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EFFECT OF WET AND DRY FINISHING AND POLISHING ON SURFACE ROUGHNESS AND MIAROHARDNESS OF BULKFILL RESIN COMPOSITES

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ABSTRACT

Objective: The aim of this in vitro study was to evaluate surface roughness and microhardness of two bulkfill resin composites after wet and dry finishing.

Materials and methods: Two Types of resin composite materials SonicFill (Sonic-activated bulk-fill Nanohybrid resin composite) and X-tra fil (Bulk-fill micro- hybrid light-cured posterior resin composite) were used. Thirty samples were fabricated of each resin composite using a metal mold measuring (6mm x 4mm). Composites were applied to molds and placed between two transparent Mylar strips and pressed flat with a microscopic glass slide. A glass slab was placed on top of the upper Mylar strip and a constant pressure was applied. The samples were cured according to manufacturers' instructions. The samples were divided into three groups (n=10). Group A: No finishing (control group), Group B: wet finishing under water coolant, and group C dry finishing. Surface roughness was evaluated using a stereomicroscope and microhardness was measured by Vicker's hardness tester. Data were analyzed using one-way ANOVA ($P<0.05$).

Results: X-tra fil showed a statistically significant higher surface roughness mean values than Sonicfill in group A (control group) and group C (dry finishing) at p value ≤ 0.015 and ≤ 0.001* respectively, while with the wet technique there was no statistically significant difference in the surface roughness mean values between X-tra fil and Sonicfill at p value> 0.05. The control group showed the lowest microhardness mean values in both materials. Dry finishing showed the highest microhardness mean values among the groups ($P<0.05$).

Conclusion: Dry finishing and polishing increased the surface roughness and microhardness of X-tra fil (microhybrid) and (nanohybrid sonic activated) Sonicfill resin composites.

KEYWORDS: Resin composite, wet finishing and polishing, dry finishing and polishing bulkfill composite, microhardness, and surface roughness.

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INTRODUCTION

The use of resin composites in posterior teeth has become a common procedure in daily practice, but current resin composites present variations in their composition, including both organic matrices and/or inorganic fillers, which may influence their polishability. In current resin composite materials the average filler particle size has been reduced in order to obtain better color stability and greater wear resistance, smoothness and strength. Hybrid resin composites contain a mixture of different particle sizes, with the microhybrids being the most widely used in posterior teeth because they provide optimal mechanical and physical properties combined with good polishability.[1]Nanotechnology offered us nanohybrids with high translucency, polish and polish retention together with physical properties and wear to be compared with hybrids.[2] Since appropriate finishing and polishing procedures play an important role in improving the esthetics and longevity of dental restorations finishing and polishing procedures are performed to shape and smoothen the surface of resin composite restorations.[3] Finishing is the gross contouring of a restoration to obtain ideal anatomy and provides a smooth surface, and polishing reduces the roughness and scratches created by finishing, provides an enamel-like luster to the restoration and reduces the surface energy. It might be assumed that due to some surface changes caused by finishing and polishing procedures some properties of resin composite materials might be affected. Surface roughness, microhardness and microleakage are these affected properties and they are critical factors that influence the clinical behavior of resin composite restoration.[1] Surface roughness is closely related to the organic matrix, inorganic filler composition of the material, and finishing and polishing procedures. Microhardness is greatly influenced by the filler volume fraction, the resin type, and the polymerization degree.[3] So, it is important to determine which finishing and polishing system and technique offers the best results for different types of resin composite materials in order to provide the smoothest restoration surfaces without altering the properties of the materials. Thus, this study aimed to assess the effect of wet and dry finishing and polishing procedures on surface roughness and hardness of one conventionally applied bulk fill microhybrid and one Sonic-activated bulk-fill Nanohybrid resin composite materials.

MATERIALS AND METHODS

In this study two new commercially available visible-light polymerized tooth-colored materials were used. Specifications of restorative materials tested, are listed in Table (1).

Specimen Preparation:

Thirty samples were fabricated of each resin composite using a metal mold measuring 6mm in diameter and 4mm in thickness. Composites were applied to molds and placed between two transparent Mylar strips and pressed flat with a microscopic glass slide. A glass slab was placed on top of the upper Mylar strip and a constant pressure was applied in order for the excess composite to leak out. The samples were light-cured for 20 seconds according to manufacturers' instructions using a quartz tungsten halogen light curing unit (Demetron LC; Kerr Corporation, Middleton, WI, USA) through the glass and the Mylar strip on top of the specimens. The intensity of light was measured by a radiometer (Model 10; Kerr Demetron, Danbury, CT, USA) prior to each time of use to ensure it was not less than 600 mW/cm2. Immediately after curing, the samples were removed from the mold and were randomly divided into three groups as follows:

Group A: This group received no finishing or polishing after removing the Mylar strip and served as the control group.

