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EFFECT OF DIFFERENT POLISHING SYSTEMS ON THE SURFACE ROUGHNESS OF MICROHYBRID COMPOSITES

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ABSTRACT

The use of composite resins in dentistry is well accepted for restoring anterior and posterior teeth. Many polishing protocols have been evaluated for their effect on the surface roughness of restorative materials. This study compared the effect of different polishing systems on the surface roughness of microhybrid composites. Thirty-six specimens were prepared for each composite [Charisma® (Heraeus Kulzer), Fill Magic® (Vigodent), TPH Spectrum® (Dentsply), Z100® (3M/ESPE) and Z250® (3M/ESPE)] and submitted to surface treatment with Enhance® and PoGo® (Dentsply) points, sequential Sof-Lex XT® aluminum oxide disks (3M/ESPE), and felt disks (TDV) combined with Excel® diamond polishing paste (TDV). Average surface roughness (*Ra*) was measured with a mechanical roughness tester. The data were analyzed by two-way ANOVA with repetition of the factorial design and the Tukey-Kramer test ($p<0.01$). The F-test result for treatments and resins was high ($p<0.0001$ for both), indicating that the effect of the treatment applied to the specimen surface and the effect of the type of resin on surface roughness was highly significant. Regarding the interaction between polishing system and type of resin used, a p value of 0.0002 was obtained, indicating a statistically significant difference. A *Ra* of 1.3663 was obtained for the Sof-Lex/TPH Spectrum interaction. In contrast, the *Ra* for the felt disk+paste/Z250 interactions was 0.1846. In conclusion, Sof-Lex polishing system produced a higher surface roughness on TPH Spectrum resin when compared to the other interactions.

Key words: Dental materials. Composite resins. Dental polishing.

INTRODUCTION

The search for esthetic materials has led to advances in the study of dental materials, especially composite resins. The main advantages of resins are related to the material's esthetic properties, decrease of marginal leakage, increased resistance of the tooth remnant, and less need for removal of healthy tooth structure[15]. In addition, the reduced polymerization contraction and improved wear resistance of resins permit their use not only in anterior but also in posterior teeth[2]. Both esthetics and longevity of restorations strongly depend on the quality of the surface finishing and polishing. The presence of irregularities can influence appearance, plaque retention, surface discoloration, gingival inflammation[4,5,16,19,20,26,29,30], solubility of the organic matrix due to the formation of acetic, propionic and lactic acids by adhered plaque, and the occurrence of secondary caries[12]. In addition, the surface roughness of composites can reduce some mechanical properties such as hardness[13,16,17] and increase the wear of restorations. Thus, polished and smooth composite resin restorations present a better esthetic appearance and greater longevity[21].

Finishing is necessary to remove excess material and to adjust the occlusion. Final polishing using extremely fine abrasives reduces the remaining roughness and is of special importance since rough surfaces accumulate more plaque and stains[14] and may cause excessive enamel wear of the antagonistic tooth in areas of occlusal contact[9].

Another important aspect is the need for removing the superficial resin layer that does not polymerize when in contact with oxygen[18]. Studies have shown that a smoother surface is obtained when the resin is cured against a strip of appropriate matrix[1,3,11] Removal of this surface by the usually required finishing procedures will produce a harder, more resistant and esthetically acceptable surface[24]. Thus, it is important to determine which finishing/polishing system will provide the smoothest surface for the different commercially available composites[23,25].

Several studies have demonstrated that flexible aluminum oxide disks provide the smoothest composite surface[23]. Unfortunately, the use of these disks is not always possible because of the anatomic shape and difficult access to the restoration. Thus, various special shapes of rubbers and abrasive-impregnated strips are necessary[21]. Factors that can influence the surface roughness of composites include the type, size and quantity of load of the composite as well as the type, size and hardness of the abrasives and the finishing and polishing technique used[10,13].

Various polishing protocols have been tested *in vitro* to evaluate their effects on the surface roughness of restorative materials. These results have been useful to establish protocols for *in vivo* application[10]. Several composite resins have been the subject of surface roughness studies, but few investigations are available comparing the surface roughness of microhybrid resins, as well as the use of a new micro-diamond polishing system (PoGo) recently launched on the market. Therefore, the objective of the present study was to evaluate the effect of three polishing systems on the surface roughness of five types of microhybrid composite resins.

