

Comparative Evaluation of Plaque Removing Efficacy of Three Different Toothbrush Bristle Designs.

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Abstract

In humankind most frequently occurring oral diseases are dental caries and periodontal disease, and the causative factor for both is dental plaque. Dental plaque is a adherent bacterial film that can irritate the gums, harden into tartar, resulting in gingivitis, a swollen bleeding gum tissue. Dental plaque if efficaciously carried away can be the most effectual method of maintaining good oral hygiene, reducing tooth decay, and promoting superior gingival health¹.

According to Experimental gingivitis study in 1965 showed that abstinence from all oral hygiene measures resulted in marginal gingivitis within 10-12 days.² Gingivitis resulted from a qualitative and quantitative change in the microbial plaque and on refurbishment of oral hygiene measures, healthy gingival condition was redeemed. Adequate plaque removal is essential for the prevention of dental caries and gingivitis, and forms the keystone of any good daily oral hygiene routine. But maintaining and achieving optimal oral health, and hence avoiding periodontal disease, requires highly effective plaque control methods.

Plaque control methods have been widely classified into mechanical and chemical plaque control. Mechanical plaque control is a simple and highly essential tool for oral prophylaxis. Particularly, the daily use of a manual

toothbrush in association with a fluoridated toothpaste is likely to be the most widely used, simple, and productive method for the prevention of oral diseases.³

The toothbrush is schemed primarily to promote cleanliness of teeth and oral cavity. The invention and use of toothbrush by Chinese in the late 16th century and was introduced to the Western world in 1640. In India, before the widespread use of toothbrush, “chewing sticks” were routinely used for oral hygiene practice. The predecessor of modern-age toothbrushes were developed in the 1930s. Toothbrush bristles were initially made from hog’s hair until 1938 when nylon bristles were introduced.⁴ Since then, manual toothbrushes have been manufactured with plastic handles and nylon bristles, making them lightweight, durable, and extremely economical. With the new and improved technology the physical and mechanical properties of toothbrush like shape, size, bristle design, texture, stiffness, angulations between head, shaft and handle. Moreover, it is commonly seen that people brushes their teeth for shorter duration by using a simple horizontal tooth brushing technique.

Now a day’s manufacturer’s aim for the innovation in the toothbrush bristles designs that will help to recompense for improper tooth brushing technique and time. There are many designs of tooth brushes that are available in market to improve periodontal condition such as Standard (Flat)

bristles and more advanced models with angled bristles like Crisscross and ZigZag. Therefore, the purpose of the present study was to evaluate the cleaning efficacy of different bristle designs of tooth brushes on plaque removal and gingivitis.

Materials and Methods

Before the start of the study, the protocol was approved from the institutional ethical committee for ethical clearance. All the subjects were informed about the protocol and those who agreed to participate in the study were made to sign an informed consent. A total of 60 dental students (36 females and 24 males; age range: 19–24 years), selected from the outpatient Department of Periodontics, Himachal Dental College Sunder nagar, Mandi, H.P, participated in this randomized controlled clinical study. The inclusion criteria were good oral and general health, having six teeth (excluding third molar) in each quadrant with no crowns, orthodontic appliances, no oral lesions. Subjects that were excluded from the study on the basis of exclusion criteria : smoking habit, having fixed, removable or implant prosthesis, presence of wasting diseases, caries or restorations, systemic diseases which would influence periodontal diseases or response to the treatment.

Study Design

All subjects were briefed about the study design well in advance. Three different types of manual toothbrushes were selected in the study with different pattern of bristles designs. The bristles of all the toothbrushes were of soft type. They were selected and compared for plaque removing efficacy and gingivitis. The brushes used were as follows:

- In Group A (20 subjects): Standard, flat bristles designed toothbrush.
- In Group B (20 subjects): Crisscross bristles designed toothbrush.

- In Group C (20 subjects): Zigzag bristles designed toothbrush.



