SHORT ARTICLE

Effects of Bristle Hardness & Duration of Manual Tooth brushing on Plaque Control

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Abstract

Background: Oral health is an integral part of general health. Poor oral health can have adverse effect on general health hence a good oral health is very essential, which in turn is achieved by good oral hygiene. Dental caries and periodontal disease are the most commonly occurring diseases affecting mankind. Dental plaque is a very important factor in the causation of both the diseases. (2) **Aim & Objective**: To evaluate efficacy of four different types of toothbrushes, with difference in duration of brushing along with different bristle hardness in removal of microbial plaque. **Material & Methods**: In a randomized controlled trial, four groups with 40 subjects used manual toothbrushes with either hard, medium, soft and ultra-soft bristles. On baseline examination, clinical parameter plaque index (Sillness & Loe, 1964) was recorded. Selected subjects were refrained from all kinds of oral hygiene measures for 24 hrs before clinical appointment. On the day of clinical appointment scores of pre and post brushing were recorded in each patient when brushing time was set for 1 minute and same procedure was repeated after a wash off period of 3 days and similar recordings were made with brushing time of $1\frac{1}{2}$ minute. Primary outcome was measured with differences in the plaque index (Sillness & Loe, 1964) compared to baseline. **Results**: Significant reduction in mean value of plaque score was observed on comparing pre-brushing and post-brushing data in all the subjects irrespective of bristle hardness in both 1 minute and $1\frac{1}{2}$ minute groups. On increasing time duration from 1 minute to $1\frac{1}{2}$ minute intergroup comparison revealed that significant correlation exist in mean plaque score reduction in subjects using medium bristle brush, soft bristle brush, ultra-soft bristle brush. However, no significant reduction in plaque score was observed on increasing duration from 1 minute to $1^{1/2}$ minute in subjects using hard bristle brush. **Conclusion**: Manual toothbrushes with hard bristles better remove plaque, but may also cause more soft tissue trauma compared to brushes with softer bristles.

Keywords

Introduction

Oral health is an integral part of general health. Poor oral health can have adverse effect on general health hence a good oral health is very essential, which in turn is achieved by good oral hygiene. Even though, the concept of good oral hygiene evolved 5000 years back, it is only in the beginning of 19th century it gained more importance. (1) Dental plaque is a very important factor in the causation of both the diseases. (2)

Realistically, these diseases are kept at bay through personal and professional oral hygiene measures. Toothbrush is one of the most commonly used adjuncts for maintaining oral hygiene. The toothbrush has undergone a great degree of sophistication and is by far the most widely accepted and adopted tooth cleaning tool. (3)

Chinese are credited for inventing the tooth brush comprising a handle with bristles made from hog hair during the tang dynasty (618-907 AD). In 1780, in England, William Addis manufactured what was termed 'The First Modern Tooth Brush'. (1) Since its introduction and particularly in the last decade, numerous designs of the manual toothbrush have emerged and the media abounds with claims of superiority in plaque removal by individual brands. The role of toothbrushes in preventing the initiation and progression of periodontal diseases has been well documented. (4)

It has been adequately demonstrated that the accumulation of microbial plaque results in the development of gingival inflammation and daily removal of plaque leads to resolution of the gingival inflammation in just a few days. (4)

Patients who have not received any professional advice regarding the type of brush to be used for cleaning, usually choose brushes based on cost, availability, advertising claims, family tradition or habit. The various designs of toothbrushes available in the market often put the common man in dilemma about the best design and they often seek professional advice on this matter. (5)

Aim & Objective

To investigate the influence of plaque removal by manual toothbrush with different degrees of bristle hardness and duration of brushing.