MATERIAL AND METHODS

Five photoactivated microhybrid composites indicated for direct restorations were used in the present study (Table 1). The specimens were prepared in acrylic resin plates (15 cm long x 5 cm wide), with one plate for each composite. Thirty-six specimens (circular cavity measuring 5 mm in diameter and 3 mm in depth) were prepared for each composite resin and divided into four groups (n=9): three

TABLE 1- Restorative materials tested

Material	Mean particle size (μm)	Filler particle range (μm)	Filler type	Filler content (%)	Resin	Manufacturer	Batch #
Charisma®	0.7 (Ba-glass)	0.02-2.0 (Ba-glass) 0.02-0.07 (SiO_2)	Barium glass, aluminum fluoride, silicium dioxide	60	Bis-GMA, TEGDMA	Heraeus Kulzer GmbH & Co. KG, Hanau, Germany	010211
Fill Magic®	0.5	0.04-3	Barium	80	Methacrylic monomers, pyrogenic silica and barium and aluminum silicate	Vigodent, Rio de Janeiro, RJ, Brazil	068/06
TPH Spectrum®	0.8 (Ba glass) 0.5 (SiO_2)	0.04-2 (SiO_2)	Barium glass, silica	78 to 79	Modified Bis-GMA urethane, boron silicate of silanated aluminum and barium, silanated pyrolytic silica, camphoroquinone, EDAB, butylated hydroxytoluene, and mineral dyes	Dentsply Latin America, Petrópolis, RJ, Brazil	554143
Z100®	0.7	0.2-4.5	Zirconium, silica	71	Bis-GMA, TEGDMA	3M/ESPE, St. Paul, MN, USA	8004
Z250®	0.6	0.01-3.5	Zirconium, silica	60	Bis-GMA, UDMA, Bis-EMA	3M/ESPE, St. Paul, MN, USA	1370

Information supplied by the manufacturer.

polishing systems and one control.

The resins were inserted into the cavities in three increments (the first layer was cured for 20 s, the second layer was cured for 20 s and the last layer was cured for 60 s) and activated using an LED curing unit (Optilight LD II, Gnatus, Ribeirão Preto, SP, Brazil) with intensity of about 5.2 W. The last layer was cured against a polyester matrix (TDV Dental Ltda., Pomerode, SC, Brazil), with pressure being applied to the ends in order to produce extravasation and trim excess material. After preparation, the specimens were stored in distilled water at 37ºC for 24 h and then submitted to finishing and polishing and subsequent analysis of surface roughness.

In the control group (group 1), the specimens were not submitted to any finishing or polishing procedure after curing against a polyester matrix. In groups 2, 3 and 4 the specimens were finished with fine grit diamond burs (gold 3168F, KG Sorensen, Barueri, SP, Brazil), followed by extra-fine diamond burs (silver 3168FF, KG Sorensen), each applied for 15 s with a high-speed handpiece under water cooling. After this step, the specimens were polished using the systems presented in Table 2 according to the instructions of each manufacturer, for a total period of 60 s.

In group 2, the specimens were polished with aluminum oxide-impregnated disks (Sof-Lex®, 3M/ESPE) (dark blue, medium blue and light blue back, measuring 19.05 mm in diameter) at intermittent pressure and low speed for 20 s each. The specimens were washed with an air/water spray to remove debris, air dried and then polished with another disk of lower grit for the same period of time.

In group 3, the specimens were polished with disk-shaped aluminum oxide-impregnated silicon points (Enhance®, Dentsply) at low speed for 30 s, followed by treatment with the PoGo diamond polishing system for an additional 30 s.

In group 4, felt disks (Diamond®, FGV) in combination with diamond paste (Excel® diamond paste, FGV) were applied to the restoration surface at low speed for 60 s.

Average surface roughness (*Ra*, in µm) of the specimens was determined with a previously calibrated mechanical roughness tester (Surftest 301, Mitutoyo America Corporation, Suzano, SP, Brazil) over a distance of 0.25 mm. Six measurements were made in the center of each specimen in two directions (three in the vertical and 3 in the horizontal direction), for a total of 54 measurements per group.

The Shapiro-Wilk test was applied to determine whether the data showed a normal distribution or not. Surface roughness was compared between the control and treatment groups by two-way ANOVA with repetition of the factorial design, with the level of significance set at 1%. When the

TABLE 2- Polishing systems tested

Polishing system	Grit	Composition	Manufacturer	Batch #
Sof-Lex®	Medium (29 µm), Fine (14 µm), Extra-fine (5 µm)	Aluminum oxide	3M do Brasil Ltda., Sumaré, SP, Brazil	1958D
Enhance®	40 µm aluminum oxide	Tripolymer (styrene-butadiene-methyl methacrylate), silanated pyrolytic silica, urethane dimethacrylate, camphoroquinone, N-methyl diethanolamine, aluminum oxide	Dentsply Latin America, Petrópolis, RJ, Brazil	507109
PoGo®	_	Tripolymer (styrene-butadiene-methyl methacrylate), urethane dimethacrylate, camphoroquinone, N-methyl diethanolamine, microparticle diamond powder, aluminum oxide	Dentsply Latin America, Petrópolis, RJ, Brazil	350776
Felt disk®	_	Natural felt and silicone rubber	FGM Ind. Brasileira, Joinville, SC, Brazil	150605
Excel® diamond paste	2-4 µm	Micro-diamond, lubricant, thickener and emulsifier	FGM Ind. Brasileira, Joinville, SC, Brazil	110806

Information supplied by the manufacturer.

