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Clinical evaluation of plaque removal efficacy of three commercially available toothbrushes

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Abstract
Background: Efficient plaque removal methods aid in achieving and maintaining optimal oral health, avoiding periodontal diseases. Most important and frequently used tool to prevent periodontal disease is by mechanical plaque control and for that manual toothbrushes are used.
Aim: The purpose of this clinical trial is to clinically evaluate the plaque removal efficacy of three commercially available tooth brushes.
Material and Methods: The study group consisted of fifty seven subjects with age ranging from 15 to 28 years distributed into 3 different groups, Group A(multi angle cross bristled toothbrush), Group B(circular bristled toothbrush), Group C(z shaped bristles toothbrush). Study was single blinded, randomized clinical trial. Rustogi modified navy plaque index (RMNPI) and Sulcular bleeding index (SBI) were assessed at baseline, 7th day and 21st day.
Results: All brushes showed significant reduction in plaque score over 3 weeks period. Comparison of mean plaque index and Average SBI between the three groups shows that Group C has the highest value of 0.9086(RMNPI) and 0.9204(SBI). However, the reduction of plaque scores is greater in Group C (oral B shiny clean) when compared to other groups.
Conclusion: The data derived from this clinical trial shows that all the tooth brushes has shown decrease in plaque scores. In comparison, z shaped bristles toothbrush [Group C] has some beneficial effects in reduction of plaque scores.

Keywords: toothbrush, plaque, mechanical plaque control

Introduction
For dental caries and gingivitis prevention efficient plaque removal is essential, and it is an important aspect for the perpetuation of proper oral hygiene [1]. In attaining and preserving good oral health and to avoid periodontal diseases efficient plaque removal aids are most essential. As a solitary means of plaque removal manual toothbrush is extensively used by the public [2]. Effective plaque control and good oral hygiene maintenance play a solid role in the maintaining oral health and prevention of these diseases [3].
Bristle toothbrush came into existence during the 18th. Predeccors's of today's brushes were introduced in the 1930's. Plastic handled nylon toothbrushes were introduced later. It was more affordable, and tooth brushing became a everyday practice in the society. Since then many technologies have been implemented to toothbrush design, like angulations of handle, head size and arrangement of bristles in order to make plaque removal more easier. Different varieties of manual toothbrushes are available in the market now [4]. A direct relation is present between bacterial plaque on the tooth surfaces causing gingival inflammation. Various epidemiological surveys admit the strong association between plaque and gingivitis. Toothbrush is the most important and frequently used tool used by the public to prevent periodontal disease as a good mechanical plaque control device [5].
The aim of this study was to clinically evaluate the plaque removal efficacy of three commercially available toothbrushes.

Material and Methods
The study was a randomized 3 cell, examiner blind clinical trial. 57 patients from the out patients reporting to department of Periodontology were enrolled in the study. They consisted of 13 males and 44 females, randomly distributed into 3 groups with age ranging from 15 to

28years. Distribution was done randomly using lottery method. The study protocol was approved by institutional ethical committee. Participants were explained about the study and later informed and written consents were taken. All the participants were dentate with minimum 28 numbers of teeth. The exclusion criteria were:

1. Participants with previous usage of antibiotics and who underwent any form of periodontal therapy in past 6 months
2. Any systemic conditions
3. Periodontal diseases
4. Subjects with severe crowding
5. Subjects with history of smoking and tobacco chewing
6. Subjects using other supplemental plaque control aids were excluded from the study.

Patients fulfilling these selection criteria were divided equally into three groups

- Group A :19 subjects using multi angle cross bristled toothbrush
- Group B :19 subjects using circular bristled toothbrush
- Group C :19 subjects using z shaped bristles toothbrush (Figure 1)

Fig 1: Toothbrushes used

A single blinded technique was used in which subjects were assigned to three different groups by the second examiner, who coded the toothbrush as I, II, III and distributed it to the patients. The study population was assigned into three groups by simple randomization using lottery method. The principal investigator adviced the subjects to brush with the respective toothbrush twice daily. To achieve standardized condition, each participant was provided with a common dentifrice (Colgate Dental Cream). Modified bass technique was demonstrated to the patients and instructed to follow the same for 3 minutes. The clinical parameters, plaque index [Rustogi modification of Navy plaque Index (RMNPI)], sulcular bleeding index [Muhlemann and Son 1971(SBI)] were recorded followed by supragingival scaling by the principal investigator.

