
Score 2: A thin continuous band of plaque up to 1 mm at the cervical margin.
Score 3: Band wider than 1 mm but less than one-third of the crown of tooth.
Score 4: Plaque covering at least one-third but less than two-thirds of the crown of the tooth.
Score 5: Plaque covering two-thirds or more of the crown of the tooth.

Then, the plaque index was calculated as per the formula:

Plaque index = total score on all the surfaces of all the teeth/number of surfaces examined.

The data thus collected were subjected to statistical analysis.

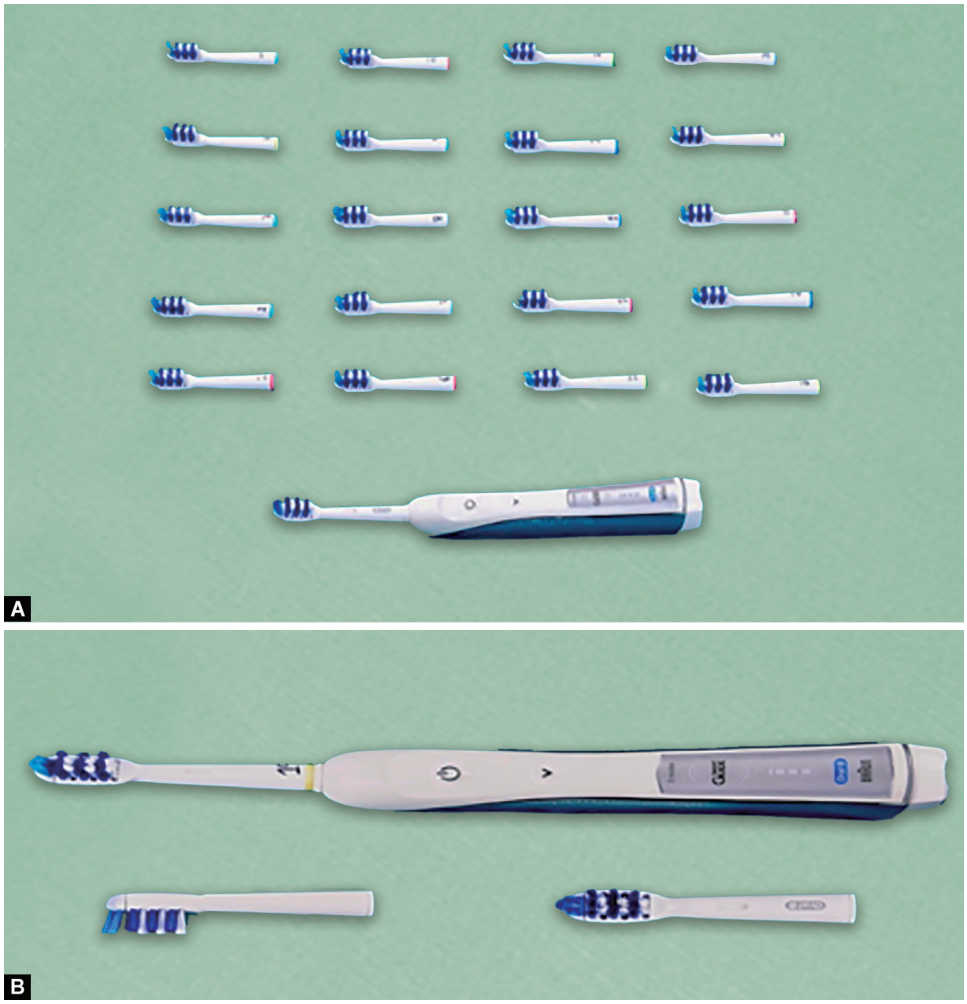
Statistical Analysis

Descriptive and analytical statistics were done. The normality of data was analyzed by the Shapiro–Wilk test. As the data of all the parameters did not follow normal distribution, the non-parametric tests were used to analyze the data. The Kruskal–Wallis test and Wilcoxon Signed Rank test was used to check differences in mean scores between groups wherever appropriate. *Post hoc* analysis was done using the Dunn test.