TABLE 3- Mean *Ra* values (μm) and standard deviations for the interaction between composite resins and polishing systems

Polishing system	Composite resin				
	Charisma	Fill Magic	TPH Spectrum	Z100	Z250
Control	0.3939 ± 0.23	0.2130 ± 0.15	0.1724 ± 0.06	0.5243 ± 0.31	0.1078 ± 0.06
Enhance+ PoGo	0.3363 ± 0.25	0.5813 ± 0.28	0.5724 ± 0.22	0.4519 ± 0.10	0.4443 ± 0.19
Felt disk+ diamond paste	0.5080 ± 0.34	0.4748 ± 0.29	0.9359 ± 0.07	0.2769 ± 0.18	0.1846 ± 0.06
Sof-Lex	1.1007 ± 0.44	1.1276 ± 0.63	1.3663 ± 0.32	0.9798 ± 0.48	0.6548 ± 0.39

TABLE 4- ANOVA results of the means obtained for the composite resins and polishing systems

Source of variation	d.f.	SQ	QM
Treatments	3	14.7000	4.9000
Blocks	4	3.1435	0.7859
Interaction	12	3.7557	0.3130
Error	160	13.9463	0.0872
F (treatments)=	56.2155	—-	—-
Degree of freedom=	3.160	—-	—-
p (treatments)=	< 0.0001	—-	—-
F (resins)=	9.0160	—-	—-
Degree of freedom=	4.160	—-	—-
p (resins)=	< 0.0001	—-	—-
F (interaction)=	3.5907	—-	—-
Degree of freedom=	12.160	—-	—-
p (interaction)=	0.0002	—-	—-

difference was statistically significant (p<0.05), the Tukey-Kramer test was used for comparison between means.

RESULTS

The data showed a normal distribution. The interaction between the two main factors (composite resin and polishing system) was highly significant (p<0.01). Table 3 shows the *Ra* values obtained for the different combinations of factors and Table 4 shows the results of factorial ANOVA.

Analysis of the *Ra* values obtained for the different polishing systems/composite resins showed that treatment of Z250 with the felt disk+diamond paste system presented the best performance (Ra = 0.1846 ± 0.06). The highest *Ra* (1.3663 ± 0.32) was obtained for the Sof-Lex system applied to TPH Spectrum, with the difference being statistically significant from the other combinations. All *Ra* values were higher than those observed for the control group (polyester matrix).

DISCUSSION

The effectiveness of surface finishing and polishing procedures is of fundamental importance for any restoration[11]. These procedures are commonly required after placement of direct composite resin restorations since they minimize the retention of plaque and stains and other problems resulting from the exposure of rough surfaces to the oral environment. Smoother composite surfaces are obtained when the material was cured against a polyester matrix[1,4,11,16,23,27]. Even if care is taken in the placement of the matrix, removal of excess material and recontouring of restorations are frequently necessary. However, these procedures significantly increase surface roughness. Thus, a large number of polishing techniques is available for composites[6].

The factors determining the micromorphology of the surface of composite resin restorations after finishing and polishing include composite characteristics such as size, hardness, type and amount of particles[1] and factors related to the abrasive system such as flexibility of the material in which the abrasive is impregnated, hardness of the abrasive, and geometry, speed and form of application of the instruments used[4,27].

In the studies of Ozgünaltay et al.[11] and Yap, et al.[28], the use of a polyester matrix resulted in the lowest *Ra*, which differed significantly from all other finishing and polishing procedures (p=0.001). In addition, all procedures used for finishing and polishing of the restorations reduced the smoothness obtained with the matrix. A similar result was obtained in the present study, with the lowest *Ra* values being obtained when the composite resins were cured against a polyester matrix and an increase in roughness being observed after surface treatment, except for Z100. In this case, a higher *Ra* was observed for the control group than when finishing and polishing were performed with the felt disk+diamond paste system. This fact might be explained by bubble formation on the resin surface when pressed against the polyester matrix during curing.

The Sof-Lex disk system yielded rougher surfaces and differed significantly from the other systems, irrespective of the composite resin used. This result disagrees with most studies comparing the Sof-Lex system with silicon points (Enhance). However, in the present study the PoGo micro-diamond system was applied after the Enhance system which resulted in better surface smoothness. Some investigators[16,19,23] reported significant differences in *Ra* between specimens polished with the Sof-Lex disk system and those polished with silicon points using the same resin, with smoother surfaces being obtained with the former and rougher surfaces with the latter.

