EFFECT OF ULTRASONIC SCALING ON THE SURFACE ROUGHNESS OF DIFFERENT RESTORATIVE MATERIALS

Original Article

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ABSTRACT

The surface roughness of dental restorative materials has a crucial effect on the health of dental and periodontal tissues as well as for the longevity of restorations.

Aim: This study evaluated the effect of ultrasonic scaling on surface roughness of four different tooth-colored class V restorations.

Material and method: Out of 48 freshly extracted human teeth, 12 teeth were randomly selected for each group, marked with the outline of class V cavity. Class V cavities were prepared on the facial surfaces of teeth of all groups except the control group. These cavities were then restored with GIC, Nanohybrid composite (Filtek Z 250 XT) and Nanofilled (Filtek Z 350 XT) composite. All the specimens were stored in artificial saliva at 37o C for 1 month. Initial surface roughness values (Ra in µm) of restorations were evaluated with the surface roughness tester. Ultrasonic instrumentation was then carried out for 60 s on the restoration surface and final roughness values were evaluated. Data were analyzed with Paired t-test, One-way ANOVA.

Results: Mean Pre-instrumentation surface roughness was highest with GIC, whereas it was least in case of Filtek Z 350 XT. Mean post-instrumentation surface roughness was highest with GIC, whereas it is least in case of Filtek Z 350 XT.

Conclusion: Highest surface roughness was seen in GIC, followed by control group, Nanohybrid (Filtek Z250 XT) and Nanofilled group (Filtek Z350 XT) when subjected to ultrasonic scaling.

KEYWORDS: Class V restorations, Filtek Z250 XT, GIC, Filtek Z350 XT, nanohybrid composite, nanofilled composite, surface roughness, ultrasonic scaling

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INTRODUCTION:

Sonic and ultrasonic scaling techniques are widely used in periodontal prophylaxis. The vibration of sonic scaler inserts ranges between 3,000 and 8,000 cycles per second, while the vibration of ultrasonic scaler operate between 18,000 and 45,000 cycles per second. Studies have confirmed that both techniques appear to attain similar results as hand instruments for removing plaque, calculus and endotoxin. The cleaning procedures, however, may increase surface roughness, which will influence bacterial colonization and increase the rate of plaque formation. Although the effects of periodontal instrumentation on tooth surfaces have been well investigated, very few studies have looked at their effects on restorative materials.

Bjornson demonstrated that all three types of periodontal instrumentation, the curette, the Cavitron scaler and the Titan-S scaler, altered the surface of resin composites but found that hand curettes yielded the most significant alterations. Prophylactic instruments may also cause surface deterioration of metal crown margins. It was reported that high goldcontent was the least resistant to surface deterioration, and the ultrasonic scaler caused the greatest surface deterioration to all of the metals tested.

However, Lee and others1 found that the use of ultrasonic scalers and hand scalers had no influence on the initially smooth porcelain surface. The relationship between dental restorations and periodontal health has been thoroughly investigated for many years. Studies have focused on different aspectsof periodontal-restorative interaction, such as surface roughness, the position of the restoration in respect tothe gingival margin, the presence of an overhang and the presence of marginal leakage. The surface roughness of restorative materials can influence staining, plaque accumulation, gingival irritation, recurrent caries and aesthetic appearance.

Bollen and others[2] demonstrated that roughness beyond 0.2 µm results in a simultaneousincrease in plaque deposits and increases the risk for caries and periodontal inflammation. Furthermore, Jones and

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others [3]claimed that a restoration surface should have a maximum roughness of less than 0.50 μm if it is not to be detected by the patient.

Several restorative materials are now available for Class V cavities. In addition to conventional resin composites and glass ionomer cements, more-recently developed tooth-colored filling materials, particularly resin-modified glass ionomer cements, polyacid-modified resin composites and flowable composites, have now broadened treatment options. The potential use of each of these five types of materials has its own advantages and disadvantages. As calculus and plaque deposits are often heaviest in the cervical area of teeth, restorations of Class V cavities are inadvertently exposed to these maintenance procedures. The effect of periodontal instrumentation on the surface roughness of these materials should be of interest.

This study investigated the effects of sonic and ultrasonic scaling on the surface roughness of five different types of restorative materials commonly used in cervical lesions.