Results

Statistically significant differences ($p < 0.001$) existed in the mean percent reduction of pre-day 1 to pre-day 28 mean percent reduction in plaque values of the ultrasonic toothbrush group (111.92 ± 25.20), the multidirectional toothbrush group (189.06 ± 52.70), and the manual toothbrush group (42.34 ± 14.77). Similar results were found in the post-day 1 to post-day 28 mean percent reduction in plaque values. The difference was statistically significant ($p < 0.001$) in mean plaque percent reduction values of the ultrasonic toothbrush group (208.14 ± 56.94), the multidirectional toothbrush group (395.19 ± 61.18), and the manual toothbrush group (63.00 ± 15.25) (Table 1).

As shown by the earlier-mentioned results, group II (i.e., multidirectional toothbrush) showed maximum mean percent reduction in prebrushing and postbrushing plaque scores at the end



Figs 2A and B: Group II (Oral-B multidirectional toothbrush)

of four weeks when compared with the baseline values followed by ultrasonic toothbrush and manual tooth brush.

Pre 1 to pre 28% reduction in plaque score showed a significant difference among all the three groups. Similarly, the post-day 1 to post 28 mean plaque values also showed significant differences among all the three groups (Table 2).

Discussion

Dental plaque has been considered a direct cause of gingival and periodontal diseases. Good plaque control facilitates good gingival and periodontal health, prevents tooth decay, and preserves oral health for a lifetime.[5] A variety of oral hygiene measures has been used since before recorded history. The first modern toothbrush was reinvented in late 18th and early 19th centuries.[1] The first electric toothbrush, an attempt to offer a brush that could simulate the action of a manual brush, was developed in 1939 in Scotland.[2] The use of an electric toothbrush can improve the efficacy of brushing. Several studies have been done to compare the efficacy of different power as well as manual toothbrushes.

There are several studies that have compared manual toothbrushes with sonic toothbrushes (Pelka),[6] ultrasonic with manual toothbrushes (Forgas-Brockmann, et al.),[7] sonic and multidirectional toothbrush (Klukowska, et al.).[8] But, there were no such studies reported in literature to compare the latest ultrasonic/sonic toothbrush with a multidirectional toothbrush. Thus, this study was aimed to compare the plaque removal efficacy of ultrasonic and sonic toothbrush (smilex ultrasonic toothbrush), Oral-B multidirectional toothbrush, and a manual toothbrush (Oral-B cross action toothbrush).

This present randomized clinical trial was conducted on sixty children who were randomly divided into three groups. This study compared the plaque removal efficacy of ultrasonic and sonic toothbrush (smilex ultrasonic toothbrush)—group I, multidirectional toothbrush (Oral-B professional deep sweep + smart guide triaction 5000)—group II, and the manual toothbrush (Oral-B cross action)—group III.

Daily supervised tooth brushing was carried out. Prebrushing and postbrushing plaque index was recorded at weekly intervals for four weeks. Dental plaque was disclosed using Ivoclar vivadent plaque test. It contains the sodium salts of fluorescein as coloring agent has been used. Fluorescein is a coloring agent that, when excited with blue light, fluoresces yellow-green in the range of 500 nm.

Prebrushing and postbrushing plaque scoring was done using Turesky modification of Quigley and Hein analysis. The TQHPI represents the broad surface area of the whole buccal or lingual surfaces while giving focus to the gingival third of the tooth and