A B C

study procedure

There was no Phase I therapy given to subjects before the start of study, but they were individually instructed for brushing by using the Modified Bass technique. The participants were instructed to brush their teeth twice daily in morning and before sleep for two minutes by using prescribed toothbrushes, during the study period. They were also asked to preclude mouthwash, medicated gels during study period. They should change their toothbrush after every 3 month. The toothbrushes and dentifrices (a basic toothpastes with no ant plaque agents) were delivered according to the allocation of randomization and all the clinical indices were performed and recorded at baseline,1,3,6 months.

Plaque index (PI) was scored according to the criteria of the **Quigley and Hein index⁵modified by Turesky⁶**. The surfaces were assessed after disclosing the dental plaque with basic fuchsin .Score 0: No plaque. Score 1: Separate flecks of plaque at the gingival margin of the crown. Score 2: A thin continuous band of plaque at the gingival margin of the crown. Score 3: A band of plaque wider than 1 mm but covering less than one third of the crown of the tooth. Score 4: Plaque covering less than two thirds of the crown of the tooth. Score 5: Plaque covering more than two thirds of the crown of the tooth.

Gingival index (GI) was scored according to the following criteria by Silness and Loe⁷: Score 0: Absence of inflammation. Score 1: A slight change in color and little change in texture. Score 2: A moderate redness, edema and hypertrophy and bleeding on probing (BoP). Score 3: A marked redness, hypertrophy and tendency to spontaneous bleeding.

Statistical Analysis

Statistical analyses were performed with a software program (SPSS version 16.0). The normality of data distribution was assessed by Shapiro-Wilk test, which indicated that the distribution of the data is non-parametric. Hence, for intra-group comparison the non-parametric Wilcoxon signed – rank test was performed. In intra group comparison, the scores obtained at different time interval for each category of bristle design were compared (horizontal dimension). For inter-group Kruskal-Wallis test was used to perform multiple comparison for mean values of the scores obtained at a specific time interval among three categories of bristle design (Vertical dimension). P < 0.05 was considered as statistically significant. And all p values were two- tailed.

Results

Demographic And Clinical Findings

The demographic information of study subjects are shown in Table 1. There were no statistically significant difference in age (20.9 ± 1.04; 22.1 ± 1.17,21.1± 1.11,respectively) between the groups. All subjects were undergraduate students and there were no smokers in all three groups. Total 60, students were recruited in the study and all had adherent the strict routine of daily brushing with given toothbrush bristles designs according to the rule and successfully accomplished the study and none of the subjects were lost during the study period.

Table 1.Age distribution and number of subjects using different types of Bristle

Bristle Type	Male subjects		Female subjects		All subject	
	Number	Age	Number	Age	Number	Age
	n (%)	mean ± SD (range)	n (%)	mean ± SD (range)	n (%)	mean ± SD (range)
Standard (N= 20)	9 (45)	20.8 ± 0.80 (19-22)	11 (55)	20.9 ± 1.22 (19-22)	20 (100)	20.8 ± 1.04 (19-22)
Crisscross (N=20)	8(40)	22.4 ± 1.19 (21-24)	12(60)	21.9 ± 0.16 (19-23)	20 (100)	22.1 ± 1.17 (19-24)
Zigzag (N=20)	8(40)	21.4 ± 1.30 (19-23)	12 (60)	21.1 ± 1.0 (20-23)	20 (100)	21.2 ± 1.11 (19-23)

Evaluation of Plaque Indices

Table 2. Intra-group comparison of PI score between different time interval for different categories of brush design

Bristle type	Time intervals	Mean ± SD	Z	p	Sig
Standard	Base	2.75 ± 0.55			
	1 st month	2.30 ± 0.47	-3.00	0.003	Sig
	3 rd month	1.75 ± 0.44	-3.32	0.001	Sig
	6 th month	1.10 ± 0.31	-3.61	0.000	Sig
Criss cross	Base	2.65 ± 0.59			
	1 st month	2.00 ± 0.46	-3.61	0.000	Sig
	3 rd month	1.35 ± 0.50	-3.61	0.000	Sig
	6 th month	0.60 ± 0.50	-3.87	0.000	Sig
Zigzag	Base	2.60 ± 0.50			
	1 st month	1.95 ± 0.22	-3.61	0.000	Sig
	3 rd month	1.25 ± 0.44	-3.74	0.000	Sig
	6 th month	0.45 ± 0.51	-4.00	0.000	Sig

