

# Cleaning Efficacy of Regular, Orthodontic and Electric Toothbrushes around Orthodontic Brackets: An In-vitro Study

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## ABSTRACT

**Introduction:** Plaque formation increases when mechanical disruption occurs in the oral cavity's self-cleaning systems during fixed orthodontic therapy. Hence, it is imperative that oral prophylaxis must be performed with more care in orthodontic patients. This can be efficiently done with the help of toothbrushes. There are various types of toothbrushes such as regular, orthodontic and electric toothbrushes which are most commonly used by patients to maintain proper oral hygiene and prevent plaque accumulation.

**Aim:** To identify which toothbrush has the best cleaning efficiency, when used around orthodontic brackets.

**Materials and Methods:** This in-vitro study was conducted in the laboratory set-up at Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India. The study was conducted for a period of two weeks from 17<sup>th</sup> January 2022 to 30<sup>th</sup> January 2022, and used 24 permanent premolars extracted for orthodontic purposes which were divided into three groups: regular, orthodontic and electric toothbrushes. There were eight tooth samples in each

group. Following premolar bracket bonding, a biofilm was formed around the teeth using *E.faecalis* culture in-vitro for three days. The samples were then carefully removed and treated with a disclosing agent before being put through a brushing simulation. The "Plaque index for Orthodontic Patients" (PIOP) index was used to estimate plaque scores before and after brushing based on how much biofilm was remaining on the tooth surfaces. One-way Analysis of Variance (ANOVA) and Tukey's Post-hoc tests were used to determine the statistical significance.

**Results:** The mean plaque scores after simulation in the toothbrush groups were 3±0.75 (regular), 1.75±0.70 (orthodontic) and 2.37±0.74 (electric). There was a statistically significant difference in mean plaque scores between groups as determined by one-way ANOVA { $F(p=0.008)$ }. A Tukey's Post-hoc test revealed that the cleaning efficacy of orthodontic toothbrushes was statistically significant compared to the other two groups.

**Conclusion:** The orthodontic toothbrushes produced a statistically greater level of tooth-cleaning effectiveness.

**Keywords:** Brushing, Cleaning efficacy, Orthodontic therapy, Plaque, Types

## INTRODUCTION

Maintaining dental health requires effective plaque control when using fixed orthodontic appliances [1]. Plaque formation increases due to the mechanical disruption of the oral cavity's self-cleaning systems during orthodontic fixed appliance therapy. Another unfavourable side effect is the development of white spot lesions, which affect around 97% of individuals undergoing orthodontic treatment [2]. According to Mohan R, fixed appliances encourage microbial growth and plaque retention [3]. Patients with inadequate oral hygiene may experience increased plaque build-up and calculus formation leading to gingivitis, bleeding on probing, gingival hypertrophy or attachment loss after orthodontic therapy [1]. The most important procedure to prevent plaque accumulation in the oral cavity, especially around tooth structures is brushing. The various types of toothbrushes available include regular, orthodontic and electric toothbrushes. The regular toothbrushes have tufts and bristles with a regular head size which could be used manually. Later electric toothbrushes were introduced, which were motor operated and orthodontic toothbrushes which had a unique arrangement of bristles based on the orthodontic bracket positions.

It is challenging to prevent plaque accumulation around orthodontic brackets, which can produce white spot lesions and enamel decalcification surrounding orthodontic appliances [2]. There is no difference found between ceramic and stainless steel brackets in terms of plaque retention around them [3]. Oral biofilms weaken the strength of adhesive bonds in addition to damaging oral tissues at this intersection. There are various types of toothbrushes that have been developed for efficient plaque removal. These toothbrushes

have varying head sizes, shapes, directions of motion and efficiency [4]. The bristle type varies from very soft to soft, as well as, hard bristles. The American Dental Association (ADA) specification of toothbrushes has 2-4 rows of bristles with 5-12 tufts per row and 80-86 bristles per tuft [4,5]. Based on this criteria, the commonly found toothbrushes are of three types, regular, electric and orthodontic toothbrushes.

