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RESEARCH ARTICLE

EVALUATION OF THE ABRASIVE POTENTIAL OF POWERED and ULTRASONIC TOOTHBRUSH ON THE SURFACE PROPERTIES OF PRIMARY TEETH ENAMEL, TYPE II and TYPE IX GLASS INOMER CEMENT: AN IN-VITRO STUDY

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ABSTRACT

Background: Tooth brushing is most commonly practiced oral hygiene procedure. The hardness, size of bristles or manner of brushing may affect enamel, dentin and surface properties of restorative materials. Powered and Ultrasonic toothbrushes are new additions to oral hygiene aids and their abrasive potential must be determined before incorporating them into daily use. **Aim and Objectives:** To evaluate and compare the abrasive effect of Ultrasonic and powered toothbrush on the surface roughness of enamel, Type II and IX GC Fuji cement. **Materials and Methods:** The study included 36extracted primary teeth divided into three groups based on the surface treated: Enamel, Type II GIC, and Type IX GIC. These were further subdivided into two groups based on the brush used: Powered and Ultrasonic toothbrush, used over period of 7days, after which the analysis was done for surface micro hardness and surface wear. **Results:** On analysis, the enamel group showed maximum roughness (Enamel=1.3µm; GCII=0.32µm and GC IX=0.19µm) measured at the baseline. Further analysis after 7 days of brushing showed that the use of powered toothbrushes (Type II=0.45µm; Type IX=0.35µm) showed significantly greater surface roughness compared to Ultrasonic toothbrush (Type II=0.26µm; Type IX=0.17µm) in all the three groups, thereby showing a significantly greater change in Ra for powered toothbrushes. Also, the type II GIC had greater surface roughness compared to type IX GIC. **Conclusion:** The results indicate that the use of powered toothbrushes causes significantly greater wear of the tooth surface than the use of ultrasonic toothbrushes on enamel and GIC.

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INTRODUCTION

Effective plaque control is critical to the maintenance of oral health, because dental plaque is the primary etiological factor in the introduction and development of both caries and periodontal disease (Yankell *et al.,* 2000). Plaque removal with a manual toothbrush represents the most frequently used method of oral hygiene in Western societies. A toothbrush should be able to reach and clean efficiently most areas of the mouth (Versteeg *et al.,* 2008). The toothbrush is the principal instrument in general use for accomplishing plaque removal as a necessary part of disease control (Hoover, 1992). Many different designs of toothbrushes and supplementary devices have been manufactured and promoted.

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Besides cleaning of teeth, the injudicious use of toothbrush has been associated with harmful effects on dentition. Some studies have found that hard toothbrushes cause more abrasion than soft brushes (Carvalho Rde, 2007; Zanatta, 2011). On the contrary, some studies have found that soft brushes lead to more abrasion than hard ones (Dyer, 2000; Tellefsen *et al.,* 2011). This is explained by the fact that soft bristles have better flexibility and hence, they cover a larger surface area and also retain more toothpaste. The wearing of the tooth surface caused by friction of tooth with a foreign object is called abrasion. Buccal surfaces of teeth are more prone to abrasion due to overzealous brushing (Grippo, 2004). Abrasion is most commonly associated with tooth brushing on the cervical margins of teeth. Various studies have shown that different variables influence toothbrush abrasion. These variables include brushing technique, force of brushing, duration and frequency of brushing, and type of brush, in particular filament stiffness (Bartlett, 2006). Surface roughness

of restorative materials has several clinical implications and alterations on surface topography and roughness are often used to determine the wear of a material. Increased roughness might be a predisposing factor to microbial colonization, which could potentially increase the risk of oral diseases. In addition, increase in surface roughness might indicate material deterioration (Yip, 1999; Yip, 1999; Yip, 2001). As ART implies in placement of a restoration that should remain in function in the oral cavity for a long period, it is important to evaluate the initial roughness of GICs usually indicated for this technique. The most commonly used parameter for characterizing surface roughness is the centre-line average roughness (*Ra*), which is the arithmetic mean deviation of the surface height from the mean line through the profile. Roughness can be related to a combination of factors that include the characteristics of the matrix, ratio and size of glass inorganic particles, exposition of these inorganic particles and formation of air bubbles during material preparation (Yip, 1999; Yip, 1999; Rios, 2002; Geiger *et al.,* 1999). The aim of this study was to assess the effect of tooth brush abrasion on the surface of Enamel, type II and type IX GC cement and compare them based on the profilometric analysis.