P < 0.001- Highly significant, p < 0.05- Significant, p > 0.05 Not significant (NS)

The results for Wilcoxon signed – rank test for intra group comparison of PI score is presented in table 2. The table showed the mean score of PI at different time interval for three different categories of bristle design along with the paired comparison between the PI scores obtained at different time interval. It appeared that for all three different categories of bristle design, the mean values of PI when compared across successive time intervals were statistically significant.

Table 3. Inter-group comparison of plaque index at different time interval for different bristle design.

Parameter	Bristle type	Mean Rank	Chi sq	P	Sig
Plaque index at baseline	Standard	32.7	0.672	0.71	NS
	crisscross	29.8			
	Zigzag	28.9			
Plaque index at 1 st month	Standard	36.5	8.11	0.17	Sig
	crisscross	28.2			
	Zigzag	26.7			
Plaque index at 3 rd month	Standard	39.5	10.78	0.005	Sig
	crisscross	27.5			
	Zigzag	24.5			
Plaque index at 6 th month	Standard	41.0	16.81	0.000	Sig
	crisscross	27.4			
	Zigzag	23.0			

P < 0.001- Highly significant, p < 0.05- Significant, p > 0.05 Not significant (NS)

Intergroup comparison of PI score obtained at different individual time interval was compared across three categories of bristle design by Kruskal Wallis H test. The test result showed that there was a statistically significant difference in PI score between the different time interval data for the different tooth brush designs.

Evaluation of Gingival Indices

Table 4. Intra-group comparison of GI score between different time interval for different categories of brush design

Brush type	Time intervals	Mean ± SD	Z	p	Sig
Standard	Base	1.25 ± 0.44			
	1 st month	1.15 ± 0.37	-1.41	0.157	NS
	3 rd month	0.95 ± 0.39	-2.00	0.05	Sig
	6 th month	0.70 ± 0.47	-2.24	0.03	Sig
Criss cross	Base	1.35 ± 0.049			
	1 st month	1.05 ± 0.22	-2.45	0.01	Sig
	3 rd month	0.75 ± 0.44	-2.45	0.01	Sig
	6 th month	0.35 ± 0.49	-2.82	0.005	Sig
Zigzag	Base	1.35 ± 0.49			
	1 st month	1.05 ± 0.22	-2.45	0.014	Sig
	3 rd month	0.70 ± 0.47	-2.65	0.008	Sig
	6 th month	0.25 ± 0.44	-3.00	0.003	Sig

P < 0.001- Highly significant, p < 0.05- Significant, p > 0.05 Not significant (NS)

The results for Wilcoxon signed – rank test for intra group comparison of GI score is presented in table 4. The table showed the mean score of GI at different time interval for three different categories of bristle design along with the paired comparison between the GI scores obtained at different time interval. It appeared that for almost all three different categories of bristle design, the mean values of PI when compared across successive time intervals were statistically significant. The only exception was the score obtained for straight brush design where the GI score obtained at first month did not appear to statistically significant as compared to the base line value.

Table 5. Inter-group comparison of Gingival index for different bristle type at different time interval

Parameter	Bristle type	Mean Rank	Chi sq	P	Sig
Gingival index at baseline	Standard	28.50	0.606	0.74	NS
	crisscross	31.50			
	Zigzag	31.50			
Gingival index at 1 st month	Standard	32.50	1.716	0.42	NS
	crisscross	29.50			
	Zigzag	29.50			
Gingival index at 3 rd month	Standard	34.72	3.388	0.18	NS
	crisscross	29.12			
	Zigzag	27.65			
Gingival index at 6 th month	Standard	38.50	8.943	0.011	Sig
	crisscross	28.00			
	Zigzag	25.00			

