Comparative evaluation of effect of tooth brushing – mouth rinse – cycling on surface roughness of nanofilled and nanohybrid composites – an in vitro study

Swati Madhavrao Wathore[1,*], Pratima R. Shenoi[2], Rajiv T Khode[3], Rajesh Kubde[4], Chetana Makade[5], Snehal Sonarkar[6]

[1]PG Student, [2]Professor & HOD, [3,6]Senior Lecturer, [4,5]Associate Professor, VSPMDCRC, Nagpur

*Corresponding Author:
Email: drswatiwathore@gmail.com

Abstract

Aim: To evaluate influence of tooth brushing – mouth rinse cycling (TMC) on surface roughness of two resin composites (Nanohybrid-Z250 & Nanofilled-Z350).

Materials and Method: 80 disc shaped specimen of two composite resins (Nanofilled – Filtek[TM] Z-350 XT(3M ESPE, U.S.A. Shade A$_2$); Nanohybrid Filtek[TM] Z-250 XT(3M ESPE,U.S.A. Shade A$_2$) were prepared (each-40) using teflon ring matrix & divided into 4 groups (n=10) according to mouthrinses to which they were subjected: Listerine(Alcoholic), Rexidine Plus (Alcohol free), Betadine Mint (Iodine) & Artificial saliva (control). Powered toothbrush mounted on standardized jig was used to deliver constant brushing strokes. Specimens were subjected to TMC for four weeks. Surface roughness was evaluated using a surface roughness tester.

Results: The result of the MANOVA (Statistical analysis) showed that the Nanofilled resin(Z-350) presented lower surface roughness than Nanohybrid (Z-250) (p<0.005) and two resin presented the higher roughness after immersion in the alcohol containing mouth rinses i.e. Listerine than Rexidine Plus and Betadine Mint (p<0.005).

Conclusion:
1. Nanofilled resin presented the best behavior (lower surface roughness).
2. Alcohol containing mouth rinses can increase the roughness of the resin composite.

Introduction

Composite restorations have became highly popular in last four decades due to greater demand for an aesthetic restorations. Composites are characterized by favorable mechanical and physical properties along with good aesthetic. Basically, composite is composed of three chemically different phases: a polymeric matrix of dimethacrylate monomers; filler particles(dispersed phase); and an organosilane, a coupling agent that bonds the fillers to polymeric matrix.[1] Based on their filler particle system composite is classified as, hybrid(0.5-3), microhybrid (0.4-1) and microfilled(0.04-0.4). A new class of composite, with the filler particles exclusively in the nanoscale, i.e., from 0.1 to 100 nm size range, is recently made available.[1] Many published studies have analyzed in vitro influence of tooth brushing[2] and mouthrinses[3] on the surface changes of resin composite. They reported that tooth brushing causes surface roughness of resin composites which may lead to the accumulation of dental biofilm a precursor to periodontitis and secondary caries lesions around the tooth resin interfaces.[4] Mouth rinses are now being routinely used as adjunct to regular tooth brushing by many patients.

This was designed study to evaluate the combined effect of tooth brushing –mouth rinse cycling(TMC) on the surface roughness of resin based composites with different filler particle systems (nanohybrid and nanofilled).

Materials and Methods

Two resin composites with different types of filler particles were analyzed (Nanofilled – Filtek[TM] Z-350 XT(3M ESPE, U.S.A. Shade A$_2$); Nanohybrid Filtek[TM] Z-250 XT(3M ESPE,U.S.A. Shade A$_2$). The mouthrinses were: Alcohol containing (Listerine- INDOCO REMEDIES LTD, INDIA), Alcohol free (Rexidine Plus- IHOOCO REMEDIES LTD, INDIA) and Iodine containing (Betadine Mint-WIN –MEDICARE PVT. LTD, INDIA). Artificial saliva (AS) used as a control, was prepared by Oschiro's method at 37°c for one month.[5] The pH of all substances was measured by using a PH meter(Bench-top pH meter with LCD display InoLab WTW a xylum brand) by replacing a 1.5 cm diameter glass PH electrode into 20ml of each substance. Powered toothbrush (Colgate 360 -20X, INDIA) mounted on standardized jig was used to deliver constant brushing strokes.

Specimen Preparation

Eighty disc shaped composite resin (Z-250 & Z-350) specimen were prepared(40 for each resin). Composite was filled in bulk in teflon ring matrix of diameter 7mm and 2mm height and a glass slide was placed on it and compressed with a device(500 g) for 20 seconds to extrude the excess material and eliminate the porosities. The material was covered with the mylar strip to produce smoothest surface after curing.[6,7] The specimens were then polymerized by placing the light cure tip in the centre, with a fully charged quartz-tungsten halogen light curing unit (woodpecker LED) operated in standard mode and emitting more than

$650mW/cm^2$ of irradiance light, for 40 sec. The prepared specimens were then randomly and equally divided into four groups (n=10) according to the mouthwash and control group (artificial saliva) to which they were assigned to.