These toothbrushes have been assessed based on their design, size and cleaning efficacy around orthodontic brackets in previous literature [6,7]. But, these studies have either been conducted on individual toothbrushes or comparing only a couple of toothbrushes. There is a lacuna present in terms of the use of standard methodology and overall comparisons of all types of toothbrushes and their ability to maintain oral hygiene in orthodontic patients. Hence, the present study was done to extensively analyse the cleaning efficacy of all three major types of toothbrushes around orthodontic brackets.

## MATERIALS AND METHODS

This in-vitro study was conducted in the laboratory set-up at Saveetha Dental College and Hospital, Chennai, Tamil Nadu, India. The study was conducted for a period of two weeks from 17<sup>th</sup> January 2022 to 30<sup>th</sup> January 2022. The present study was approved by the institute review board of Saveetha University. The ethical committee approval number was designated as IHEC/SDC/ORTHO-2101/23/009.

**Inclusion criteria:** The study was done under in-vitro conditions and the samples were selected as caries-free premolar teeth, that had been extracted for orthodontic purposes.

**Exclusion criteria:** Teeth with caries, fillings or stains were excluded from the study.

**Sample size calculation:** The sample size calculation was done using G\*Power software (version 3.1.9) and the calculated sample size was found to be 24.

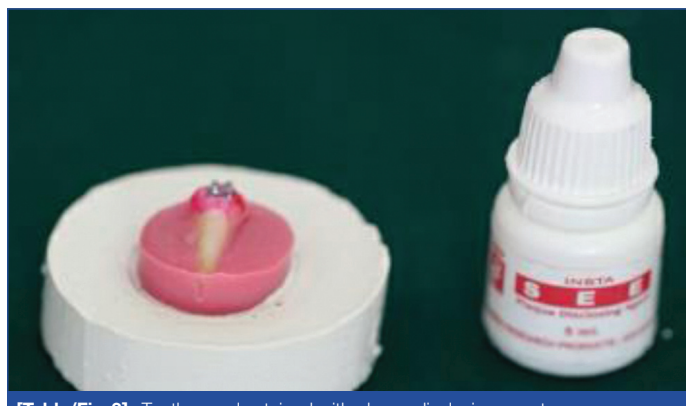
### Study Procedure

The samples were divided into three groups with eight samples in each group. A 0.2% thymol solution was used to clean the teeth' surfaces. Each tooth was embedded along its long axis in self-cure acrylic resin leaving the buccal surface completely free of the resin. The sample was divided into three groups namely- a) Regular toothbrushes (Colgate slim soft bristles toothbrush); b) Orthodontic toothbrushes (Stim Ortho MB); c) Electric toothbrushes (Oral-B Cross action power). A different toothbrush of the respective type was used on each sample within the groups.

The bonding of the brackets was done under aseptic conditions in the laboratory set-up. The labial surfaces of the extracted premolars were etched with 37% orthophosphoric acid (Prime etchant), after which the bonding agent (Transbond) was applied and cured. The composite (Ormco enlight composite) was placed on the brackets which in turn were positioned and cured. Once the brackets were bonded, each sample was placed inside individual containers consisting of *E. faecalis* broth culture for three days in it as shown in [Table/Fig-1]. A biofilm was formed around the bonded premolar surfaces by incubating the samples at 37°C [Table/Fig-2]. After three days, the samples were removed from the culture broth and analysed for biofilm formation using a disclosing agent (Insta Plaque disclosing agent, made in India) [Table/Fig-3]. The amount of disclosing agent on the labial surfaces was noted by visual examination. The scoring was done based on Orthodontic Plaque Index (OPI) given by Beberhold K et al., the bonded premolars were then subjected to brushing simulation [8]. Each sample was subjected to brushing simulation (SD Mechatronik 3.8 brushing simulator) for a period of two minutes. The toothbrushes in the brushing simulator were kept parallel in the direction of the brackets. Each toothbrush head was applied with a pea-sized toothpaste (Colgate strong teeth) and the brushing simulation was done as shown in [Table/Fig-4]. The OPI was used to compare the scores for the amount of biofilm present before and after brushing (about 20 strokes in the brushing simulator for a period of two minutes equivalent to brushing twice a day for one day) based on the amount of disclosing agent found on the tooth surfaces [7,9]. Based on the modified PIOP, the scoring criteria are mentioned in [Table/Fig-5].