The clinical parameters were measured at baseline, 7th day and 21st day by the principal investigator. The toothbrush samples were coded by a second examiner and was decoded after recording the clinical parameters of all 57 subjects included in the study.

Statistical analysis

In a one-way ANOVA study, sample sizes of 19 each were obtained from the 3 groups whose means are compared. The total sample of 57 subjects achieves 81% power to detect differences among the means versus the alternative of equal means using an F test with a 0.05000 significance level. The size of the variation in the means is represented by their standard deviation which is 0.09. The common standard deviation within a group is assumed to be 0.20.

Results

All fifty seven subjects completed the study protocol. Age of the participants ranged from 15 to 28years and the mean age is 25.50±2.13years [SD] and there was statistically significant difference in values of plaque index and bleeding index in group C (z shaped bristles toothbrush).

Comparison of mean plaque score and sulcular bleeding score of each group from baseline to 7th day, baseline to 21st day and 7th to 21st day values are given under each group below;

Group A

- On comparison of the mean values of RMNPI baseline and RMNPI 7th day the mean values of RMNPI baseline is higher with a difference of 0.0563158 is statistically significant with a p value of 0.001.
- On comparison of the mean values of RMNPI and RMNPI 21st day the mean values of RMNPI baseline is higher with a difference of 0.0942105 is statistically significant with a p value of <0.001.
- On comparison of the mean values of RMNPI 7th day and RMNPI 21st day the mean values of RMNPI 7th day is higher with a difference of 0.0378947 is statistically significant with a p value of 0.015.
- On comparison of the mean values of SBI baseline and SBI 7th day the mean values of SBI baseline is higher with a difference of 0.03 is statistically significant with a p value of 0.004.
- On comparison of the mean values of SBI baseline and SBI 21st day the mean values of SBI baseline is higher with a difference of 0.0847368 is statistically significant with a p value of <0.001.
- On comparison of the mean values of SBI 7th day and SBI 21st day the mean values of SBI 7th day is higher with a difference of 0.0547368 is statistically significant with a p value of <0.001**.** (TABLE 1)

Table 1: Paired t test values for group A

GROUP			Mean	N	Std. Deviation	Paired Differences		t	df	P VALUE
						Mean Difference	Std. Deviation			
GROUP A	Pair 1	RUSTOGI MODIFIED NAVY PLAQUE INDEX BASELINE	0.754737	19	0.130357	0.056316	0.061392	3.998	18	0.001
		RUSTOGI MODIFIED NAVY PLAQUE INDEX 7th DAY	0.698421	19	0.150269					

	Pair 2	RUSTOGI MODIFIED NAVY PLAQUE INDEX BASELINE	0.754737	19	0.130357	0.094211	0.091002	4.513	18	<0.001
		RUSTOGI MODIFIED NAVY PLAQUE INDEX 21st DAY	0.660526	19	0.179768					
	Pair 3	RUSTOGI MODIFIED NAVY PLAQUE INDEX 7th DAY	0.698421	19	0.150269	0.037895	0.061606	2.681	18	0.015
		RUSTOGI MODIFIED NAVY PLAQUE INDEX 21st DAY	0.660526	19	0.179768					
	Pair 4	SULCULAR BLEEDING INDEX BASELINE	0.734737	19	0.120709	0.03	0.04	3.269	18	0.004
		SULCULAR BLEEDING INDEX 7th DAY	0.704737	19	0.122355					
	Pair 5	SULCULAR BLEEDING INDEX BASELINE	0.734737	19	0.120709	0.084737	0.051572	7.162	18	<0.001
		SULCULAR BLEEDING INDEX 21st DAY	0.65	19	0.142127					
	Pair 6	SULCULAR BLEEDING INDEX 7th DAY	0.704737	19	0.122355	0.054737	0.035019	6.813	18	<0.001
		SULCULAR BLEEDING INDEX 21st DAY	0.65	19	0.142127					

