Original Article

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Effect of finishing and polishing techniques on the surface roughness of a nanoparticle composite resin

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Abstract

Aim: To evaluate the surface roughness of the resin Filtek Z350 (3M ESPE) after different finishing and polishing techniques. **Methods:** Sixty specimens of 7x2 mm were made and distributed in 6 groups (n=10), according to the technique employed: G1 (control) – polyester strip – no finishing or polishing; G2- multi-blade burs; G3- diamond burs 3195F and 3195FF; G4- Diamond Pro Discs (FGM); G5- Sof-Lex Discs (3M ESPE); G6- Robinson bristle brushes with pumice paste for 20 s and felt disc with 2-4 μm diamond paste for 30 s. The specimens were stored in artificial saliva at 37°C for 7 days. After the finishing and polishing techniques, surface roughness (*Ra*, μm) was measured using Surf-Corder profilometer SE 1700. Data were subjected to one-way ANOVA and Tukey's test at 5% significance level. **Results:** G3 presented the highest surface roughness mean value (0.61). G5 presented the lowest surface roughness mean value (0.15), but it was not significantly different from G1, G4 and G6. **Conclusions:** According to the obtained results, Z350 composite resin presented the lowest surface roughness when finishing and polishing systems were used (Sof-lex and Diamond Pro discs and Robinson bristle brush with pumice plus Diamond® felt disc with Diamond Excel® paste). The use of diamond burs (G3) resulted in the highest composite surface roughness. There was no significantly different between G1, G4, G5 and G6.

Keywords: dental polishing, composite resin, nanotechnology.

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Introduction

Due to their broad use in dentistry since their introduction, light-activated composite resins have been constantly improved. One of the most significant improvements regarding is related to the used of nanotechnology. The new composites, named nanocomposites, have advantages such as lower polymerization shrinkage, improved mechanical properties, favored optical behavior, better brightness, extended maintenance of surface smoothness, better color stability and lower wear[1-3]. Filtek Z350 composite resin (3M ESPE), one of those nanoparticle composites, presents zirconia and silica particles[4], with approximate size between 5-20 nm and pre-polymerized nanoclusters ranging from 0.6 to 1.4 micrometers[5].

The organic matrix structure and the characteristics of fillers exert a direct influence on the surface roughness and staining susceptibility of composite resins.

Besides the effect of composition and conversion degree, finishing and polishing procedures can also influence the surface quality of composite resins and are related to roughness and staining[6-7].

Clinical procedures including finishing and polishing of composite resins improve esthetic results and restoration longevity. Rough surfaces predispose restorations to increase of bacterial biofilm accumulation, facilitating the development of secondary caries[8], discoloration and staining[9], and compromise final brightness and esthetics[9-10]. Greater surface roughness also increases the absorption of chemical components from beverages and foods, which, once retained within the previously formed bacterial biofilm, diffuse into the composite possibly affecting the formed polymer, inducing degradation[11].

Finishing and polishing procedures require sequential use of instruments with gradual decrease in particles abrasiveness, aiming to obtaining a brighter and smoother surface[12]. There is no consensus in the literature regarding the effectiveness of the different systems used for finishing and polishing of composite resins. While some reports state that the use of multi-blade burs prior to abrasive discs or rubbers is a key step to achieve adequate surface smoothness[13], others advocate the effectiveness of "one-step" polishing systems[14-16]. Moreover, Heintze et al.[17] observed a considerable decrease on the mean surface roughness after 20 s of polishing of practically every restorative materials tested in their study and stated that increasing the polishing time did not result in significant improvements on surface smoothness[17]. The aim of this study was to evaluate the surface roughness of the nanocomposite resin Filtek Z350 (3M ESPE) after different finishing and polishing techniques. The tested hypothesis was that different finishing and polishing techniques provide different surface roughness on the resin.

Material and methods

Sixty specimens of Filtek Z350 composite resin (3M/ESPE) were used (n=10). The characteristics of Filtek Z350 are described on Table 1.

The procedures were performed in a special room according to the American Dental Association specification #27 for direct composite resin restorations. Those specifications are related only to the temperature and humidity conditions to insert the composite resin into the matrix[18].