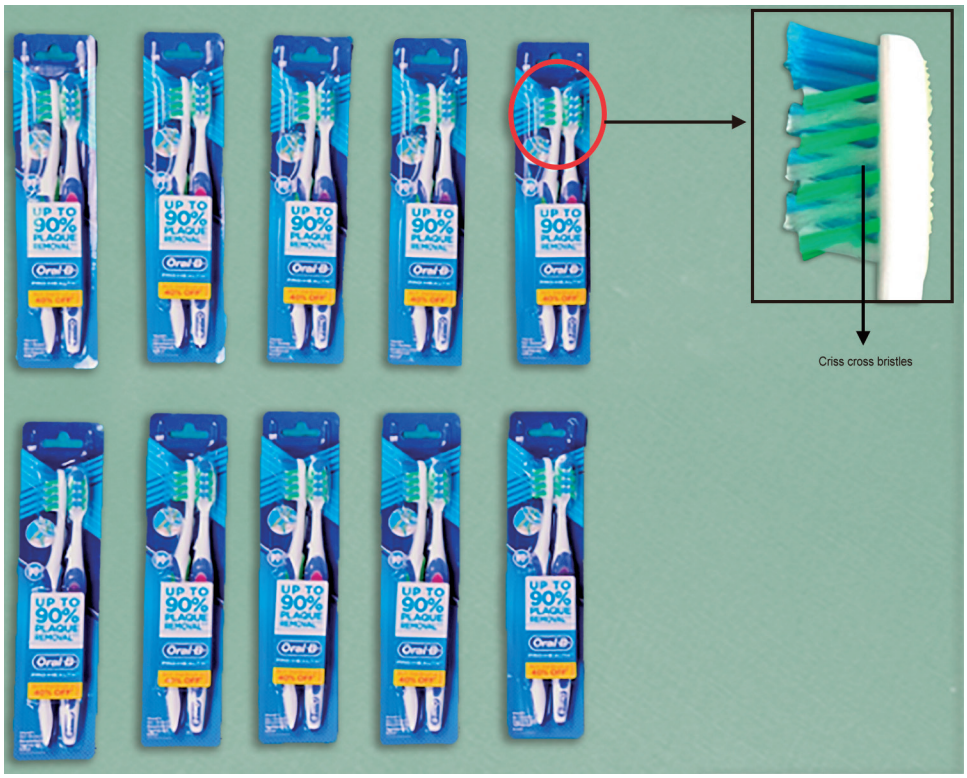


Fig. 3: Group III (Oral-B cross action manual toothbrush)

Fig. 4: Plaque appearing fluorescent yellow under polymerization light

grades plaque and debris on a scale 0–5 (0 = no plaque/debris, 5 = plaque covering two-thirds or more of the crown of the tooth). Modifications of the TQHPI include separating each buccal and lingual aspect into three surfaces (mesial, distal, and mid), using the line angles of the tooth to the contact point bordered by the gingival margin as guidelines for approximal regions, to give a total of six surfaces per tooth.[9]

When the amount of decrease in plaque score was noted starting from the baseline to the 4 weeks, it was found that group II (i.e., multidirectional toothbrush) showed maximum mean percent reduction in prebrushing and postbrushing plaque scores at the end of four weeks when compared with the baseline values followed by ultrasonic toothbrush and manual tooth brush (Table 1). This difference among the groups was found to be statistically significant. Prebrushing plaque score at day 1 to prebrushing plaque score at day 28 percent reduction showed a significant difference between the ultrasonic and the multidirectional toothbrush group ($p = 0.004$). The difference was found to be significant between the ultrasonic and the manual toothbrush group ($p < 0.001$) and between the multidirectional and the manual toothbrush group ($p < 0.001$) (Table 2). The postbrushing plaque score at day 1 to postbrushing plaque score at day 28 mean reduction also showed significant differences between the pairs: ultrasonic vs manual toothbrush group ($p = 0.001$); and multidirectional vs manual toothbrush group ($p \leq 0.001$); ultrasonic and multidirectional group ($p = 0.001$) (Table 2).

This highest decrease in plaque score by multidirectional toothbrush may be attributed to the fact that its brush head has multi-directional movement for superior plaque removal. Its multi-directional movements are delivered by 7,600–8,800 direction changes per minute, creating shearing forces that battle the firmness and stickiness of plaque biofilm.[4]

Naresh et al. compared the plaque removal efficacy of multidirectional toothbrush with the manual toothbrush. The study concluded that multidirectional toothbrush had significantly superior antiplaque effects compared to the manual toothbrush.[8]

The multidirectional toothbrush covers 43% wider area than an ADA manual toothbrush head during toothbrushing via its wide-sweeping bristles. It provides a wide-sweeping motion that allows the brush head to cover a wider area (including the approximal surfaces) when compared to the manual toothbrush.[8]

As described by Mielczarek et al., the multidirectional toothbrush outperformed the sonic toothbrush in reducing all-over plaque and biofilm accumulation in both the harder-to-clean gingival margin and interdental spaces.[4]

In this study, when compared to the baseline values, multidirectional toothbrush outperformed ultrasonic and manual toothbrush. The multidirectional toothbrush showed maximum mean percent reduction in plaque scores (64.61%) followed by ultrasonic (52.58%) and manual toothbrushes (29.18%).