Material & Methods

Study Population: A total of 40 patients attending the outpatient department of Periodontology, Seema Dental College and Hospital, Rishikesh were randomly selected as per the inclusion and exclusion criteria. Written informed consent was obtained from each subject after explaining the study protocol. **Exclusion criteria**: Subjects were excluded from the study if they had infectious diseases (e.g., hepatitis A/B/C, human immunodeficiency virus), renal failure, seizure or neurologic disorders, addiction (alcohol, drugs), pregnant females, had diabetes type I or II or severe periodontal disease, used antibiotics or drugs with anti-inflammatory effects within 2 weeks before the first examination and should not be going under any fixed orthodontic treatment. In the inclusion criteria, the subjects should be at least 18 years old, caries-free, sufficiently conservatively prosthetically treated dentition and having a minimum of 20 original teeth and shows prevention-oriented behavior.

Material used: Hard bristled toothbrush (Colgate®), Medium bristled toothbrush (Colgate®), Soft bristled toothbrush (Colgate®), ultrasoft bristled toothbrush (Colgate®), Digital Vernier caliper, Disclosing agent: Plaksee – MD (ICPA HEALTH PRODUCT LTD), Dentrifirce: Colgate (Colgate®).

Study design: The study was assessed and approved by the ethical committee of Seema Dental College and Hospital, Rishikesh. A randomized clinical controlled trial was designed in a split mouth fashion by selecting 40 patients from the outpatient department of periodontology, out of which 20 patients were randomly selected to brush with hard and ultrasoft and other 20 patients with medium and soft bristles brush on randomly distributed sides that is right & left.

Pre-study protocol: Before the commencement of the study all the patients were demonstrated to use modified bass technique. Study brushes were given to the patient & asked to bring on appointments. Selected subjects were refrained from all kinds of oral hygiene measures for 24 hours before baseline recordings.

Procedure: At baseline visit disclosing agent was applied on all the surfaces of the teeth and patients were asked to chew the tablet and swish it after 1 minute. Disclosing agent stained the plaque in different color depending on duration of plaque deposition and area of presence. It stained new plaque in red, old plaque are stained blue, plaque deep inside tooth area was visible using UV light as green spots. In the present study only plaque stained red and blue in color was recorded. Plaque score

were recorded on all the 4 surfaces of the teeth i.e. Buccal/Facial, Mesial, Distal, Lingual/Palatal as per the plaque index (Sillness & Loe, 1964). Further patients were asked to brush using dentifrice Colgate® for 1 minute with hard bristle tooth brush on one side of the mouth (including upper and lower arch) and with Ultra soft bristle tooth brush on the other half for another 1 minute. Once brushing was over plaque score was recorded again using disclosing. For the other 20 patients, same protocols was followed except that they were asked to brush using dentifrice for 1 minute with medium bristle tooth brush on one side of the mouth (including upper and lower arch) and with soft bristle toothbrush on the other half. After wash off period of 3 days both the groups were asked to brush with the same protocol but duration was increased to $1^{1/2}$ minutes and subsequently post brushing plaque score recordings were made using disclosing agent.

Statistical analysis: The statistical analysis was performed with the GraphPad Quick Calcs Software (Online Software© 2012, Graph Pad Software Inc) using paired and unpaired 't' test for the data collected.

Results

A total of 40 subjects were registered and analyzed for the study. No dropouts were observed during the study period. Out of these 40 subjects 20 were male and 20 were female with a mean age of 29.05±4.72 yrs.

Mean with standard deviation pre-brushing plaque score of subjects using hard bristle brush was 1.34±0.33,1.20±0.19; Medium bristle brush was 1.27±0.32,1.10±0.26; Soft bristle brush was 1.24±0.25, 1.07±0.30 and Ultrasoft bristle brush was 1.23±0.18, 1.16±0.10 for 1 minute and $1^{1/2}$ minute groups respectively (Table 1). No significant difference was observed in pre-brushing scores for all the subjects in both the groups.