A metallic matrix (2 mm high and 7 mm diameter) was used to fabricate the specimens. Composite resin was inserted into the matrix, covered with clear polyester matrix strips, pressed with glass slides and light activated following the manufacturer's instructions using a halogen light device (Optilux 501, Kerr Corp., Orange, CA, USA). The curing tip was positioned perpendicular to specimen surface and a power output density of 620 mW/cm^2 was used, as frequently monitored with a curing radiometer.

The specimens were stored at 37ºC and 100% relative humidity for 7 days prior to finishing and polishing procedures. Finishing and polishing systems and their respective compositions are described in Table 2. The specimens were divided into 6 groups (n= 10) according to the finishing and polishing systems as described on Table 3.

The roughness (*Ra*, µm) readings were carried out using a profilometer (Kosaka Lab. SE 1700) with 0.25 mm cutoff and 0.1 mm/s speed. Three consecutive measurements in different areas on the polished surface were made and an average number was calculated. The specimens were polished by a single operator in order to reduce technique variability and surface roughness was measured again immediately after polishing.

Data were analyzed by one-way ANOVA and Tukey's test for individual comparisons between groups. The significance level was set at 5%.

Results

The mean values, standard deviation and statistical comparisons for surface roughness (µm) are shown on Figure 1.

A one-way ANOVA test indicated significant effects of the finishing/polishing techniques. The use of fine and ultrafine diamond burs (G3) resulted in the roughest surfaces, followed by multi-blade burs (G2), although there was no statistically significant difference between them ($p>0.05$). Robison bristle brush with pumice plus felt disc with diamond paste (G6) did not differ significantly from Control (G1), Diamond Pro discs (G4), Sof-Lex discs (G5) and multi-blade burs (G2). G1, G4 and G5 presented the smoothest surfaces and differed significantly ($p<0.05$) from G2 and G3.

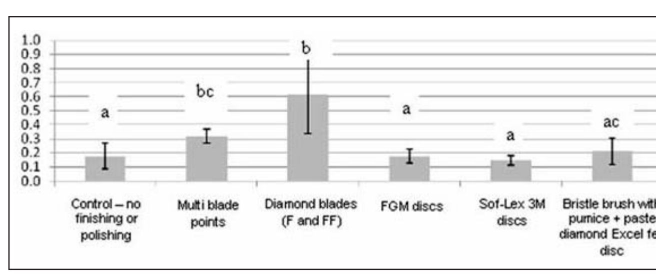

Fig. 1 - Roughness means according to experimental groups. Black vertical lines means standard deviation. Different small letters mean statistically significantly difference between means.

Table 1 - Characteristics of Filtek Z350 composite resin.

Manufacturer	Composition	Type	Shade	Amount of particles	Batch #
3M ESPE, St Paul, MN, USA	Matrix: Bis-GMA, TEGDMA, UDMAFiller Particle: silica nanofillers (5-75 nm), zirconia/silica nanoclusters (0.6-1.4 µm)	Nanoparticle composite	A3	78.5 wt.%59 vol.%	8NW

Table 2 - Finishing and polishing systems and their respective compositions.

Product	Manufacturer	Composition	Batch #
Carbide multi-blade burs	KG Sörensen, Barueri, SP, Brazil	Pressed carbide	2976511
Fine diamond burs	KG Sörensen, Barueri, SP, Brazil	46 µm diamonds	39520308
Ultrafine diamond burs	KG Sörensen, Barueri, SP, Brazil	30 µm diamonds	061027
Diamond Pro® sequential discs	FGM, Joinville, SC, Brazil	Al_2O_3 discs 20 µm 10 µm 5 µm 03 µm	2011
Sof-Lex® **d**iscs	3M ESPE, St. Paul, MN, USA	Al_2O_3 discs 29 µm 14 µm 5 µm	081720027
Diamond® felt disc	FGM, Joinville, SC,Brazil	Natural or artificial felt	2011
Diamond Excel® diamond polishing paste	FGM, Joinville, SC, Brazil	Diamond (2 to 4 ìm)	141207

Table 3 - Distribution of groups according to the finishing and polishing systems