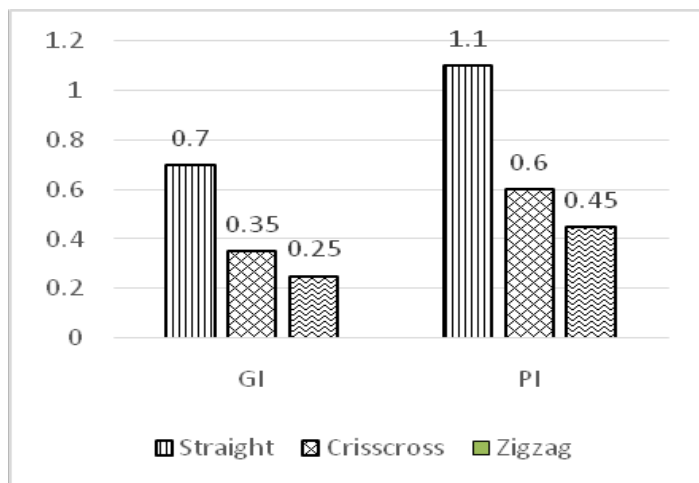
P < 0.001- Highly significant, p < 0.05- Significant, p > 0.05 Not significant (NS)

Intergroup comparison of GI score obtained at different individual time interval was compared across three categories of bristle design by Kruskal Wallis H test. The test result showed that there was a statistically significant difference in GI scores between among the three categories of brush design only at 6th month. The

difference between the mean GI at other time intervals were not statistically significant.

Comparison of GI and PI scores for different bristle design at 6th month

Figure 1. Comparison of GI and PI values among three different brush designs at 6th month interval



To compare the effectiveness of different tooth brush design in GI and PI recession, the mean values of GI and PI obtained at sixth month was plotted against the corresponding bristle design. This is presented in figure 1. It is clear from the figure that lowest values of both the parameters were obtained for zigzag pattern and highest values are obtained for Straight pattern of bristle. While crisscross pattern produced intermediate values.

Discussion

Manual tooth brushing has served humanity for many years to prevent dental caries and periodontal diseases. Tooth brushing is the most common, simple, and inexpensive means of plaque control. Mechanical tooth cleaning and tooth brushing have been emphasized since 3500–3000 BC, the era of Babylonians and Egyptians, who made a brush by fraying the ends of a twig.⁸ Around 1600 BC, Chinese developed chewing sticks made from aromatic tree twigs. The chewing sticks were gradually replaced by the first natural bristle toothbrush, made from hog hair embedded in bone or bamboo handle, developed

by the Chinese. The first modern toothbrush was designed by William Addis in 1780 in England. The handle was carved from an ox thighbone and the bristles made from cow's tail. Gradually, as toothbrushes underwent evolution, natural bristles were replaced by nylon bristles and toothbrush handles were made of plastic after the invention of nylon in 1938.⁹ By the 1950s, brushes with synthetic nylon bristles were commonly used. By the late 1960s, increased awareness began to prevail regarding enamel abrasion and gingival recession due to hard bristles, following which soft nylon bristles became the recommendation of choice. Since then, industry has flooded the markets with different toothbrushes have undergone a number of modifications in the bristle configuration, handle, shank, head design, configuration, diameter, and length.

Many studies had been conducted for different time periods and no fixed duration has been agreed upon. Some studies ranging from single use to 1 month, 3 month, 6 months had been conducted. So it is difficult to compare the results of our study with other studies.

The present study was conducted for the periods of 6 months, in which three different bristles designs compared for plaque removing efficacy and gingivitis. A total 60 dental students comprising males and females in the age group of 19-24 years were randomly allocated to Group A-Standard, flat bristles designed toothbrush, Group B - Crisscross bristles designed toothbrush, Group C - Zigzag bristles designed toothbrush.