Post-brushing plaque score of subjects using hard bristle brush was 1.02±0.20, 0.85±0.33; Medium bristle brush was 1.07±0.17, 0.63±0.15; Soft bristle brush was 1.06±0.20, 0.63±0.14 and Ultrasoft bristle brush was 1.04±0.22, 0.72±0.15 for 1 minute and $1^{1/2}$minute groups respectively (Table 1). Significant difference was observed in post-brushing scores of subjects using medium bristle brush, soft bristle brush and ultasoft bristle brush on increasing duration from 1 minute to $1^{1/2}$ minute. However, no

such significant difference was observed in subjects using hard bristle brush.

Highly significant reduction in mean value of plaque score was observed on comparing pre-brushing and post-brushing data in all the subjects irrespective of bristle hardness in both 1 minute and $1^{1/2}$ minute groups (Table 2).

On intra group comparison in 1 minute group no statistical significant plaque reduction was observed in subjects using different bristle stiffness (Table 3). However, on increasing duration to $1^{1/2}$ minute significant reduction was observed in subjects using medium bristle brush and soft bristle brush when compared to subjects using hard bristle brush. Similarly, it was observed that reduction in plaque score was significant in subjects using ultrasoft bristle brush when compared to subjects using medium bristle brush. Also, significant reduction in $1^{1/2}$ minute group was seen between subjects using ultrasoft bristle brush and soft bristle brush subjects (Table 4).

Discussion

Good oral hygiene is an essential component of good oral health. Simple oral hygiene activities on day to day basis can prevent the most common dental diseases without any additional cost. Today a variety of oral hygiene aids, both mechanical and chemical are available to maintain good oral hygiene at a low cost. A combination of these on individuals needs can be used for effective maintenance of the oral hygiene. It is the duty of the dental professional to inform and motivate the people to use these oral hygiene aids, in the right way to promote oral health and prevent damage to oral tissues. (1)

A positive correlation exists between bacterial plaque and tooth surface and gingival inflammation leading to chronic diseases like periodontitis. To prevent such kind of detrimental diseases apart from professional clinical treatments the patient can render home-based oral hygiene more effectively, many types of manual and powered tooth brushes and other means such as interdental brush tongue cleaner have been developed for providing home based oral hygiene. Among which tooth brushes stand most frequently used dental cleaning aids on community level.

The "average brushing force" has been reported to range from 92 to 175 grams for electric toothbrushes and 318 to 471 g for manual brushes. In addition, they observed that 300 grams seems for both

children and adults the most effective brushing force when using a manual toothbrush. Although brushing force is not the sole factor which determines efficacy. Other factors such as, action of the brush, size of the brush head, brushing time, and manual dexterity may be of greater importance. (6,7)

A study by Ferrera M P *et al* (8) showed that the modified bass technique is significantly more effective in removing supra-gingival plaque than normal practice both in buccal and lingual sites. After 21 days, normal practices did not significantly decreases mean plaque indices compared to the scores calculated after 7 days but did so with the modified Bass technique. This technique was especially efficient at the lingual sites where it was 2.9 folds more effective than normal practices in reducing plaque scores. In the present study, all subjects were demonstrated modified bass technique of brushing on the day of baseline recording also brushing was performed by the subjects under expert supervision.

Hawkins BF *et al* (9) evaluated the plaque reduction of a manual toothbrush over four different brushing times. They suggested that there was a 'monotonic' progression of plaque reduction as the brushing time increased from 30 seconds to 3 minutes. (9)

In the present study pre-brushing plaque score of subjects using Hard, Medium, Soft and Ultrasoft bristle brush had no significant difference in both the groups. However, pre-brushing plaque score was highest for subjects using hard bristle brush and Ultrasoft bristle brush in both the groups. This was in accordance with study conducted by Sripriya N *et al* (10)

On comparing pre-brushing and post-brushing data in all the subjects irrespective of bristle hardness in both 1 minute and $1^{1/2}$ minute groups, significant reduction in mean value of plaque score was observed. Significant reduction was seen in subjects using Hard bristle brush when compared to medium, soft and ultrasoft bristle brush on increasing time from 1 minute to $1^{1/2}$ minute. Such significant reduction in plaque score was observed when post brushing plaque score for hard bristle brush was compared in both the groups. The results are in accordance with the study of Niemi M L *et al* (11) who stated that on statistical analysis of the amounts of plaque remaining after use of either the hard or the soft toothbrush for cleaning the teeth in one half of the mouth indicates that the plaque removing capacity of the hard brush was better than that of

the soft bristle brush, irrespective of type of dentifrice used.