MATERIALS AND METHODS

The study included 60 extracted teeth (20 deciduous molars, 40 orthodontically extracted premolars), which were flattened using diamond disks and further mounted on acrylic blocks. These teeth were stored in artificial saliva (Wet Mouth; ICPA Pvt Ltd) over the course of the study to maintain oral-like condition for the tooth surface. The teeth were divided into three groups of 20 teeth each based on the material used to restore them. Cavities of a standardized size (6 mm × 4 mm × 1.5 mm) were prepared on the surface of the teeth using a diamond bur. In Group I (Enamel) the teeth were left intact with no restoration. In Group II, the teeth restored with GC Type II and Group III teeth were restored with GC Type IX. These groups were further divided into two subgroups based on the type of brush used; Subgroup I included the use of Powered toothbrush and Subgroup II included the use of Ultrasonic toothbrush. Initially, the specimens were scanned for determining the average surface roughness (Ra) using a profilometer: Alicona Infinite Focus at the department of Mechanical Engineering, IIT Powai, Mumbai. The imaging was done under 10X magnification for all the specimens prior to the intervention with the brushes, which was based on the focus variation technology with 3D optical imaging. Further, Group II and III teeth were subjected to abrasive challenge of brushing with powered and ultrasonic toothbrush respectively. The brushing was done for 2mins, three times daily for 7 days using the Colgate anti-cavity toothpaste. In the intervals of the brushing, the teeth were stored in artificial saliva kept in a container to maintain optimum in vivo conditions. After 7 days, these teeth were scanned again with the profilometer to determine the average surface roughness (Ra) post the effect of brushing and further the specimens were subjected to statistical analysis.

Analysis: The data was analysed by Statistical Package for Social Sciences Version 16 (SPSS 16) Statistical Software. Descriptive statistics of minimum and maximum range, mean and standard deviation of each group was calculated. Comparison of paired findings was done using Paired t test to find out mean difference. Unpaired t test was used to compare mean findings in between different groups. The p value less than 0.05 was considered statistically significant to evaluate the difference

RESULTS

The samples were analysed at baseline and after 7 days for each group with powered and ultrasonic toothbrush. At baseline, the mean values for surface roughness was higher for Group I (1.45µm) compared to Group II (0.41µm) and Group III (0.29µm). After brushing the values for surface roughness were maximum for powered tooth brush (1.56µm) and ultrasonic tooth brush (1.45µm) on enamel. The least surface roughness was seen in Type IX cement with ultrasonic toothbrush (0.43µm). Overall, all the groups had shown increased values for surface roughness after brushing compared to baseline, which was statistically significant ($p<0.001$). In the intergroup comparison, the mean difference in the surface roughness change was greater for powered toothbrush used in Type II (0.45µm) and Type IX (0.35µm) cements, followed by ultrasonic toothbrush in Type II (0.26µm) and IX (0.17µm) cements. The least changes were seen in Group I for both powered and ultrasonic toothbrush. These mean differences for all the groups were highly statistically significant (<0.001). On further analysis of these results, it was seen that the mean difference for change of surface roughness values for powered toothbrushes significantly greater than ultrasonic tooth brushes for all the three groups (Group I= 0.118µm; Group II=0.175µm; Group III=0.174µm). Thereby, the results show that the effect of powered toothbrushes was significantly higher than ultrasonic toothbrush in Enamel, Type II and Type IX cements.

