International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Quantitative Assessment of the Surface Roughness of Two Esthetic Restorative Materials after Tooth Brush Abrasion Using 3-D Profilometer and Scanning Electron Microscope

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Received: 29/12//2012 *Revised: 16/01/2013* *Accepted: 23/01/2013*

ABSTRACT

Objective: The aim of this study was to assess the surface roughness of two aesthetic composite restorative materials after tooth brush abrasion by profilometric methods.
Materials and methods: Class I cavity preparations for a posterior composite resin were made on the occlusal surfaces of extracted molars and the samples were restored with Nano ceram X mono (Dentsply) and Giomer (Shofu), light cured and polished (Shofu kit).The samples were then subjected to a custom made abrasion testing machine, simulating tooth brush abrasion at 20,000 cycles in two consecutive runs, with 10,000 cycles each in a tooth paste slurry using a weight load of 250g.The surface texture and roughness of the worn samples after each cycle were examined by SEM and Profilometer.
Results: The scanning electron microscopy analysis showed selectively more abraded matrix particles in Giomer compared to the nanocomposites. ANOVA proved highly significant differences between the two groups.
Conclusion: Within the limitations of this study it can be concluded that toothbrushing abrasion of the nanocomposite resin results in significantly different surface roughness and surface morphology.
Key words: Nanocomposites, Prolifometer, Toothbrushing

INTRODUCTION

Wear is a natural process that can occur in teeth or restorative material. An ideal restorative material should neither wear against nor produce wearing of the antagonist natural tooth. The use of resin based composite material for restoring posterior teeth has increased significantly in recent years. This increase is attributed primarily to a demand for improved esthetics, conservative removal of tooth structure, less complex tooth preparation and ability to bond to tooth structure. [1] One of the most important properties for a restorative material is the high resistance to wear. Clinically wear can occur at the occlusal contact area (OCA) and contact free area (CFA), from attrition of food bolus as well as tooth brushing(abrasion wear) by the action of tooth brush and dentrifice. Although clinicians tend to concentrate on occlusal wear, some researchers have demonstrated that the abrasion process produced by oral hygiene methods can adversely affect the surface characteristics of restoratives. Therefore this process could interfere with both health and esthetics, as rough surfaces may predispose to biofilm accumulation and extrinsic staining. One of the important but clinically neglected parameters in detecting the efficiency of a posterior restorative material is wear resistance. Therefore the aim of this study was to evaluate the surface roughness and texture of two types of posterior composite resins subjected to in vitro tooth brushing abrasion.

MATERIALS AND METHODS

The two resin composites used in this study Nano ceram X mono (Dentsply) and Giomer (Shofu)

Specimen preparation: Twenty caries free, unrestored human molars were selected and stored in a 1% chloramines solution for 24hours. A standardized adhesive class I preparation was made on the occlusal surfaces. Occulusally, the tooth was reduced by 2mm and the cavity was 3mm wide. A +_ 0.3 mm tolerance in the measurements was considered acceptable for including the specimen in the trail.

The teeth were randomly divided into two groups of 10 specimens each. 10 of the specimens were restored with Ceram X mono (Dentsply), Nano Group and the other ten specimens with Giomer(Shofu), Giomer Group, using the oblique incremental technique of posterior composite resins, and light cured for 40seconds (blue phase curing unit). The Ceram x mono samples was polished using Shofu polishing kit. The Giomer group polished using compomaster kit.

Toothbrush abrasion testing:

All the tooth specimens were mounted over a dental stone block and subjected to a custom made tooth brush abrasion testing machine to simulate tooth brush abrasion in the oral cavity. The device was equipped with a soft nylon bristled powered tooth brush (Oral-B, India) oscillating at 7,200/sec under a brush head load of 200g.The specimens were immersed in a slurry of dentrifice (Colgate, India) and distilled water, in a ratio of 1:1. Each specimen was placed under the oscillating brush head and tooth brush abraded for 20,000 cycles in two consecutive runs of 10,000 cycles each.