In the study conducted by Gupta P *et al* (12) it was found that the total, vestibular and oralQHI (Quigley and Hein index) in subjects using hard bristle toothbrushes were statistically significant lower compared to subjects using soft bristle tooth brushes after 8 weeks (p<0.001, p<0.05 and p<0.001, respectively). This means that plaque removal was improved more in subjects using hard bristle tooth brushes. Also, a statistically significant lower QHI was obtained for hard compared to medium bristle tooth brushes after 8 weeks (p<0.01). Statistically significant less plaque was found inter proximally as measured by the MAPI (Modified approximal plaque index) for hard bristle toothbrushes versus soft bristle tooth brushes after 8 weeks (p<0.05).

Zimmer S *et al* (13) stated that the QHI and MAPI showed lower index scores in subjects who used hard-bristled toothbrushes after 8 weeks (p <0.05 and p<0.001, respectively). In contrast, subjects who used toothbrushes with hard bristles demonstrate more gingival lesions (p<0.01) and higher PBI scores after 4 and 8 weeks (p <0.001) compared to subjects who used soft- or medium-bristled toothbrushes and concluded that manual toothbrushes with hard bristles may better remove plaque, but may also cause more soft tissue trauma compared to brushes with softer bristles.

It is known since long that main cause of gingival recession and cervical abrasion is faulty tooth brushing technique. (14) In a study by Greggianin BF *et al* (15) hard bristle toothbrush showed to cause more trauma as compared to soft bristle toothbrush. Gupta P *et al* (12) also stated that the toothbrushes with different bristle stiffness should be recommended focusing on the individual patient. For subjects with poor oral hygiene, a toothbrush with hard bristles should be considered. If the patient already shows soft tissue damage, a soft tooth brush may be recommended. Tomofuji T *et al* (16) in an animal study also stated that tooth brushing may cause increased turnover rate of the junctional epithelium, repairing small breaks in the continuity preventing access of bacterial pathogens. Emine Cifcibasi *et al* (17) also concluded in his study that Bristle design has little impact on plaque removal capacity of a toothbrush. Standard, flat-trim bristles brushes are safe enough to prevent gingival recession as long as soft bristle material is used. In literature, the studies comparing the efficacy of all 4

types of tooth brushes, ultra-soft, soft, medium and hard show that toothbrushes with hard bristles type have better efficacy in plaque removal, however they cause some soft tissue trauma. The soft tissue trauma is technique dependent and if patients follow proper technique it may never occurs. Thus, every patient visiting dental office must be instructed upon the use of proper brush which is effective in plaque removal and proper brushing technique.

In the present study, manual toothbrushes with hard bristles removed more plaque on free smooth surfaces compared to the same toothbrush type with different bristle hardness (medium, soft and ultrasoft). The results for the medium bristle toothbrushes were in between. Dose-response relationship for bristle stiffness was also observed.

Conclusion

There are various studies available in literature stating that there is no superior design of manual toothbrush favoring efficiency in brushing technique. In the present study, manual toothbrushes with hard bristles removed more plaque on free smooth surfaces compared to the same toothbrush type with different bristle hardness (medium, soft and ultrasoft). The results for the medium bristle toothbrushes were in between. On increasing the duration of brushing from 1 minute to $1^{1/2}$ minute on each side that is increasing total duration from 2 minutes to 3 minutes for whole mouth significant reduction in plaque is seen with all type of bristle stiffness.