DISCUSSION

Brushing is the most widely practiced method of personal oral hygiene management, and a proper brushing technique can effectively control dental plaque (Maryann, 2006). Many researchers recommend brushing as a basic method of effective oral hygiene management for infants as well, as it has been reported that proper brushing is highly effective for the prevention of childhood cavities (Ahn, 1985; Lee, 1990; Chang, 1987). Surface quality of restorations is in fact one of the important factors that determine their clinical success. A smooth surface can improve longevity and esthetics of restorations by reducing plaque accumulation and surface staining, allowing successful mimicking of the tooth's natural appearance (Lu *et al.,* 2005; van Dijken, 1987). Glass ionomer cements have a great demand in pediatric dentistry due to their optimal characteristics, such as ability to chemically bond to enamel and dentin, biocompatibility, fluoride release, less volumetric contraction and coefficient of thermal expansion similar to that of tooth structure. Nevertheless, their sensitivity to moisture, low mechanical strength and low wear resistance make glass ionomer restorations usually less durable (Hse, 1999). Wear resistance and surface roughness in oral environment are important criteria to determine and predict the clinical deterioration of restorative materials (Sidhu, 1997; Yip, 1999; Yip, 1999). Surface characteristics of glass ionomer restorations are particularly important because rough surfaces might be prone to faster bacterial colonization and maturation of plaque, thus increasing caries risk (Rios *et al.,* 2002). The present study evaluates the surface roughness of two different types of GIC and enamel, after brushing to analyse its abrasive effect and compare them accordingly, for which two types of brush (Powered and Ultrasonic) are used.

Table 1. Surface roughness from baseline to that of powered or ultrasonic brush use in Enamel, Type II cement and Type IX cement

Group	Subgroups	Minimum	Maximum	Mean	Std. Deviation
Enamel	Baseline	1.27	1.45	1.3690	0.06208
	Powered	1.47	1.56	1.5160	0.03658
Enamel	Baseline	1.25	1.37	1.3040	0.04377
	Ultrasonic	1.35	1.45	1.3980	0.03327
Type II	Baseline	0.25	0.41	.3260	0.05060
	Powered	0.73	0.85	.7770	0.03622
Type II	Baseline	0.26	0.39	.3340	0.04789
	Ultrasonic	0.55	0.65	.6020	0.03584
Type IX	Baseline	0.17	0.26	.2010	0.03178
	Powered	0.49	0.61	.5600	0.04110
Type IX	Baseline	0.15	0.29	.2150	0.04601
	Ultrasonic	0.35	0.43	.3860	0.02875

Table 2. Paired comparison of change of average surface roughness (Ra) from baseline in groups and their subgroups

Paired Differences	Mean difference	t value	p value
Powered on Enamel	0.1470	-5.751	p<0.001
Ultrasonic on Enamel	0.0940	-5.850	p<0.001
Powered On Type II	0.4510	-32.352	p<0.001
Ultrasonic on Type II	0.2680	-15.315	p<0.001
Powered On Type IX	0.3590	-17.543	p<0.001
Ultrasonic on Type IX	0.1710	-9.056	p<0.001

P<0.05 is considered significant, with <0.001 considered highly significant.

Table 3. Comparison of surface roughness between powered and ultrasonic brush in different groups

Between Powered and Ultrasonic toothbrush	Mean Difference	t	p value
Enamel	0.1180	7.547	<0.001
Type II	0.1750	10.860	<0.001
Type IX	0.1740	10.971	<0.001