[Table/Fig-2]: Samples incubated for three days.



[Table/Fig-3]: Tooth sample stained with plaque disclosing agent.



[Table/Fig-4]: Brushing simulation.



[Table/Fig-1]: Bonded premolars placed in individual containers with *E. faecalis* broth culture.

Score	Interpretation
0	Tooth surface is plaque-free
1	Isolated plaque islands on one tooth surface at the bracket base
2	Plaque on two tooth surfaces at the bracket base
3	Plaque on three tooth surfaces at the bracket base
4	Plaque on all tooth surfaces at the bracket base

[Table/Fig-5]: Orthodontic Plaque Index scoring criteria.

### STATISTICAL ANALYSIS

The scores were tabulated and statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software (IBM version 23.0). The tests used for the present study included the one-way ANOVA test and Tukey's Post-hoc tests for multiple comparisons within the groups.

### RESULTS

The mean plaque scores of each tooth brush group is tabulated in [Table/Fig-6]. There was a statistically significant difference between groups as determined by one-way ANOVA ( $p=0.008$ ). A Tukey's Post-hoc test revealed that the cleaning efficacy of orthodontic toothbrushes was significantly better ( $p=0.006$ ) compared to the

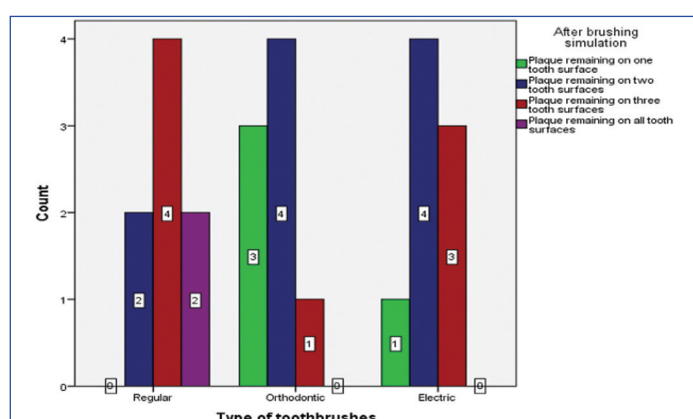
other two groups [Table/Fig-7]. Thus, orthodontic toothbrushes, as opposed to regular and electric toothbrushes had higher cleaning efficiency around orthodontic brackets. Additionally, biofilm on all tooth surfaces was present in the regular group, whereas no samples with biofilm retained around all the tooth surfaces (score 4) were present in the orthodontic and electric toothbrush groups. The results were graphically represented as shown in [Table/Fig-8].

Groups	Type of toothbrushes	Number of samples	Plaque scores before brushing simulation (mean)	Plaque scores after brushing simulation mean±sd	p-value
a	Regular	8	4	3±0.75	0.008*
b	Orthodontic	8	4	1.75±0.70	
c	Electric	8	4	2.37±0.74	

[Table/Fig-6]: Mean plaque scores in each toothbrush group. One-way ANOVA, \*p<0.05 depicting significant difference

Type of toothbrushes (i)	Type of toothbrushes (j)	Mean difference (i-j)	Significance
Regular	Orthodontic	1.250*	0.006
	Electric	0.750	0.120
Orthodontic	Regular	-1.250*	0.006
	Electric	-0.500	0.368
Electric	Regular	-0.750	0.120
	Orthodontic	0.500	0.368

[Table/Fig-7]: Multiple comparisons using Tukey's Post-hoc test. p-value <0.05 indicating significance between the orthodontic toothbrush and regular toothbrush.



[Table/Fig-8]: Sample distribution after brushing simulation for all three groups according to OPI scoring criteria.

Orthodontic toothbrushes show a greater reduction in plaque retention on three or more surfaces compared to regular and electric toothbrushes.

## DISCUSSION

The present study found that the orthodontic toothbrushes had a superior cleaning efficacy compared to the regular and electric toothbrushes (p=0.008). This could be due to the shape of the brush head and orientation of the toothbrush bristles which helped in better cleaning efficacy of orthodontic toothbrushes

around orthodontic brackets. On multiple comparison between the groups, there was significant difference between orthodontic and regular toothbrushes (p=0.006) and the cleaning efficacy between orthodontic and electric toothbrushes were somewhat similar.