Group B (wet finishing and polishing): In this group, the samples were subjected to finishing

TABLE (1):

Material	Specification	Composition	Particle size	Manufacturer	Lot number
SonicFill	Sonic-activated bulk-fill Nanohybrid light-cured resin composite	**Matrix:** Ethoxylated Bis-GMA, Bisphenol-A-bis-(2-hydroxy-3-mehacryloxypropyl) ether, TEGDMA, and 3-trimethoxysilylpropyl methacrylate **Filler:** Silica and barium aluminoborosilicate glass (83.5 weight %) **Others:** special modifiers that react to sonic energy	unreported	Kerr Corporation, Orange, CA, USA	4827265
X-tra fil	Bulk-fill micro-hybrid light-cured posterior resin composite	**Matrix:** Bis-GMA, UDMA, and TEGDMA. **Filler:** Barium–boron–alumino–silicate glass (86% weight)	(2–3 µm)	Voco, Cuxhaven, Germany	1539279

and polishing using Sof-Lex polishing disks (3M ESPE, St. Paul, MN, USA) in the descending order of granulation, including coarse (60µm), medium (40µm), fine (24µm) and ultrafine (8µm) grit sizes respectively under water coolant provided by a water syringe held by a second operator with a flow rate of 20 cc/minute. The disks were used on slow speed for 10 seconds each.

Group C (dry finishing and polishing): The samples in this group were subjected to finishing and polishing using the same coarse, medium, fine and ultrafine discs, respectively as in group B but without water coolant. After using each disc, the samples were rinsed for 10 seconds to remove debris and dried for 5 seconds. Each disc was used for 10 seconds with mild pressure and planar movement in a low-speed (5000rpm) hand piece (Ti-Max Electric hand piece; NSK, Tokyo, Japan). In both groups **B** and **C** discs were discarded after one time use and all phases of finishing and polishing were performed by the same operator, who was blinded to the group allocation of samples. After finishing and polishing, all samples were rinsed and dried. Then the samples were placed at 37°C in distilled water for 24 hours prior to measurement of surface roughness and hardness.[4]

Measurement of surface roughness:

Images of each sample were taken using Canon digital camera connected to Zeiss Stereomicroscope (Technival 2) and Ra factors were measured using an image analyzer software (Image J1.52, Image ware, USA).

Measurement of microhardness:

Microhardness was measured using a Vickers hardness tester (4503,NEXUS 4000TM, INNOVTEST, Netherland). Three indentations were made in each sample by applying 500g load within 15 seconds (dwell time), and the mean value was calculated. A minimum of 1mm distance was considered between indentations.[5]

Statistical analysis

Data showed parametric distribution. One-way ANOVA used to show the difference between tested condition followed by Tukey's (HSD) post hoc test for pairwise comparison. Independent t-test used to compare between tested groups. (α=0.05) (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.)

RESULTS

The surface roughness mean values of resin composites subjected to different finishing procedures were presented in table (2). The one way ANOVA revealed that, for sonicfill, there was a statistically significant increase in the surface roughness mean values at p value ≤0.001.Group C (dry finishing) showed the highest surface roughness mean values among the groups followed by group B (wet finishing),while Group A (control group) which received no finishing and polishing showed the lowest surface roughness. With X-tra fil, there was a statistically significant difference in the mean values between the groups at p value ≤ 0.007. Pair wise comparison between the groups revealed that, Group B (wet finishing) showed the lowest surface roughness mean values among the groups. There was no statistically significant difference between group A (control group) and C (dry finishing) at p value > 0.05 both showed the highest surface roughness values. X-tra fil showed a statistically significant higher surface roughness mean values than Sonicfill in group A (control group) and group C (dry finishing) at p value ≤ 0.015 and ≤0.001* respectively, while with the wet technique there was no statistically significant difference in the surface roughness mean values between X-tra fil and Sonicfill at p value> 0.05.

The microhardness mean values of resin composites subjected to different finishing procedures were presented in table Table (3). The one way ANOVA revealed that, there was a statistically significant increase in the microhardness means for both materials with different finishing procedures at p value ≤ 0.001. Group C (dry finishing) showed the highest microhardness mean values among the groups followed by group B (wet finishing). The control group showed the lowest microhardness mean values in both materials. X-tra fil showed the higher microhardness mean values compared to Sonicfill in all the groups. Group A (control group) and group B (wet finishing) showed a statistically significant increase in the mean values of X-tra fil compared to Sonicfill at p value ≤ 0.003 and 0.001 respectively. However for the dry technique, there was a no statistically significant difference in the mean values of both materials at p value = 0.911.