P<0.05 is considered significant, with <0.001 considered highly significant

The study was carried out for duration of 7 days, in which the evaluation for average surface roughness (Ra) was done at the baseline and after 7 days with the help of a profilometer. The extracted teeth used for the study were mounted to prepare circular specimens in accordance with the method used by Francisconi et al.,[2008], thereby standardising the procedure. These specimens were stored in artificial saliva in a similar composition as used in the study by Hooper *et al., (*2003] to maintain clinical conditions over the period of 7 days, thereby providing the maintenance of the role of saliva against abrasion during the study. In order to simulate the abrasive effect, the ultrasonic and powered toothbrush was used along with a dentrifice (Colgate), in which every specimen was brushed for 2 min 3 times a day making a total of 6 min brushing per day for 1 week in accordance with the study of Yu et al. (2009). As seen in the results, the enamel had a greater surface roughness initially and being more susceptible to abrasion, there was significantly increased average surface roughness (Ra) seen in enamel after brushing at the end of the study compared to GC Type II and IX groups. This was in accordance with Francisconi *et al., (*2008] and Yu *et al., (*2009] where the resistance of enamel to toothbrush was less than the other three restorative materials. Further, when the groups were compared based on the abrasive effect of the powered and ultrasonic toothbrushes before and after the study, the change in surface roughness was significantly greater for GC Type II compared to Enamel and GC type IX. Also the mean difference was greater for GC type II, with powered toothbrushes showing the greatest change in surface roughness for all the groups. In the comparison of the abrasive effects of Powered and ultrasonic toothbrushes, the mean difference for change in surface roughness was significantly greater for the Powered tooth brush compared to ultrasonic toothbrush for all the groups. The powered tooth brush had a more aggressive effect on the surface of all the specimens than ultrasonic toothbrush, thereby suggesting its intentional wearing of tooth surface at a higher rate. However, there have been studies suggesting the advantages of both powered and ultrasonic toothbrushes, where Weigand et al.,[29] found that the brushing force was greater for manual toothbrushes (1.6±0.3 N) than the powered toothbrushes (0.9±0.2 N), thereby suggesting Ultrasonic brushes or powered brushes being less abrasive than manual toothbrushes on hard and soft tissues. Also, Knezevic et al, suggested that Powered toothbrushes produce less wear than manual brushes but further mentioned that there could be varying levels of enamel wear produced, depending on their design and applied forces. In recent studies, Weijden *et al.,* (2011) concluded that over last 2 decades oscillating-rotating toothbrushes to be safe compared to manual toothbrushes, demonstrating that these power toothbrushes do not pose a clinically relevant concern to hard or soft tissues. Therefore, these studies provided basis for further research in bringing forward the advantages and clinical application of these electric toothbrushes in everyday use for improving the efficiency of tooth brushing among the children and young adults and further utilizing the added benefits for providing superior results. In view of these studies, there was minimal research seen on ultrasonic tooth brushes for daily use and its added advantages over other toothbrushes, therefore this study aimed at comparison of ultrasonic toothbrushes with the widely studied powered toothbrush seen over the years. This study analysed the effects of Ultrasonic and powered toothbrush on the enamel as well as GIC restored teeth in the regular daily life conditions to help understand its

clinical efficacy and provide improved results over each other. The results of the study suggested a more compliant abrasive effect of ultrasonic toothbrush, whereas the powered toothbrush had a more harsh effect on the surface of the tooth and restorative material. Thereby, providing a positive outcome for ultrasonic toothbrush and being the first of the few studies analysing and pointing towards the advantage and clinical application of Ultrasonic tooth brush over powered toothbrush.

Conclusion

In today's world, owing to the daily life routine and dietary habits, the occurrence of abrasion and tooth wear is increasing with greater significance. There have been efforts at changing the behavioural and dietary patterns of the individual for minimizing these abrasive effects including the guidance for the brushing method. But at the same time it becomes important to assess the effects of the various types of toothbrushes and accordingly utilize its benefits for superior results. In this view, the present study concluded that the use of Ultrasonic toothbrushes provides a lesser abrasive effect than the powered toothbrush and a decreased surface roughness and suggesting it for daily use resulting in decreased tooth wear and a better patient compliance. Also the GC Type IX cement demonstrated a decreased surface roughness compared to GC Type II, suggesting GC Type IX to be a more advantageous option to help resulting in minimal abrasion. Also based on the positive results for ultrasonic toothbrush, this study provides a platform for further research on Ultrasonic toothbrushes to testify it in different parameters with respect to the type of tooth, age, duration and frequency of the usage.

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