The capacity of disks impregnated with aluminum oxide particles to produce smooth surfaces is related to their ability of equally removing particles and organic matrix. The plane movement of the disk contributes to a smoother surface[15]. However, this system has limitations because of geometry. The disks are difficult to produce, as is the finishing and polishing of the anatomic contours of the surfaces, especially in the posterior regions of the mouth[3,11]. In contrast, the Enhance polishing system consists of a rubber-like flexible material, a polymerized resin impregnated with an abrasive. This system may wear the resin matrix and only contour prominent surfaces, resulting in a higher surface roughness[27]. Therefore, in the present study the Enhance system was combined with PoGo points in order to refine the previous polishing. Türkün and Türkün[24] observed no significant difference between surfaces polished with the PoGo system and the control group (p=0.01), and concluded that among the polishing systems tested the PoGo system produced the smoothest finishing for all composite resins.

In the present study, the combination of diamond paste and felt disks was highly efficient, resembling a final polishing in view of the low grit diamond particles (2-4 µm) used in composite restorations[5]. The felt disk+diamond paste group produced low *Ra* values for the composites tested, similar to the control and Enhance+PoGo groups, except for the TPH resin/felt disk+diamond paste group. This combination presented the highest RA when compared to the other groups, demonstrating that each resin behaves according to the polishing system used. This finding agrees in part with the study of Turssi *et al.*[25], who observed a smoother surface when the specimens were polished with Sof-Lex followed by Prisma Gloss aluminum oxide paste, while the worst result was obtained when only Enhance points were used. Similar to the present study, other investigators[4,6] also showed that the effect of diamond-impregnated felt disks on the surface roughness of hybrid composites is superior to that of flexible disks.

The polishing methods tested had different effects on the surface of the composites. The lowest *Ra* was observed after polishing with the felt disk+diamond paste for composite Z250 (Ra = 0.1846 ± 0.06). The present results showed a significant change in the surface of the composites according to the polishing system used. This finding agrees with those reported in previous studies[7,8].

A similar study reported that polishing Z250 composite resin with micro-polisher disks (PoGo) (0.51 ±0 .15) resulted in significantly lower surface roughness than the use of aluminum oxide (Sof-Lex) (1.12 ± 0.27) and rubber polishing disks (Identoflex) (1.53 ± 1.70). In addition, no significant difference in surface roughness was found between unfinished materials (polyester matrix surface)[22]. This study agrees with our findings.

The structure of the composites (particle size, consistency and quantity of load, type of matrix and degree of reticulation) can also influence the results[8]. In the present study, significant differences were observed between some of the composite resins (Table 1). TPH presents the highest mean particle size according to manufacturer data. In contrast, Z250 contains a smaller range of filler particles than the other composites tested and presents one of the smallest mean particle sizes, which may partially explain the lower roughness obtained with this composite resin.

Reis, et al.[13] (2003) reported that the smoothest surfaces were recorded for Z250 microhybrid resin when compared to Solitaire, SureFil and ALERT (condensable) composites, and better polishing was obtained when diamond paste was applied. The good results observed for this composite might be explained by particle size (0.01 to 3.5 µm) and arrangement. In addition, these authors concluded that Z250 is more easily polished than condensable composites and presents low staining susceptibility, in agreement with the present study in which the smoothest surface was observed for Z250, especially when polished with the felt disk+diamond paste system. With respect to particle size, the present findings agree with the manufacturer information that the mean size of the Z250 particles is one of the smallest among the resins studied. On the other hand, although the highest Ra was obtained for TPH, Z100 presented the largest particle size (4.5 µm).

The critical surface roughness threshold established for bacterial adhesion is 0.2 µm. Whereas no reduction in bacterial accumulation is expected below this threshold, any increase in surface roughness above 0.2 µm results in a simultaneous increase of plaque accumulation and of the risk of caries and periodontal inflammation, because can promise the esthetics and longevity of the restoration[1]. Since all treated surfaces presented a *Ra* higher than 0.2 µm, the effect of the finishing/polishing systems on the finished surface of microhybrid composite resins is clinically relevant. Thus, the role of polishing is to produce a smooth glossy aspect on the restoration surface similar to that of enamel. This procedure is routinely used in daily dental practice and the absence of these characteristics may compromise the esthetics and longevity of restorations.

CONCLUSIONS

Surface roughness of microhybrid composites is influenced by the type of finishing system used. The lowest surface roughness was observed for microhybrid composites submitted to finishing and polishing procedures with disk-shaped aluminum oxide-impregnated silicon points and felt disks using diamond paste or felt disks plus diamond paste.

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