Group B

- On comparison of the mean values of RMNPI baseline and RMNPI 7th day the mean values of RMNPI baseline is higher with a difference of 0.0384211 is statistically significant with a p value of 0.014.
- On comparison of the mean values of RMNPI baseline and RMNPI 21st day the mean of RMNPI baseline is higher with a difference of 0.0647368 is statistically significant with a p value of 0.001.
- On comparison of the mean values of RMNPI 7th day and RMNPI 21st day the mean values of RMNPI 7th day is higher with a difference of 0.0263158 is statistically significant with a p value of 0.03.
- On comparison of the mean values of SBI baseline and SBI 7th day the mean values of SBI baseline is higher with a difference of 0.0326316 is statistically significant with a p value of 0.01.
- On comparison of the mean values of SBI baseline and SBI 21st day the mean values of SBI baseline is higher with a difference of 0.0478947 is statistically significant with a p value of 0.016.
- On comparison of the mean values of SBI 7th day and SBI 21st day the mean values of SBI 7th day is higher with a difference of 0.0152632 is statistically not significant with a p value of 0.285.(TABLE 2)

Table 2: Paired t test values for group B

GROUP			Mean	N	Std. Deviation	Paired Differences		t	df	P VALUE
						Mean Difference	Std. Deviation			
GROUP B	Pair 1	RUSTOGI MODIFIED NAVY PLAQUE INDEX BASELINE	0.675263	19	0.117396	0.038421	0.061848	2.708	18	0.014
		RUSTOGI MODIFIED NAVY PLAQUE INDEX 7th DAY	0.636842	19	0.122204					
	Pair 2	RUSTOGI MODIFIED NAVY PLAQUE INDEX BASELINE	0.675263	19	0.117396	0.064737	0.068424	4.124	18	0.001
		RUSTOGI MODIFIED NAVY PLAQUE INDEX 21st DAY	0.610526	19	0.124832					
	Pair 3	RUSTOGI MODIFIED NAVY PLAQUE INDEX 7th DAY	0.636842	19	0.122204	0.026316	0.048558	2.362	18	0.03
		RUSTOGI MODIFIED NAVY PLAQUE INDEX 21st DAY	0.610526	19	0.124832					
	Pair 4	SULCULAR BLEEDING INDEX BASELINE	0.663684	19	0.109606	0.032632	0.049536	2.871	18	0.01
		SULCULAR BLEEDING INDEX 7th DAY	0.631053	19	0.1107					
	Pair 5	SULCULAR BLEEDING INDEX BASELINE	0.663684	19	0.109606	0.047895	0.078781	2.65	18	0.016
		SULCULAR BLEEDING INDEX 21st DAY	0.615789	19	0.115052					
	Pair 6	SULCULAR BLEEDING INDEX 7th DAY	0.631053	19	0.1107	0.015263	0.060311	1.103	18	0.285
		SULCULAR BLEEDING INDEX 21st DAY	0.615789	19	0.115052					

Group C

- On comparison of the mean values baseline and 7th day the mean values of baseline is higher with a difference of 0.0605263 is statistically not significant with a p value of 0.264.
- On comparison of the mean values of baseline and 21st day the mean values of baseline is higher with a difference of 0.1173684 is statistically not significant with a p value of 0.12.
- On comparison of the mean values of 7th day 21st day the mean values of 7th day is higher with a difference of 0.0568421 is statistically not significant with a p value of 0.548.

On comparison of the mean values of SBI baseline SBI 7th day the mean values of SBI baseline is higher with a difference of 0.0121053 is statistically not significant with a p value of 0.08.

- On comparison of the mean values of SBI baseline and SBI 21st day the mean values of SBI baseline is higher with a difference of 0.0026316 is statistically not significant with a p value of 0.628.
- On comparison of the mean values of SBI 7th day and SBI 21st day the mean values of SBI 21st day is higher with a difference of 0.0094737 is statistically not significant with a p value of 0.228. (TABLE 3)