TABLE (2): Mean ± standard deviation (SD) values and results of comparison of surface roughness of Sonicfill and X-tra fil with different finishing procedures.

		SonicFill™		x-tra fil		p-value
		Mean	SD	Mean	SD	
Surface roughness	Control	77.18[c]	0.33	82.86[a]	0.91	0.015*
	Wet	81.85[b]	1.55	79.54[b]	3.80	0.199 NS
	Dry	86.04[a]	0.90	84.40[a]	0.49	≤0.001*
p-value		≤0.001*		0.007*		

Means with the same letter within each column indicates insignificant difference at p>0.05

TABLE (3): Mean ± standard deviation (SD) values and results of comparison of microhardness of Sonicfill and X-tra fil with different finishing procedures.

		x-tra fil		SonicFill™		p-value
		Mean	SD	Mean	SD	
Microhardness(VHN)	Control	81.07[a]	9.49	80.56[b]	4.87	0.003*
	Wet	90.27[a]	7.62	63.60[c]	5.81	≤0.001*
	Dry	108.24[b]	5.84	99.01[a]	3.82	0.911 NS
p-value		≤0.001*		≤0.001*		

Means with the same letter within each column indicates insignificant difference at p>0.05

DISCUSSION

Resin composites are one of the most commonly used direct restorative materials nowadays. The surface quality of these dental restorations is an important parameter influencing their clinical behavior. Clinicians always aimed to produce the smoothest surface which will provide longevity for these esthetic restorations. The mechanical properties tested in the present study, as surface roughness, and microhardness of resin composites are affected by finishing and polishing procedures and interfere with the clinical appearance of the restoration.[3]

The materials selected for this study were selected because they have different filler compositions as well as superior properties.[6]

Finishing and polishing procedures are necessary clinical steps to restore an anatomical and morphological form of the tooth after any restorative procedure. Smooth surface enables clinical durability, good esthetic appearance, better optical compatibility with natural enamel tissue and surface gloss, as well as, preventing the discoloration and staining of the restoration.[7]

A wide variety of materials and techniques have been introduced for contouring, finishing, and polishing,but there is no universally accepted method for finishing procedures. [3] Marigo et al.[8] showed that characteristics of finishing and polishing tools such as their flexibility, shape and hardness of abrasive particles affect the resultant surface roughness of composite, and flexible aluminum oxide discs are ideal for obtaining a smooth composite surface, we used Sof-Lex aluminum oxide discs in this study.

Also, manual planar movement yields the lowest surface roughness following finishing and polishing of composite.[9] Thus, we finished and polished the composite samples of this study using manual planar movement in order to better simulate the clinical setting as again stated by the same author [9], and since the applied load and speed of finishing and polishing are widely variable among different operators, one operator performed finishing and polishing of all composite samples in our study.

In our study generally dry finishing and polishing increased the surface roughness and the microhardness of both tested resin composite materials. Variability in the results of this study can be explained by the difference in filler content of the two resin composite materials tested. Also good linear correlation between mechanical properties and filler mass fraction was observed. Particle size was also a reason for the difference in mechanical properties between the investigated materials and this was the same reason in the study performed by Leprince et al in 2014. [10]

In dentistry surface roughness measurements are usually carried out with the help of profilometry. In this study too, a profilometer was used to evaluate the surface roughness of the tested materials. Arithmetical mean deviation (Ra) is the most commonly used parameter in the assessment of surface roughness. Nevertheless, the sum of the height of the largest profile (Rp) and the largest profile valley depth within the evaluation length (Rv) could be another means of expressing the values. The limitation of the present methodology involves the impossibility of measuring the homogeneity in the maximum profile valley height and depth. For these reasons Ra was preferred in this study to evaluate the surface roughness.[11]

The surface finish obtained by the Mylar strip was used as a control group in our study, although this surface finish is perfectly smooth, it is resin-polymer rich and may contain some voids. Therefore, removal of the outermost resin by finishing is essential to produce a relatively standard and stable surface. It has been shown that removal of this superficial layer will increase the wear resistance of the surface. The experimental finishing and polishing procedures were kept to a minimum time, 10 seconds for each step, as they are inherently destructive to the restoration and may lead to micro-cracks formation.[7]

Nasohi et al.[9] again stated that composites polymerized with a clear matrix on the surface will leave a resin-rich surface layer that is easily abraded in the oral environment, exposing unpolished, rough, inorganic filler material. Thus, polishing is required to prevent wear and discoloration on the resin-rich surface. In accordance with the above, the surface roughness results determined by mylar strip in the present study were satisfying but the microhardness results were poor.