Table 1: A comparison of mean percent reduction in plaque index (PI) scores among the three groups—the ultrasonic toothbrush, multidirectional toothbrush, and manual toothbrush group from pre-day 1 to pre-day 28 and post-day 1 to post-day 28

	Pre-day 28			*Post-day 28*		
Variables	*Ultrasonic*	*Multidirectional*	*Manual*	*Ultrasonic*	*Multidirectional*	*Manual*
N	20	20	20	20	20	20
Mean	111.92	189.06	42.34	208.14	395.19	63.00
SD	25.20	52.70	14.77	56.94	61.18	15.25
Median	110.71	192.13	39.47	206.28	397.74	59.43
Min.	69.13	116.32	14.26	106.97	308.24	42.88
Max.	154.06	375.27	74.48	333.63	546.03	103.03
Z value	49.206			51.940		
p value*	<0.001†			<0.001†		

**p* value derived from Kruskal–Wallis test; †significant at $p < 0.05$

Table 2: A pairwise comparison of mean percent reduction in plaque index (PI) scores among the three groups—the ultrasonic toothbrush, multidirectional toothbrush, and manual toothbrush group from pre-day 1 to pre-day 28 and post-day 1 to post-day 28

Timeline	*Pairs*	*Statistic*	*p value**
Pre-day 1–pre-day 28	Ultrasonic vs multidirectional	−3.232	0.004†
	Ultrasonic vs manual	3.775	<0.001†
	Multidirectional vs manual	7.008	<0.001†
Post-day 1–post-day 28	Ultrasonic vs multidirectional	−3.549	0.001†
	Ultrasonic vs manual	3.658	0.001†
	Multidirectional vs manual	7.207	<0.001†

**p* value derived from Dunn *post hoc* test; †significant at $p < 0.05$

The multidirectional showed 12.03% more plaque reduction when compared to the ultrasonic toothbrush.

There are several other studies comparing different types of manual and powered toothbrushes. Biesbrock et al.[10] in 2008 compared plaque removal efficacy and safety of an advanced rotation-oscillation power toothbrush with sonic toothbrush. Results showed that Oral-B Triumph was significantly ($p < 0.0001$) more effective in plaque removal than Sonicare FlexCare. Kallar et al.[11] reported that powered brushes showed significant plaque reduction when compared to the manual brushes. Supervised group of both brushes showed a greater plaque reduction.

Re et al.[2] compared the plaque removal efficacy of sonic toothbrush and the manual toothbrush. A significant additional 10% reduction was found for subjects without any previous use or familiarization with the sonic technology.

On the basis our results, the multidirectional toothbrush showed better plaque reduction when compared to ultrasonic and a manual toothbrush owing to its triple zone of action. Additional studies measuring long-term use and clinical outcomes are needed for comparing these newer technologies of ultrasonic and sonic toothbrush and multidirectional toothbrush.

Conclusion and Clinical Significance

This study has lead us to conclude that when compared with ultrasonic and sonic toothbrush, multidirectional toothbrush has shown better plaque reduction and it can be safely used by children to maintain their oral hygiene. However, further longitudinal studies are required to compare different powered toothbrushes with the manual toothbrushes under daily supervision of toothbrushing.

Manufacturers Names

- SMILEX AU 300-E Ultrasonic toothbrush, Manufactured by: Asahiirica Exportco, Ltd. Komatsu Kounosu City, Saitama, Japan.
- Oral-B Professional Deep Sweep Triclean 5000 toothbrush, Manufactured by: Procter and Gamble, USA.
- Oral-B cross action manual toothbrush, Manufactured by: Procter and Gamble, USA.
- Ivoclar vivadent plaque test, manufactured by: Ivoclar Vivadent AG Bendererstrasse 2 FL-9494 Schaan.

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