Table 3: Paired t test values for group C

GROUP			Mean	N	Std. Deviation	Paired Differences		t	df	P VALUE
						Mean Difference	Std. Deviation			
GROUP C	Pair 1	Rustogi modified navy plaque index baseline	0.967895	19	0.096182	0.060526	0.229019	1.152	18	0.264
		Rustogi modified navy plaque index 7th day	0.907368	19	0.250441					
	Pair 2	Rustogi modified navy plaque index baseline	0.967895	19	0.096182	0.117368	0.313118	1.634	18	0.12
		Rustogi modified navy plaque index 21st day	0.850526	19	0.327303					
	Pair 3	Rustogi modified navy plaque index 7th day	0.907368	19	0.250441	0.056842	0.404489	0.613	18	0.548
		Rustogi modified navy plaque index 21st day	0.850526	19	0.327303					
	Pair 4	Sulcular Bleeding Index Baseline	0.925263	19	0.15211	0.012105	0.028398	1.858	18	0.08
		Sulcular Bleeding Index 7th Day	0.913158	19	0.174644					
	Pair 5	Sulcular Bleeding Index Baseline	0.925263	19	0.15211	0.002632	0.023296	0.492	18	0.628
		Sulcular Bleeding Index 21st Day	0.922632	19	0.155451					
	Pair 6	Sulcular Bleeding Index 7th Day	0.913158	19	0.174644	-0.00947	0.033078	-1.248	18	0.228
		Sulcular Bleeding Index 21st Day	0.922632	19	0.155451					

Comparison of mean plaque index between the three groups shows that group C has the highest value of 0.9086 and group B has the least mean value of 0.6409. (Graph 1) This difference is statistically significant with a test value of 18.41 and p value of <0.001. (TABLE 4)

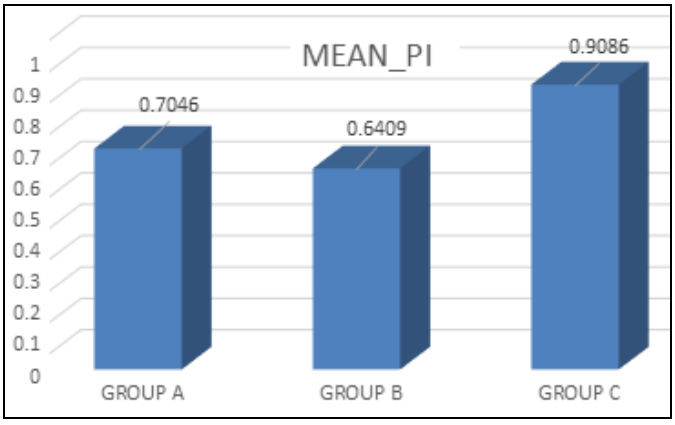
Table 4: One way ANOVA test results

	GROUPS	N	Mean	Std. Deviation	Statistics/ mean squares	df2(welch) / F(Anova)	P VALUE
MEAN_PI	Group a	19	0.7046	0.14901	0.372	18.41	<0.001
	Group b	19	0.6409	0.11644			
	Group c	19	0.9086	0.15748			
	Total	57	0.7513	0.18094			
Average Sulcular Bleeding Index	Group a	19	0.6965	0.12638	0.424	24.133	<0.001
	Group b	19	0.6368	0.10552			
	Group c	19	0.9204	0.1602			
	Total	57	0.7512	0.17923			

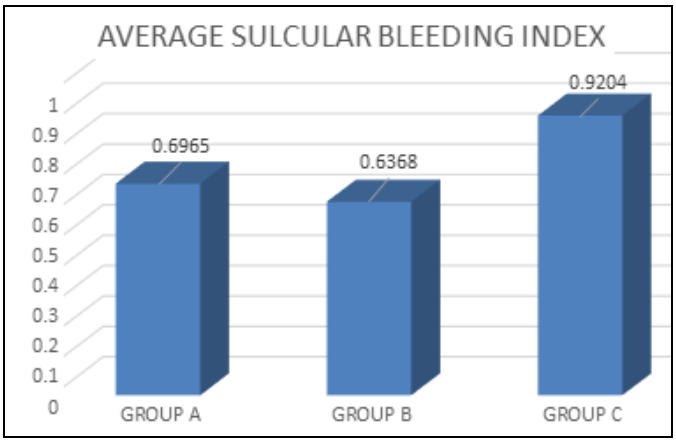
Comparison of average SBI between the three groups shows that group C group has the highest value of 0.9204 and group B has the least value of 0.6368**.** (GRAPH 2) This difference is statistically Significant with a test value of 24.133 and p value of <0.001(TABLE 5). Intergroup comparisons of Plaque index and bleeding index are presented in TABLE 2. Mean plaque and bleeding index for individual group is given in GRAPH 3 and GRAPH 4.