Measurement of surface roughness:

All the specimens were subjected to a profilometric study before the tooth brush abrasion and the initial average roughness (Rai) values were recorded. After each 10,000 brushing cycle the specimens were taken out of the slurry, rinsed under tap water, and gently air dried for another surface roughness determination. The average final roughness (Raf) post tooth brush abrasion were obtained after 10,000cycles and 20,000 cycles.

Scanning electron microscopy:

One random sample of each composite material, pretreatment, after 10,000 and 20,000 brush cycles were selected foe SEM analysis. The samples were sputtered with Pt and photographs were taken of representative areas at 1000x and 3000x magnifications.

RESULTS

The average superficial roughness of two different tested composite materials, as an outcome of the profilometric studies have been tabulated in Table 1:

Table 1: Mean roughness recorded in the two groups in the three cycles

Group	Cycles	Mean	Std dev	Median	Min	Max
NANO GROUP I	Initial/Control Ra initial	0.36	0.09	0.34	0.21	0.51
	Ra final 10,000 cycles	0.43	0.10	0.43	0.30	0.57
	Ra final 20,000 cycles	0.49	0.13	0.50	0.32	0.69
GIO GROUP II	Initial/Control	0.56	0.10	0.56	0.41	0.71
	Ra final 10,000 cycles	0.66	0.09	0.68	0.51	0.77
	Ra final 20,000 cycles	0.80	0.13	0.85	0.59	0.96

Both the materials presented a significant increase in surface roughness after tooth brush abrasion. The Nano Ceram X mono (group I) exhibited the smallest Ra (average roughness) figures at all tested conditions. There was a slight but significant increase in Ra with increasing number of brushing cycles. The maximum roughness was found for Giomer (group II) after 20,000 brushing cycles.

Scanning electron microscopy:

The textures of two types of resin composite surfaces pre and post abrasion were compared in fig.1A, 1B, 1C and fig.2A, 2B, 2C. In the SEM analysis of all polished tooth specimens, smooth surfaces were observed before abrasion, although scatches were present owing to the polishing and finishing procedures. In contrast, SEM observations of abraded tooth specimens revealed altered surface morphology for both types of composite materials.

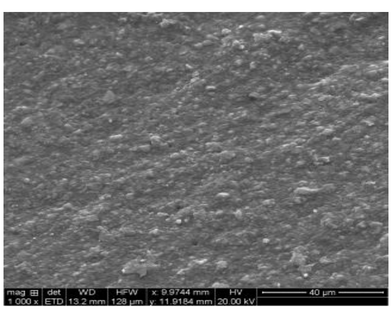

Figure 1A: Scanning electron micrographs at 1000X and 3000X magnification. Nano Ceram X mono - Polished and finished restored surface before toothbrush abrasion.

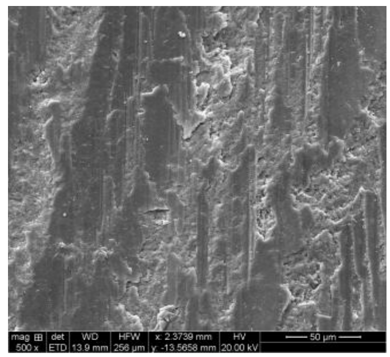

Figure 1B: Scanning electron micrographs at 1000X and 3000X magnification. Nano Ceram X mono - Surface after 10,000 cycles showing coarse protruding filler particles,superficially abraded nanoclusters in the resin matrix.