Group (n=10)	Material	Technique
Group 1	Polyester strip matrix No finishing or polishing	Direct contact with surface
Group 2	Multi-blade carbide burs	Conventional rotation, mean time of 30 **s**.
Group 3	Fine (46 µm) and ultrafine (30 µm) diamond burs	Conventional rotation, mean time of 30 s **(**15 s each bur).
Group 4	Diamond Pro® sequential discs	Intermittent use for 15 s for each grain at low speed. Air/water spraying and air drying of composite surface at each change of disc
Group 5	Sof-Lex® system	Intermittent use for 15 s for each grain at low speed. Air/water spraying and air drying of composite surface at each change of disc
Group 6	Robinson bristle brush with pumice and Diamond® felt disc + Diamond Excel® diamond polishing paste	Robinson bristle brush with pumice for 15 s, air/water spraying and air drying of composite surface followed by 15 s application of Diamond® felt disc with Diamond Excel® diamond polishing paste. Final air/water spraying and air drying of composite surface.

Discussion

The surface roughness of composite resin is dependent on the microstructure created by the sequence of physical procedures used to modify this surface. In this study the tested hypothesis was partially accepted. Different finishing and polishing techniques provided different surface roughness values.

The use of clear polyester strips over the last increment of material in composite resin restorations is a usual step to avoid the oxygen inhibition layer on the resin surface. However, the resulting surface is rich in organic matrix brought about from the material, leading to a relatively unstable surface. The use of finishing and polishing techniques is essential to favor the chemical stability and improve the mechanical properties of the composite resin surface[13]. However, these procedures can increase surface roughness at different degrees, depending on the polishing system and material used. In the present study, the smoothest surface was obtained using Diamond Pro (G4), sequential Sof-Lex system discs (G5), and Robison bristle brush with pumice plus felt disc with diamond paste (G6), but they did not differ from the surfaces obtained with use of clear polyester strips (G1 - control group). These results corroborate those of Yap et al. 2004[19].

The geometric structure of the filler particles content of Filtek Z350 3M ESPE might be a possible explanation for these results. Furthermore, the micromorphology of composite resin surfaces after finishing and polishing is strongly influenced by the amount, geometry and size of fillers. As the tested material is a nanoparticle composite resin, the fillers are round, smaller and more homogeneously distributed, leading to less wear (which will also be more homogeneous if it occurs)[13]. Composite resins with smaller fillers provide "protection" to the resin matrix and consequently a better clinical performance with less wear and improved polishing[11]. Özgünaltay et al. (2003)[20] stated that Sof-Lex discs provide smoother surfaces and can be indicated when necessary. Other discs may also provide good polishing results. The Diamond Pro (FGM) sequential discs (G4) provided adequate polishing, being similar to Sof-Lex system discs (G5), and similar results were found in this study.

Group 3 (diamond polishing burs) provided the highest roughness, differing significantly different from the other groups, except for G2 (multi-blade burs). This is possibly because the diamond bur is highly wear resistant[6], but it makes difficult surface leveling for the final polishing. Therefore, these bur should be only used for polishing in cases where extensive removal of composite resin is required[1].

The combination of polishing pastes after the use of abrasives (G6) did not show different mean surface roughness values from the the Diamond Pro (G4) sequential discs alone or the Sof-Lex polishing system (G5). Polishing systems like Diamond Pro (G4) have smaller abrasive particles and, theoretically, they should have promoted the best composite polishing in association with felt discs, providing smooth and bright surfaces. However, this fact was not observed in the present study. According to Costa et al. (2007)[21], it could be explained by the quality of abrasive used in each system. Differences in composition and the physical properties, such hardness, are expected to influence the surface polishing more than the dimensions of abrasive particles[6].

Bollen et al. (1997)[22] stated that surface roughness greater than 0.2 μm (*Ra*) may lead to bacterial colonization onto the restoration and increase the risk of secondary caries. *Ra* values lower than 0.2 μm were obtained in the present study for Filtek Z350 3M ESPE composite resin in the control, Sof-Lex, Diamond Pro sequential discs and Robinson bristle brush/pumice + diamond paste/felt disc groups.

According to the obtained results, Filtek Z350 composite resin presented the smoothest surface when no finishing and polishing was done and when these procedures were performed with Sof-lex and Diamond Pro Al_2O_3 flexible discs and Robinson bristle brush with pumice followed by Diamond® felt disc with Diamond Excel® diamond polishing paste. Multi-blade and diamond polishing burs (bur/point) did not promote an adequate surface smoothness.

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