Tooth brushing –mouth rinse Cycle

Specimens were submitted daily to TMC as follows, initially all the specimens were kept in artificial saliva at 37^oc. Twice a day (12 hour intervals), each specimens of all the groups were subjected to tooth brushing for 1 minute. Brushing was carried out by using powered toothbrush (Colgate 360) mounted on a standardized zig to deliver constant brushing strokes on each specimen, at a speed of 360rpm, with a dentifrice slurry (Colgate Total and distilled water, 1:1 ratio). After brushing the specimens were then abundantly rinsed with distilled water and immersed in 20ml of mouth rinse for 1 minute according to the above prescribed groups (control group is kept only in the artificial saliva). The specimens were then washed in distilled water and replaced in artificial saliva (overnight). The surface roughness was evaluated at the end of fourth week.

Surface Roughness Analysis

All the specimens were evaluated by using a surface roughness tester (Mitutoyo, Japan, SJ 210). The average roughness (Ra) was determined for each specimen.

Statistical Analysis

Surface roughness were analyzed by multifactor analysis of variance (MANOVA) and Tukey post hoc test. All the analysis were performed at a significance level of $P < 0.05$.

10 samples of each composite was used and mean reading of surface roughness in micrometers for each mouth rinse for the two composite materials: Z250(nanohybrid) and Z350(nanofilled) were calculated.

Observations

Table 1: Composition of resin composite analyzed in this study (according to the manufacturer)

Resin composite	Composition	Shade
Nanofilled – Filtek^{TM} Z-350 XT(3M ESPE,U.S.A.)	Filler: 78.5% by weight (63.3% by volume) combination of aggregated zirconia/silica cluster ranging from 0.6 to 1.4 µm, with the primary particle size, 5-20nm and non-agglomerated 20nm silica filler, 4 to 11 nm zirconia filler.	A$_2$
Nanohybrid – Filtek^{TM} Z-250 XT(3M ESPE,U.S.A.)	Filler Percentage Weight: 82% Volume: 60 %The particle size distribution is 0.01µm to 3.5µm with an average particle size of 0.6µm.	A$_2$

Table 2: Composition and characteristics of the substances used in this study (according to the manufacturer)

Substance	Composition	ph	Alcohol content(v/v%)
Rexidine Plus	Chlorhexidine gluconate solution IP diluted to chlorhexidine gluconate 0.2%	7	0
Betadine mint	Povidone –iodine IP 2%.	7.5	8.38%
Listerine	Ethanol, benzoic acid, eucaptol, menthol, methyl silicate, thymol.	4.9	26.9
Artificial saliva	KCL, NaCl, MgCl, CaCl, Nipacin, Carboxy methyl cellulose, sorbitol, and deionized water.	6.4	0

Table 3: Comparison of Nanohybrid and Nanofilled with respect to mean Surface roughness on using various mouth rinses

Group	Mouth Rinse	Z250 surface Roughness (Ra)µm	Z350 surface Roughness (Ra) µm
I	Rexidine	0.114	0.065
II	Betadiene	0.118	0.068
III	Listerene	0.168	0.096
IV	Artificial saliva	0.096	0.049

**Graph 1: Comparison of nanohybrid and nanofilled
with different mouth rinses**
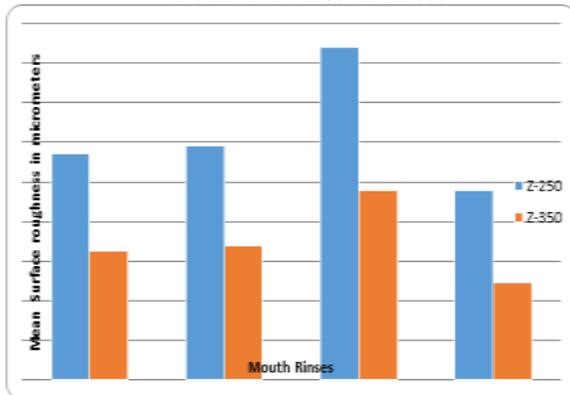
**Fig. 1: Nanohybrid(Z250) and Nanofilled (Z350)
composite (Shade A$_2$)**

Fig. 2: Mouth washes
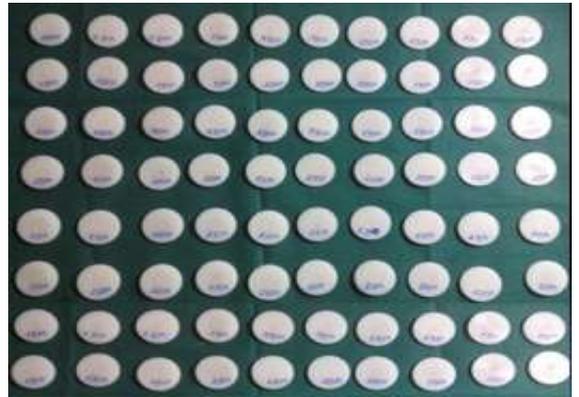
Fig. 3: Prepared Specimens