Although the surface obtained by the use of the Mylar strip is perfectly smooth, it is rich in the resin organic binder. Therefore, removal of the outermost resin by finishing–polishing procedures would tend to produce a harder, more wear resistant, and hence a more aesthetically stable surface. Despite the careful placement of the matrixes, removal of excess material or recontouring of restorations is often clinically necessary.[11] So Wet and Dry Finishing and Polishing were performed in this study.

The surface roughness property of any material is the result of the interaction of multiple factors. Some of them are intrinsic that are related to the material itself, such as the filler (type, shape, size, and distribution of the particles), the type of resinous matrix as well as the ultimate degree of cure reached, and the bond efficiency at the filler/matrix interface. Other factors are extrinsic that are associated with the type of polishing system used, such as the flexibility of the packing material in which the abrasives are embedded, the hardness of abrasives, the geometry of instruments, the light curing method, and the way by which the finishing tools are used.[6]

When surface smoothness was compared between the wet and dry techniques a significant difference occurred between the two tested materials. The dry finishing and polishing revealed significantly rougher surface than the wet finishing and polishing with both materials, these results were the same obtained by Dodge et al.[12] Also Kaminedi et al[13] found among the nano-composite (same as SonicFill) group and again the hybrid (same as X-trafil) that dry finishing recorded the highest surface roughness.

In this study both finishing protocols (dry and wet) in X-trafil composite recorded a higher surface roughness mean value than in SonicFill, this was in agreement with Kaminedi et al.[13] The results of this study showed that nanohybrid SonicFill composite had smoother surface under both conditions of finishing and polishing than the micro hybrid X-trafil composite because in the micro hybrid, the particle size is larger, leaving the surface rough due to pluck out of filler particles after wearing out of resin matrix during finishing and polishing, this was also claimed by Kaminedi et al.[13]Also it was clearly presented in this study that the uncontrolled heat obtained during the dry finishing and polishing protocol in this study, created a lot of cracks and excessive roughness on the surface both resin materials. The same was found in two studies by Ozgünaltay et al.[14]

Hanadi et al.[13] also found higher surface roughness values with X-tra fil than with sonicFill with wet and dry finishing and they stated that this might be due to the high filler volume fraction and the larger filler size of x-tra fil which may contributed to its high surface roughness. It was also previously found that larger filler particles of hybrid composites could be a possible consequence of increased surface roughness. However, the high roughness value of X-tra fil can be explained by the fact that the abrasives may abrade the minimum amount of resin matrix available in that composite, leaving the large filler particles protruding.

Microhardness is defined as the resistance of a material to indentation and is an important mechanical property that predicts the polymerization degree of cure of restorative materials. Changes in microhardness may reflect the state of the setting reaction of a material and the presence of an ongoing reaction or maturity of the restorative material.[3] A direct correlation was found in many studies between the hardness and the surface roughness of resin composites, indicating that a composite with a higher hardness value was usually associated with a higher surface roughness[6], this was also present in our study since x-tra fil showed higher hardness and roughness values in comparison to Sonic Fill in both control groups.

In our study, hardness of all composite samples increased by dry finishing and polishing. The hardness of composite increases by raising the temperature due to increased cross-linking between polymer chains. Temperature at the surface of composite subjected to dry finishing and polishing is about 140°C or higher, such a temperature rise increased cross-linking and hardness because this temperature is higher than the glass-transition temperature of resin content. This temperature rise is not hazardous for dental pulp because composites are heat insulators, and the generated heat during dry finishing and polishing is confined to the composite surface such that at 0.2mm depth from the composite surface, and so temperature does not exceed 10°C.[15]

In this study, x-tra fil nanohybrid composite yielded higher microhardness than sonic fil after both dry and wet finishing and polishing because this composite has 86wt% filler content, which is higher than that of sonic fill (83.5 wt%). Increase in filler content enhances the hardness of composites. According to Leprince et al.[10] and Geethu Francis et al.[5], X-tra fill is similar to microhybrid restorative materials with high-filler loading and this possibly explained its high microhardness, which wasperfectley in accordance with the present study.

CONCLUSION

Within the limitations of this study, it can be concluded that dry finishing and polishing could increase the surface roughness and microhardness of microhybrid and nanohybrid sonic activated bulkfill resin composites.

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