Table 5: Inter group comparisons of plaque index and sulcular bleeding index

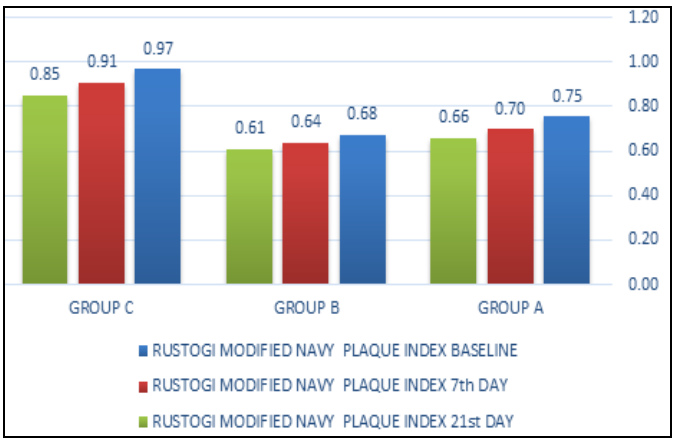
	GROUPS	N	Mean	Std. Deviation	T value	P Value	Posthoc Assessment	
							groups	Difference (P VALUE)
Rustogi modified navy plaque index baseline	GROUP A	19	0.754737	0.130357	32.608	<0.001	GROUP A - GROUP B	0.0794737 (0.095)
	GROUP B	19	0.675263	0.117396			GROUP A - GROUP C	-.2131579* (<0.001)
	GROUP C	19	0.967895	0.096182			GROUP B - GROUP C	-.2926316* (<0.001)
	Total	57	0.799298	0.168532				
Rustogi modified navy plaque index 7th day	GROUP A	19	0.698421	0.150269	11.433	<0.001	GROUP A - GROUP B	0.0615789 (0.556)
	GROUP B	19	0.636842	0.122204			GROUP A - GROUP C	-.2089474* (0.002)
	GROUP C	19	0.907368	0.250441			GROUP B - GROUP C	-.2705263* (<0.001)
	Total	57	0.747544	0.214154				
Rustogi modified navy plaque index 21st day	GROUP A	19	0.660526	0.179768	32.582	0.005	GROUP A - GROUP B	0.05 (0.777)
	GROUP B	19	0.610526	0.124832			GROUP A - GROUP C	-.1900000* (0.034)
	GROUP C	19	0.850526	0.327303			GROUP B - GROUP C	-.2400000* (0.005)
	Total	57	0.707193	0.246394				
Sulcular bleeding index baseline	GROUP A	19	0.734737	0.120709	20.974	<0.001	GROUP A - GROUP B	0.0710526 (0.214)
	GROUP B	19	0.663684	0.109606			GROUP A - GROUP C	-.1905263* (<0.001)
	GROUP C	19	0.925263	0.15211			GROUP B - GROUP C	-.2615789* (<0.001)
	Total	57	0.774561	0.168513				
Sulcular bleeding index 7th day	GROUP A	19	0.704737	0.122355	21.14	<0.001	GROUP A - GROUP B	0.0736842 (0.239)
	GROUP B	19	0.631053	0.110700			GROUP A - GROUP C	-.2084211* (<0.001)
	GROUP C	19	0.913158	0.174644			GROUP B - GROUP C	-.2821053* (<0.001)
	Total	57	0.749649	0.181885				
Sulcular bleeding index 21st day	GROUP A	19	0.650000	0.142127	27.98	<0.001	GROUP A - GROUP B	0.0342105 (0.728)
	GROUP B	19	0.615789	0.115052			GROUP A - GROUP C	-.2726316* (<0.001)
	GROUP C	19	0.922632	0.155451			GROUP B - GROUP C	-.3068421* (<0.001)
	Total	57	0.729474	0.194169				