Fig. 4: Toothbrush mounted on jig

**Fig. 5: Surface roughness tester. (Mitutovo, Japan,
SJ 210)**

Results

The result of the MANOVA (Statistical analysis) showed that the Nanofilled resin(Z-350) presented lower surface roughness than Nanohybrid (Z-250) $p<0.005$ and two resin presented the higher roughness after

immersion in the alcohol containing mouth rinses i.e. Listerine than Rexidine Plus and Betadine Mint p<0.005.

Discussion

The degradation of resin based material in the oral environment is a complex process, which involves the mechanical and chemical mechanisms[1]. The characteristics of the filler particle system (concentration, size, and shape) is the most crucial factor affecting the wear of resin composite.[1] Several published studies have shown that Nanofilled resin composites present the lowest roughness after polishing making it suitable for restoration of anterior tooth.[2,8,9]

At the beginning of the experimental protocol, it is aimed to ensure that all specimens had the similar initial surface roughness values so the final results represented the actual material behavior. Thus in the present study all the specimens were cured against mylar strip as according to Bjorson et al the smoothest surface of a composite resin is produced when restoration is cured against a mylar strip.[6]

The clinical performance of surface roughness can be demonstrated in two ways: firstly, the roughness provides a niche and increases the surface area 2 to 3 times which facilitate accumulation of plaque.[10,11] Many studies have stated that there is definite correlation between surface roughness and increased bacterial colonization.[6] This roughness may lead to more plaque accumulation, staining, recurrent caries, gingival irritation and increased patient discomfort.[12]

In the present study, the powered tooth brush (Colgate 360) mounted on a standardized zig to deliver constant brushing strokes is used to exert the constant brushing strokes.[13,14] so as to standardized the effect of force on the final result of surface roughness of composite resin.

In the present study the Nanohybrid presented the greater surface roughness than Nanofilled composite, this may be because of the Nanofilled composite (20nm) has an average filler particle size less than that of Nanohybrid resin composite(0.6 μm).[15] According to the many other studies the, the roughness of resin composites is directly related to their filler particle systems, i.e., the amount, size, shape, hardness, and interparticle spacing.[16,17] These can be used to explain the poor behavior presented by Nanohybrid composite resin. When the filler particles and polymeric matrix are bonded with the silane coupling agent, the filler particles may be plucked out during brushing, thus it is possible that due to greater size of filler particle of Nanohybrid protruded more through the composite surface than did the filler particle of the Nanofilled (5-20nm). This extended protrusion provided longer cantilevers, leading to the higher angular moments that facilitated the filler being pulled out from the material.[1,18] It is known that when there is a higher content of smaller filler particles as found in the Nanofilled, the distance between the neighboring particles is small, which may act as a barrier

against polymeric matrix wear.[18] Thus the polymeric matrix of Nanofilled is less worn than that of Nanohybrid.[19,20]

The alcohol containing mouth rinses (Listerine) produced the greatest surface roughness in the two resin composites than Rexidine plus and Betadine mint, this result was expected and can be explained by plasticizing effect of ethanol. This polar solvent penetrates into the resin composite causing the material swelling, pulling apart the polymeric matrix chains, and decreasing its cross linking density, resulting in a decrease in wear resistance and enhancing the deleterious effect of brushing. The findings of Almeida and others[21] found that the sorption and solubility of a hybrid and a Nanofilled resin composite were higher after immersion in alcohol containing mouth rinses and claimed that this was due to swelling of their polymeric matrixes produced by the ethanol contained in the mouth rinses and increasing the elution of non-reacted monomers and oligomers from those materials. Listerine was the medium that produced the greatest increase in roughness in the two resin composites. This may be because greater content of ethanol (26.9%), and its low pH (4.1), which causes degradation of ester groups present in the dimethacrylate monomers present in the resin composites, in the current study (i.e., Bis-GMA, UDMA, TEGDMA) can undergo degradation through hydrolysis in environments with low ph.[22] It is possible that these aspects acts synergistically to potentiate the negative effects of tooth brushing, thereby increasing the roughness of resin composites.

Conclusion

1. Nanofilled resin presented the best behavior (lower surface roughness), suggesting that it is more adequate to be used in the surface layer of anterior restorations; and
2. Alcohol containing mouth rinses can increase the roughness of the resin composite, thus clinician should consider this when prescribing these substances to their patients.

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