On intergroup comparison of Plaque index (PI) score between different time intervals for different categories of bristles designs shown in Table 2. In group A, B, C showed statistically significant reduction in plaque index score from baseline to 1st month, for 3rd month and for 6th month which was found to be in accordance with the study conducted by *Keisar and Groeneveld*,¹⁰ where all tooth

brushes shows reduction in plaque scores. However this study was in contraindication to study by **Bergenholtz et al.**,¹¹ who conducted a similar study comparing the toothbrush having v-shaped bristles with a flat-trim toothbrush and concluded no significant differences between the toothbrushes, **Staudt et al.**,¹² compared the efficacy of three different toothbrushes namely, convex bristle, multilevel bristle and flat-trim bristle, using a computer-based plan metric plaque index, which is considered to be superior in terms of sensitivity, objectivity and reliability. And they came to a conclusion that none of the tested toothbrush bristles designs was superior over other.

On intergroup comparison of Gingival index (GI) score between different time intervals for different categories of bristles designs in Table 4. In group A, showed statistically Non significant reduction in GI score from baseline to 1st month, and showed statistically significant reduction for 3 and 6 months statistically. Group B and C showed statistically significant reduction in GI score from baseline, to 1st month, for 3rd month and for 6th month which was in accordance to study conducted by **Yan-Fang Ren et al.**,¹³ in which there was reduction in gingival score, when comparing three manual toothbrushes bristles designs on dental plaque and gingival inflammation, **Nathoo S et al.**,¹⁴ conducted the study which showed that there was significant reduction in gingival inflammation using new manual toothbrushes bristle design, **S Narang et al.**,¹⁵ conducted the study in which there was significant decrease in gingival score in different time intervals in two different toothbrush bristle design. **A Moointaghavi et al.**,¹⁶ conducted the study in which there was significant reduction in gingival score after brushing with three different type of tooth brushes On comparing GI and PI indices for three different bristles designs at 6th month showed in figure 1. Indicated that lowest values of

both the parameters were obtained for zigzag bristles pattern and highest values are obtained for Standard pattern of bristles. While crisscross bristles pattern produced intermediate values. This was in accordance with the study conducted by **Turner et al.**,¹⁷ and **Kakker et al.**,¹⁸ which showed that zigzag tooth brush bristles removed more plaque than flat trim tooth brush, Another study by **Cohen**,¹⁹ who compared a newly introduced brush with bristles inclined upward and outward and a flat trim toothbrush and he concluded that the new brush showed superior plaque removal. A study conducted by **NAM Rosema et al.**,²⁰ to test the plaque removal efficacy of a multi-level manual toothbrush with flat-trimmed manual control tooth brush and concluded that the multi-level toothbrush was significantly more efficacious than the flat-trimmed, but the present study was contraindicated by **Sripriya N et al.**,²¹ who showed that zigzag was equally effective as flat trim toothbrush, also contraindicated by **A-Aravind et al.**,²² who concluded that there was no superior toothbrush bristles designs between Flat and Zig-Zag bristles. **Kashif et al.**,²³ conducted a study to evaluate the efficacy of four different designs of manual toothbrushes, to check for the plaque removal efficacy and they concluded that no single toothbrush is found extraordinary in plaque removal efficacy. **Claydon et al.**,²⁴ conducted a study to compare the plaque removal efficacy of 8 manual toothbrushes and found that there was no design superior in manual toothbrushes.

According to various studies done by **Kremers et al.**,²⁵ **Kropff**,²⁶ **McClure**,²⁷ and **Sangnes et al.**,²⁸ recommended that the modified bass technique was efficacious in complete plaque removal of both coronal surfaces and gingival margins when compared with other brushing techniques.

It was worth noting that as the samples of our study were dental students with great oral hygiene consideration, they

may respect the protocol of the study and brushes twice daily with given toothbrush bristles designs and by performing modified Bass technique. These may be the reasons of why there was significant reduction in plaque and gingival scores in all three groups from baseline to 1month, 3 month,6 month.

Conclusion

The present study concluded that all the tooth brush bristles designs were effective in removing plaque and gingivitis. Out of three different bristles designs Zig-Zag bristles showed the highest reduction in plaque and gingival scores. But the individual skills and proper brushing technique are more important in improving periodontal status than the bristle designs.

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