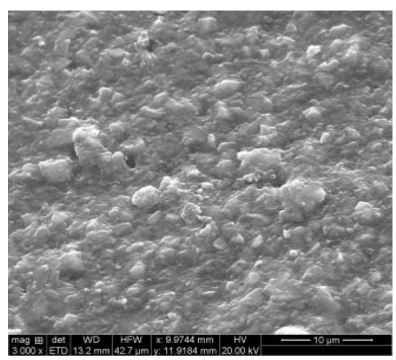

Figure 1C: Scanning electron micrographs at 1000X and 3000X magnification. Nano Ceram X mono - Combination of medium and small protruding particles in the abraded matrix is observed,this showed to have the least unaltered surface after toothbrush abrasion

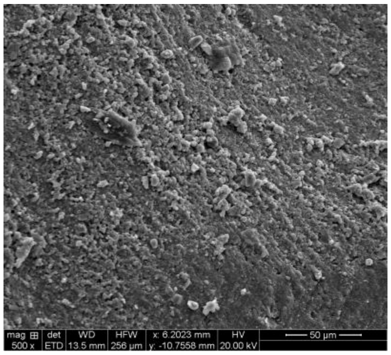
Figure 2A: Giomer - Polished and finished surface of Giomer showing before abrasion.

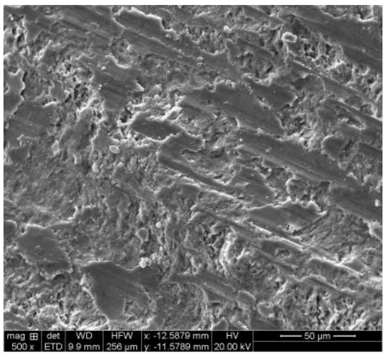
Figure 2B: Giomer - Surface after 10,000 brushing cycles shows most of the fillers with a flat ground that are protruding from the surface while the matrix is selectively more abraded.

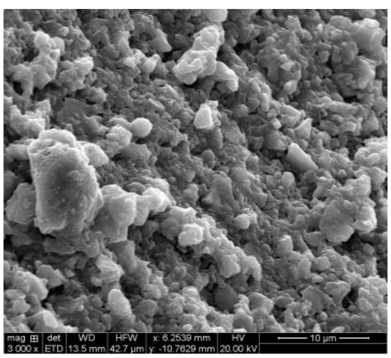
Figure 2C: Giomer - Surface after 20,000 cycles shows a comparatively larger glass filler particles clearly protruding from the surrounding matrix and the distance between the larger particles are wider.

DISCUSSION

An increasing demand for esthetic dentistry has led to the development of resin composite materials for direct restorations with improved physical and mechanical properties, esthetics and durability. The latest development in the field has been the introduction of nanofilled materials by combining nanometric particles and nano clusters in a conventional resin matrix. Restorations in posterior areas especially the molars are constantly subjected to functional loading. Nano filled materials are believed to offer excellent wear resistance, strength and ultimate esthetics due to their excellent polishability, polish retention and lustrous appearance. [1] Ceram X is a nano hybrid containing organically modified ceramic nano particles comprising polysiloxane back bone. These nanoceramic particles consist of inorganic – organic hybrid particles where the inorganic siloxane part provides strength and the organic methacrylic part makes the particles compatible and polymerizable with the resin matrix. [1]

In the present study Nano group showed less surface abrasion changes than giomer group. According to the current outcomes, the composites with larger fillers disclosed significantly higher surface roughness than composites with finer particles. It is because of small fillers that enhance the packing of particles, producing composites with shorter inter-particle spacing. This provides better protection for the resin matrix, generally improving the abrasion resistance of the material. [2] As tooth brushing wear results from a combination of factors, such as resin erosion, debonding of resin-filler interfaces and filler loss, the larger the size of the lost particles, the greater the resulting decrease in weight.

According to recent studies, the small particle size of composite resins could provide some protection to the matrix against abrasion. The reason behind this may be filler particles which have a high modulus of elasticity and are abrasion-resistant, and when small enough, they can effectively reduce the spacing among them, which would protect the matrix. [3] An explanation for the improvement of the wear resistance with the smaller particles is that the mean distance between neighboring particles was smaller than that with the coarsest filler particles. In fact, the greater the number of particles on the surface subjected to wear, the larger the contact area between the particles and the antagonist, and hence the better the wear resistance offered by the particles. [4]