Effective plaque removal is severely hampered in patients with fixed appliances for orthodontic treatment with plaque build-up, gingival irritation and gingival overgrowth being some of the majorly recognised issues [6]. Creeth JE et al., stated that plaque removal increased across the time range of 30 seconds to two minutes tending towards a maximum at longer brushing times. The study concluded that toothbrushing for a minimum of two minutes increased the amount of plaque removal to a greater extent and provided clinically significant oral health benefits [10]. The average amount of time spent on oral hygiene is more significant than how frequently, it is carried out each day in terms of achieving adequate plaque reduction [9]. Three types of toothbrushes are generally available namely regular, electric and orthodontic toothbrushes. Powered toothbrushes may be beneficial for certain populations that have difficulty maintaining oral hygiene such as mentally and physically challenged patients, poor compliance patients, children and young adults [11].

Earlier studies have also compared tooth cleaning based on the type of toothbrushes used, the direction and duration of brushing and the use of mouthwashes along with brushing. Borutta A et al., and Silvestrini Biavati A et al., showed increased plaque removal using powered or electric toothbrushes [11,12]. Barnes CM et al., showed significant results with the use of an electric toothbrush [13]. Moritis K et al., and Platt K et al., found that sonic toothbrushes were more efficient than regular brushes in plaque removal [14,15]. Terezhalmay GT et al., showed an ultrasonic toothbrush to be more efficient than that a manual toothbrush in removing plaque in patients without severe periodontal disease [16]. Erbe C et al., compared regular and orthodontic toothbrushes based on their design and function and found that orthodontic toothbrushes had smaller and irregular heads leading to better adaptation of the brush head at specific surfaces of teeth with fixed orthodontic appliances. This led to more bracket coverage and better cleaning of interdental spaces along the gumline [17].

Costa MR et al., found no statistical difference among ultrasonic, electric and manual toothbrushes when evaluated for their clinical and microbiological parameters [18]. However, in the present study, orthodontic toothbrushes had better tooth-cleaning efficacy compared to regular toothbrushes. One of the main reasons for the result could be the orientation of the bristles on the toothbrush head which caused better cleaning of surfaces surrounding the brackets and the size of the brush head which led to better adaptation. There was no significant difference between the plaque scores between regular and electric toothbrushes. This was similar to the study by Thienpont V et al., where two electric and two regular toothbrushes did not show differences in plaque removal in patients with fixed orthodontic appliances [19]. Cirelli T et al., compared electric, ultrasonic and regular toothbrushes and found that the ultrasonic and electric toothbrushes removed biofilms more effectively than regular toothbrushes [20].

Creeth J et al., also stated that an increase in the amount of dentifrice use and duration of brushing also influenced the effectiveness of

S. No.	Author's name and year	Place of study University/Country	Number of subjects	Toothbrushes compared	Parameters assessed	Conclusion
1	Borutta A et al., 2002 [11]	Centre for Dentistry, Jena, Germany	80 subjects	Powered vs manual toothbrushes	Plaque removal and gingival inflammation	Powered toothbrushes showed superior plaque removal effect (p=0.0001) and reduction in gingival inflammation (p<0.05)
2	Silvestrini Biavati A et al., 2010 [12]	University of Genoa, Italy.	20 subjects	Manual vs oscillating-rotating electric toothbrushes	Plaque levels, gingival bleeding and hypertrophy	The electric oscillating-rotating toothbrush was found to better in improving the plaque index and gingival bleeding index.
3	Barnes CM et al., 1999 [13]	College of Dentistry, Lincoln, USA	60 subjects	Two powered toothbrushes Rowenta MH700 vs Braun Plak Control Ultra	Plaque accumulation, gingivitis, and gingival bleeding	The Rowenta group did not demonstrate a significantly greater reduction in plaque index or gingival bleeding index than the Braun group at either examination.