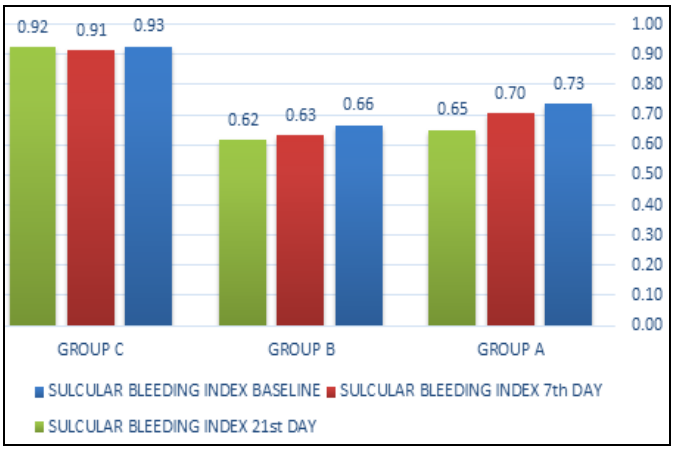
Graph 1: Mean Plaque Index



Graph 2: Average Sulcular Bleeding Index



Graph 3: Mean Plaque Index for Individual Groups



Graph 4: Mean Bleeding Index for Individual Groups

Discussion

A wide array of toothbrushes are available in the market, with advances in the design of the brush handle and head. In order to maximize the comfort of the patient toothbrushes with different brush head design and arrangement of bristles were introduced which helps in better adaptation. The adequacy of manual toothbrushes in plaque removal were assessed in various studies. The results are discrepant, with some studies reporting that some designs of toothbrushes are not superior. So this study was conducted to evaluate the plaque removal efficacy of three commercially available toothbrushes.

The results of the present study showed statistically significant differences between three brushes which is not in conformity with Bergenholtz *et al.* [6] who conducted a study comparing a toothbrush with flat-trim bristles with v-shaped bristles and concluded no significant differences between the toothbrushes. Staudt *et al.* [7] compared three toothbrushes with different brush head designs using a computer-based index (PPI). And they came to a conclusion that none of the tested toothbrush head design was superior over the other. Comparative clinical studies were found useful in deciding the corresponding plaque removal effectiveness of toothbrushes that might provide an indication of gingival health benefits on long term [8, 9, 10]. For clinically evaluating the cleaning efficacy of toothbrushes many indices have been developed. According to Fischman *et al.* [11] for the estimation of plaque removal efficacy of toothbrushes modified Turesky index is suggested. The plaque index used in our study was rustogi modified navy plaque index (RMNPI). According to RMNPI the scoring of plaque include the mesial and distal tooth surfaces and at the marginal areas as well as the total tooth surface. Buccal and lingual surfaces of tooth is divided into nine segments and are scored for the presence or absence of plaque by providing dichotomous values.

In our present study toothbrush with z shaped bristle showed higher plaque removal efficacy compared with angular bristled tooth brush and circular bristled toothbrushes.

Supriya N *et al.* conducted a study to compare the efficacy of four different types of commercially available manual toothbrushes. They concluded that none of the toothbrush design was effective in complete plaque removal. Though some minor differences in plaque removal efficacy of the brushes were seen, they were not statistically significant [12].

A study conducted by NAM Rosema *et al.* to test the plaque removal efficacy of a multi-level manual toothbrush (Profit-Haije-Brush) with a flat-trimmed manual control toothbrush and they concluded that the multi-level PHB was significantly more efficacious than the flat-trimmed ADA [13].

On comparing the sulcular bleeding index scores it was observed that group A and group C had higher sulcus bleeding score compared to group A and when values from baseline to 21st day were compared there were no statistically significant reduction in the scores. Where as in group B on comparing values from baseline to 21st day, a statistically significant reduction was observed. (GRAPH 4)

Kashif *et al.* [14] conducted a study to evaluate the efficacy of four different deigns of manual tooth brushes available in the market, to check for the plaque removal efficacy and they concluded that though different varieties of toothbrush bristle designs are introduced in the market, no single toothbrush is found extraordinary in plaque removal efficacy.

Claydon *et al.* [15] conducted a study to compare the plaque removal efficacy of 8 manual toothbrushes using a professional tooth brusher. Findings from the study states that there is no one superior design of manual toothbrush. Walters

et al. [16] conducted a study to compare and assess the plaque removal efficacy of five different toothbrushes and concluded that all brushes were highly effective, but comparisons between brushes showed consistent and statistically significant results with some brushes. These differences demonstrate that advances in toothbrush design can produce even greater plaque removal results.

Conclusion

Tooth brush continues to be the most promising plaque control device. However proper brushing technique and individual skills are more critical in plaque removal. In this study oral B shiny clean toothbrush (Group C) had a significant plaque removal efficacy compared to colgate zig-zag and colgate extra clean.

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