This hypothesis was originally described by Jorgensen and Asmussen (1978) and further explored by Bayne et al. [5] Besides a less favorable surface area-to-volume ratio, larger particles tend to protrude further through the surface and as such their cantilever is longer, which leads to a higher angular moment, thereby causing earlier pulling out of the particles. [4] The filler size of Giomer ranges between 0.01- 5 µm, and that of the nano composite varies from 20- 70nm.In 2000, a new innovative filler technology of resin composite was developed (Shofu Inc. Kyoto, Japan) that created a stable Glass-ionomer phase on a glass core in which they induced an acid-base reaction between acid reactive fluoride containing glass and polycarboxylic acid in the presence of water - developed as a Pre-Reacted Glass-ionomer (PRG) filler. [6]

The resin composite material with PRG filler technology is totally different from other compomers or resin modified glass-ionomer cements, consequently these new PRG filler containing products are categorized as a Giomer. [7] Giomer is a biphasic restorative material and each of the phases differs in hardness values with no uniform abrasion. [8] The matrix phase in resin-based composite materials is preferentially removed during prophylaxis procedures since the abrasives in prophylactic agents are harder than the matrix. Therefore, the fillers are exposed and left unsupported. Subsequently, displacement of fillers will lead to an increased surface roughness. [9] The results of this study revealed that the use of tooth brush with slurry paste resulted in significant Giomer surface roughening. These results coincide with the results of studies conducted on conventional glass ionomer and polyacid modified composites. [10] Wear of dental materials is a complex process involving fatigue, erosive, adhesive, abrasive, and corrosive components. Nevertheless, wear occurs via microfracture and material removal; hence it is inherently related to mechanical properties. [11]

A number of tooth brushing simulators have been proposed in literature with differences in fundamental design principles. However, so far no consensus has been reached on which design and parameter settings are most predictive for tooth brushing wear of aesthetic restorative materials.

In most of the published studies on tooth brushing abrasion of aesthetic restorative materials, commercial tooth pastes have been used. Studies have suggested a strong correlation between wear of the restorative materials and the cleaning power of dentifrices. Concern has been expressed about the wear of restorative materials due to the abrasiveness of currently available dentifrices. Several authors have evaluated surface roughness in vitro using automatic brushing machines to simulate tooth brushing. Hence in this study a commercial tooth paste has been used to aptly simulate in vivo tooth brushing wear.

In this study a medium hard type powered tooth brush was used. Supposedly, the type of toothbrushes and bristle stiffness has scarcely any effect on resin composite wear. It has been documented that brushing of unfinished composite specimens with water had almost no effect on composite wear. [12]

The loading force of toothbrush and the number of tooth brushing cycles are the matter of dispute, as there is no set standard for this either. In a clinical trial on 94 patients the average tooth brushing force registered was 350 g with a range from 140 through 720g. This study is in agreement with Cho et al. to use a 500g brushing force as a means to presumably accelerate wear in our simulator. It is assumed that 10,000 toothbrush strokes simulate approximately one year of toothbrush wear. In our study we applied 20,000 cycles in two consecutive runs with 10,000 cycles each. Variations of brushing speed have apparently no significant effect on wear. [13]

CONCLUSION

The present study can be concluded that toothbrushing abrasion of the nanocomposite resin results in significantly different surface roughness and surface morphology. Regarding the manufacturer's classification of these composites as universal types raises doubts whether the nanocomposite material with the comparatively low toothpaste abrasion resistance can fulfill this claim. The Nano composites show a reasonably moderate wear; however, giomer develops high surface roughness during the tooth brushing procedure. However factors like the weight load applied, type of abrasive and slurry used also contribute to the variations in the results of the study. However nanocomposites have proven to be a material of superior efficiency as an esthetic restorative material compared to Giomer.

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How to cite this article: Haldal S, Shashikala, Rajesh P et. al. Quantitative assessment of the surface roughness of two esthetic restorative materials after tooth brush abrasion using 3-D profilometer and scanning electron microscope. Int J Health Sci Res. 2013;3(1):43-49.

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