MATERIALS AND METHODS

Fourty eight freshly extracted human teeth excluding mandibular incisors were used in this study. Out of these, 12 teeth were randomly selected and included in the control group (Group I). These were marked with area of 2 × 4 mm to simulate outline of class V cavity; however, no cavity preparation was done on them. Class V cavities of 4 mm width, 2 mm length, and 1.5 mm depth were prepared on facial surface of remaining 36 teeth with FG1 and FG 271 carbide bur (Fig 1).

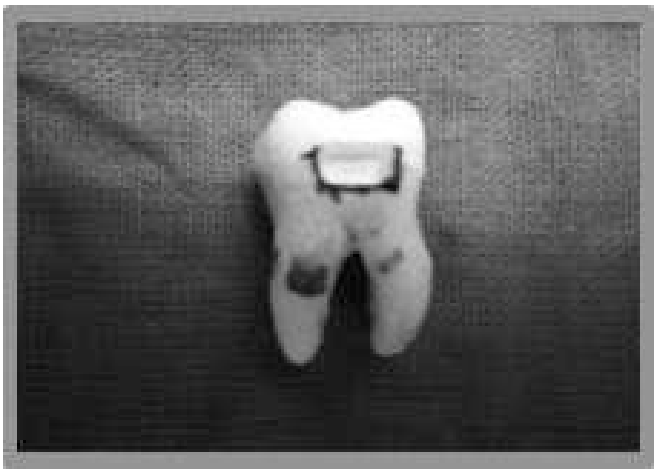

Fig 1 : Cavity prepared on teeth

Each pair of these burs was discarded after preparation of eight class V cavities. These 36 class V cavities were randomly and equally divided into 3 groups (n = 15) according to type they were restored with:

Group II: GIC (EASY MIX, 3 M ESPE)

Group III: Nanohybrid composite (Filtek Z 250 XT, 3M ESPE, St. Paul, MN, USA).

Group IV: Nanofilled composite (Filtek Z 350 XT, 3M ESPE, St. Paul, MN, USA).

Restorative materials in each group were manipulated according to manufacturer's instructions and placed into the prepared cavity. A transparent matrix band was placed over it, and pressure was applied to extrude excess material. Restorations in Group 3 and Group 4 were cured against a Mylar strip with light curing unit for 40 seconds. After initial set of each material, excess was carefully removed. Restorations in Group II were covered with petroleum jelly and allowed to set in 100% humidity. All specimens were then stored in artificial saliva prepared by Oshiro's method4 at 37o C for 1 month. (Fig 2)

Fig 2 : Teeth stored in artificial saliva

Specimens in each group were rinsed in running tap water for 30 seconds and further cleaned in an ultrasonic cleaner for 6 minutes. They were air dried, and initial surface roughness was evaluated in terms of Ra value (μm) using Surface Roughness Tester with stylus moving at the speed 0.5 mm/s.

Later, ultrasonic scaling was performed on all specimens with SATELLAC (Satellac, Cedex, France) ultrasonic scaler having N1 insert/tip under copious water flow for 60 seconds at level 2 power setting. The scaling tip was angled approximately

15o to the restoration surface. The direction of scaling was approximately perpendicular to the long axis of the tooth in the horizontal plane, moving the scaler insert slowly from gingival to coronal third of the restoration. All instrumentations were performed by one experienced periodontist who was not aware of the type of restorative material and their groups. The specimens were rinsed in running tap water for 30 seconds and cleaned in an ultrasonic bath for 6 minutes. All specimens were air dried, and post-ultrasonic instrumentation roughness was then evaluated as mentioned previously (Fig 3). Data were analyzed with paired t-test, one-way ANOVA, Tukey's test.

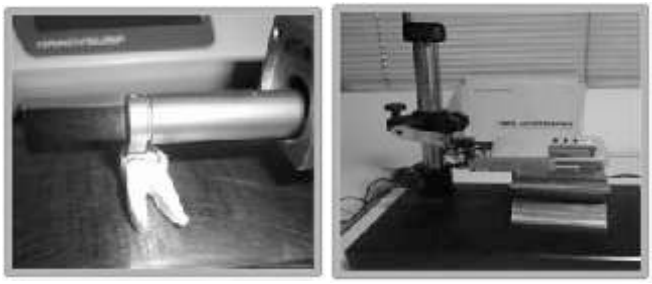

Fig 3 : Teeth being tested under surface roughness tester

RESULTS

Initial surface roughness values (Ra) from highest to lowest were in the order of control group, GIC, Filtek Z 250 XT, and Filtek Z 350 XT, whereas post-instrumentation surface roughness were in the order of GIC, control group, Filtek Z 250 and Filtek Z 350 XT.