Limitation of the study

Further studies with larger sample size and long duration are required for generalization of results.

Relevance of the study

Efficacy of different bristle hardness and brushing duration can be understood which is an important factor to control plaque accumulation.

Authors Contribution

S.: intellectual content, conception and design; VA: intellectual content, conception and design; SA: analysis and interpretation of the data; RR: writing of the manuscript.

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Tables

TABLE 1 STATISTICAL COMPARISON OF PREBRUSHING AND POST BRUSHING MEAN PLAQUE INDEX SCORE FOR DIFFERENT BRISTLE STIFFNESS BETWEEN 1 MINUTE AND $1^{1/2}$ MINUTE GROUPS.

Parameter	Bristle stiffness	1 Minute (mean±sd)	$1^{1/2}$ Minute (mean±sd)	P value
Pre brushing	Hard	1.34±0.33	1.20±0.19	p > 0.115
	Medium	1.27±0.32	1.10±0.26	p > 0.073
	Soft	1.24±0.25	1.07±0.30	p >0.063
	Ultrasoft	1.23±0.18	1.16±0.10	p >0.148
Post brushing	Hard	1.02±0.20	0.85±0.33	p >0.065
	Medium	1.07±0.17	0.63±0.15	p <0.001
	Soft	1.06±0.20	0.63±0.14	p <0.001
	Ultrasoft	1.04±0.22	0.72±0.15	p <0.001

TABLE 2 STATISTICAL COMPARISON OF PREBRUSHING AND POST BRUSHING MEAN PLAQUE INDEX SCORE FOR DIFFERENT BRISTLE STIFFNESS WITHIN 1 MINUTE AND 11/2 MINUTE GROUPS.

Bristle stiffness	1 Minute			$1^{1/2}$ Minute		
	Pre brushing	Post brushing	P - value	Pre brushing	Post brushing	P - value
Hard bristle	1.34±0.33	1.02±0.20	p < 0.001	1.20±0.19	0.85±0.33	p < 0.001
Medium bristle	1.27±0.32	1.07±0.17	p < 0.001	1.10±0.26	0.63±0.15	p < 0.001
Soft bristle	1.24±0.25	1.06±0.20	p < 0.001	1.07±0.30	0.63±0.14	p < 0.001
Ultra soft bristle	1.23±0.18	1.04±0.22	p <.005	1.16±0.10	0.72±0.15	p < 0.001

TABLE 3 STATISTICAL COMPARISON OF POST BRUSHING MEAN PLAQUE INDEX SCORE FOR DIFFERENT BRISTLE STIFFNESS WITHIN 1 MINUTE GROUP.

Groups	Bristle stiffness		(mean±sd)	P value
1 Minute	Hard 1.02±0.20	Medium	1.07±0.17	> 0.45
		Soft	1.06±0.20	> 0.57
		Ultrasoft	1.04±0.22	> 0.70
	Medium 1.07±0.17	Soft	1.06±0.20	> 0.91
		Ultrasoft	1.04±0.22	> 0.71
	Soft 1.06±0.20	Ultrasoft	1.04±0.22	> 0.76

TABLE 4 STATISTICAL COMPARISON OF POST BRUSHING MEAN PLAQUE INDEX SCORE FOR DIFFERENT BRISTLE STIFFNESS WITHIN 11/2 MINUTE GROUP.

GROUPS	BRISTLE STIFFNESS		(MEAN±SD)	p VALUE
$1^{1/2}$ Minute	Hard 0.85±0.33	Medium	0.63±0.15	> 0.01
		Soft	0.63±0.14	> 0.01
		Ultrasoft	0.72±0.15	> 0.09
	Medium 0.63±0.15	Soft	0.63±0.14	> 0.98
		Ultrasoft	0.72±0.15	> 0.08
	Soft 0.63±0.14	Ultrasoft	0.72±0.15	> 0.07