4	Moritis K et al., 2002 [14]	Dental Research Centre, USA	25 subjects	The Sonicare Elite toothbrush vs soft-bristled manual toothbrush (Oral-B 35).	Evaluation of plaque reduction	The Sonicare Elite had a significantly greater reduction in plaque than the manual toothbrush (36.0% compared to 25.7%; $p<0.05$ )
5	Platt K et al., 2002 [15]	Dental Research Centre, USA	45 subjects	The Sonicare Elite toothbrush vs original Sonicare toothbrush (Sonicare Advance).	Plaque reduction	The Sonicare Elite was statistically superior in removing supragingival plaque from the dentition taken as a whole (ANOVA; $p<0.05$ )
6	Terezhalmay GT et al., 1995 [16]	Department of Dentistry, Ohio	54 subjects	Ultrasonic toothbrush vs conventional toothbrush	Evaluation of supragingival plaque, gingivitis, and gingival bleeding	The ultrasonic toothbrush was significantly more effective in reducing plaque formation ( $p<0.05$ ), removing plaque ( $p<0.05$ ), and reducing gingivitis ( $p<0.05$ ) during the six month study period.
7	Erbe C et al., 2013 [17]	Department of Orthodontics, University Medical Centre of the Johannes Gutenberg-University, Germany.	45 subjects	oscillating-rotating electric toothbrush vs electric toothbrush with regular head vs regular manual toothbrush	Differences in plaque removal	Plaque removal with the electric toothbrush with the orthodontic brush head was superior (2.2%; $p=0.007$ ) to the regular brush head
8	Costa MR et al., 2007 [18]	São Paulo State University-Araraquara Dental School, Brazil.	21 subjects	Ultrasonic toothbrush vs electric vs manual toothbrush	Reduction in plaque scores	No significant change in reducing gingival inflammation or plaque scores.
9	Cirelli T et al., 2021 [20]	São Paulo State University-Araraquara Dental School, Brazil	36 subjects	Manual vs electric vs ultrasonic toothbrushes	Plaque removal, gingivitis, amount of tooth wear	The ultrasonic and electric toothbrushes had a more significant effect on biofilm removal than a manual toothbrush, but the ultrasonic toothbrush promoted greater dentin tissue wear.
10	Present study	Saveetha Dental College, Chennai, India	24 tooth samples	Regular vs electric vs ultrasonic toothbrushes	Plaque removal efficacy by alteration in plaque scores	The orthodontic toothbrushes produced a statistically greater level of tooth-cleaning effectiveness.

**[Table/Fig-9]:** Tabulation of previous study results [11-18,20].

oral prophylaxis and lead to an increase in the fluoride concentration [21]. In the present study, samples with a complete absence of plaque were observed in orthodontic and electric toothbrush groups. The present study is also in line with the reviews by Nassar PO et al., and Marçal FF et al., who have advocated the use of an Orthodontic toothbrush over a conventional toothbrush as it resulted in an improvement in plaque index [22,23]. Newer types of toothbrushes such as ultrasonic toothbrushes have also been evaluated for plaque removal. In a recent study by Marçal et al., orthodontic toothbrushes caused a reduction in plaque scores when compared to conventional toothbrushes [23]. The present study also used oral hygiene indices to assess the oral hygiene situation around orthodontic brackets as mentioned in previous studies such as by Beberhold K et al., [8]. The findings of the above mentioned studies have been tabulated in [Table/Fig-9] [11-18,20].

### Limitation(s)

The limitation of the present study was that, the study was conducted in an in-vitro set-up. The brushing technique differs from individual to individual and from the brushing simulator to some extent thereby giving varied results. Another limitation is that, the study explained about only plaque accumulation on brackets alone, which did not include archwires, ligature or elastic ties.

### CONCLUSION(S)

The orthodontic toothbrushes produced a statistically greater level of tooth-cleaning effectiveness in the present study. Thus, it can be used as a crucial tool for maintaining oral hygiene and preventing plaque accumulation around orthodontic brackets and gingival margins. Thus, further clinical studies with increased sample sizes are recommended, in order to confirm the results of the present study. More studies comparing ultrasonic and orthodontic toothbrushes in patients with orthodontic treatment are required to find the most effective toothbrush, for adequate oral hygiene in orthodontic patients.

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