The difference (δ) between the mean pre-instrumentation and post-instrumentation roughness, which gives actual effect of ultrasonic scaling on the surface roughness of control and test group, was highest in case of GIC, followed by control group, Filtek Z 250 XT and Filtek Z 350 XT [table 1]. Though initial surface roughness values of all the groups were significantly different, there was no correlation found between initial surface roughness and change in mean surface roughness (δ).

PAIRED T TEST FOR COMPARING BEFORE AND AFTER

GROUP		Mean	N	Std. Deviation	Paired Differences		T	df	P VALUE
					Mean Difference	Std. Deviation			
CONTROL	before	3.163333	12	2.738196	-0.27	3.245531	-0.288	11	0.779
	After	3.433333	12	2.099495					
GIC	before	2.739167	12	1.741068	-1.2775	1.421166	-3.114	11	0.01
	After	4.016667	12	2.269094					
FILTEK 250XT	before	2.409167	12	1.479997	-0.23	2.008373	-0.397	11	0.699
	After	2.639167	12	1.668873					
FILTEK Z350 XT	before	1.866667	12	1.100391	-0.42417	1.547957	-0.949	11	0.363
	After	2.290833	12	1.10328					

DISCUSSION

Class V caries usually develops due to many reasons like unclean tooth surface, caries inducing diet, gingival recession, a reduced salivary flow caused by certain medical conditions (e.g., Sjogren's syndrome), medication or head and neck radiation therapy.[5] The other cervical lesions that need to be restored are abrasion, abfraction, and erosion. 5 To restore such defects, materials used should have qualities and properties such as strength, longevity, ease of use, past success, esthetics, being able to bond to tooth structure, good finishing and polishing ability.[5] Glass ionomer cements are typically used to restore cervical lesions because of its true adhesion, anticariogenic property and high flexural strength6.However, recently it has been found that nanohybrid composites also possess better flexural properties and low surface roughness[7,8.]

Glass ionomers have the initial setting time ranging from 4-7 minutes, but entire setting reaction continues for several weeks (ion-exchange mechanism). In this study, prior to ultrasonic instrumentation, we have stored all the specimens in artificial saliva for 1 month to simulate oral conditions that may have effect on surface characteristics of restorations.

Ultrasonics, which basically works on acoustic streaming, acoustic turbulence, and cavitation phenomenon are widely used in routine dental practice for diagnostic, therapeutic as well as for cleaning of the instruments before sterilization[9]. Its main uses are scaling and root planning of the teeth[9]. In Endodontics, they are used for access refinement, finding calcified canals, and removal of attached pulp stones, removal of intracanal obstructions

(separated instruments, root canal posts, silver points, and fractured metallic posts), to enhance the action of the irrigating solution, condensation of gutta percha, placement of mineral trioxide aggregate (MTA), and root canal preparation. In surgical endodontics; it is used for root-end cavity preparation, placement and refinement of root-end obturation.[10]

Ultrasonic scaling is essential part of periodontal therapy that includes elimination of plaque, calculus, and bacterial endotoxins from the tooth and exposed root surfaces. Ultrasonic scaling is routine oral prophylaxis advocated by periodontist by every 6 months[11]. Plaque and calculus are deposited heavily in cervical regions of the teeth; thus, class V restorations also need regular periodontal prophylaxis. These cleaning procedures may lead to a number of unintended side effects most commonly increase in the surface roughness of dental hard tissues and restorative materials.[1] This kind of surface irregularities increases the available surface area 2 to 3 times, which provides the niche to attach and grow to the microorganisms leading to quicker plaque accumulation and more difficult plaque removal[3]. Eid et al. have mentioned that bacterial adhesion is directly proportional to surface roughness of the restorations. Ikeda et al., also stated that surface roughness has a positive influence on S. mutans biofilm adherence[12].

In this study, no additional finishing and polishing procedure were carried out to avoid intergroup variation. Bjorson et al. mentioned that the smoothest surface of a composite resin is produced when restoration is cured against a Mylar strip. Pre- and post-instrumentation roughness were calculated in terms of Ra values (μm). Ra can be defined as the arithmetic mean of the departure of the profile from a mean line derived from the top and bottom of the undulations on the trace.

Ultrasonic instrumentation has significantly altered the surface roughness of all the specimens. This may be due to the preferential removal weak matrix phase; thus leaving the harder unreacted glass or filler particles protruding out from the surface[13,14]. Eid et al. also mentioned that differences in the roughness of different composites is due to differences in their size and content of filler particles.[17] That means higher the powder particle size of test group higher will be the post-ultrasonic roughness. Nanofilled composites have shown to have round-shaped nanoclusters, while the nanohybrids present irregular-shaped small and medium particles,

The nanohybrid composites contain a small fraction of filler particles in the nanoparticle size range (less than 0.1μ or 100 nm), they also contain a range of substantially larger filler particles. The nanohybrids have some particles in the nanofiller size range less than 100 nm (0.1um), but they also contain particles in the submicron range (0.2 to 1μ).When any of these materials are subjected to abrasion, the resin between and around the particles is lost, leading to protruding filler particles (bumps). Eventually the entire filler particle is plucked from the surface, resulting in craters. These bumps and craters create a roughened surface[15]

Whereas, Filtek Z 350 XT showed least pre- and post-ultrasonic instrumentation roughness, which is attributable to a unique combination of individual nanoparticles and nanoclusters. Nanoparticles are discrete nonagglomerated and nonaggregated particles of 20 nm in size. Nanocluster fillers are loosely bound agglomerates of nano-sized particles. The agglomerates act as a single unit enabling high filler loading and high strength when compared to other test groups.

Also, the difference might be due to the difference in their compositions. Nanofilledresin composites presented Silicon (Si) and Zirconia (Zr) as the main components of the inorganic fillers, wherein zirconia leads to an increase in strength and density and hence a decrease in porosity of the composites[19]. While, the nanohybrids presented Silica and Barium as main components and also presented a small amount of Aluminium, which is the same as traditional hybrids.[16]

The other reason might be the form of the restorative materials in which they are supplied. Composite is a single component material, whereas in case of Glass ionomers, powder has to be mixed with liquid, therefore risking the more air bubble incorporation and increased porosity[17]. These porosities may get enhanced after ultrasonic instrumentation leading to greater surface roughness.

When the critical threshold roughness for plaque

(0.2 μm) is considered[2], initial surface roughness of control and all the test groups except GC2 was well below it. Post-ultrasonic instrumentation roughnesses of all except Filtek Z 350 XT were well above this critical level. Thus, Filtek Z 350 XT has been found to withstand the vibrations of ultrasonic instrumentation better than other test groups and will cause no problem regarding plaque accumulation and patient discomfort.

However, the results of this in-vitro study may vary in in-vivo conditions as they are frequently subjected to various deleterious actions inside oral cavity like abrasion (brushing), attrition and erosion (citrus drinks, fruit, soft drinks, alcoholic and non-alcoholic beverages), exogenous substances including acids, bases, salts, alcohol, oxygen, etc. contacting the restoration surfaces during food and fluid intake and also to the cyclic flexural forces in the cervical region during occlusal loading. However, Roselino et al. and Zuryatietal. concluded that abrasiveness of dentifrice and home bleaching procedure did not change the surface roughness of the composites. In contrast, Uppalet al.[18] have concluded that oral hygiene maintenance procedure can significantly increase the roughness of the restorations. Results after ultrasonic scaling are also subjected to vary depending on operator, power setting, tip to surface angle, sharpness of the working edge, instrumentation time after placement of the restoration, which may require further long-term studies for different time periods.

CONCLUSION

Within the limitations of this study, ultrasonic instrumentation has caused significant changes in the surface roughness of both control and test specimen. Type II GIC had highest, whereas nanofilled composites had lowest pre- and post-instrumentation roughness values. Nanofilled composites are found to withstand the US instrumentation better than other tested materials, but still we would like to pass a message that carry out the routine ultrasonic scaling with caution, and subsequently polish the roughened restorations after scaling.

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