

Effect of Different Finishing/Polishing Systems on the Surface Roughness of Two Heat-Treated Composite Resins

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The aim of this study was to compare the surface roughness achieved by different finishing/polishing systems on two composite resins for direct use after thermic treatment. The specimens ($n = 40$ per group (G); G1 = Filtek™ P60; G2 = Fill Magic®) were set up on a matrix of stainless steel with circular internal niches ($\varnothing = 10.0$ mm; $h = 2.0$ mm). Next, they were subjected to thermal treatment in a heated chamber at 170 °C for 10 minutes. They were then divided randomly into four subgroups (Sg) to receive the surface treatment according to the finishing/polishing systems tested ($n = 10$): Sg A: Control; Sg B: Diamond® felt disc + Diamond Excel® diamond paste; Sg C: Sof-Lex® discs; and Sg D: Enhance™ silicon tips. The mean roughness (Ra) was determined using a digital surface roughness tester. Data was analyzed by two-way ANOVA and Tukey's post-hoc test ($\alpha = 0.05$). Differences between the surface treatments were found on both resins ($p < 0.05$). In G1, the lowest mean Ra values were observed using Sg C (0.07 μm) and the highest for Sg D (0.12 μm) ($p < 0.05$). There was no difference between Sg B (0.08 μm) and Sg C (0.07 μm) ($p = 0.076$). In G2, there was a progressive increase in mean Ra values from Sg D (0.05 μm) to Sg C (0.06 μm) and to Sg B (0.07 μm) ($p < 0.05$). It was concluded that the finishing/polishing systems modified Ra on both resins.

Keywords: composite resins, dental polishing, heat treatment

1. Introduction

Since the increasing value placed on esthetic facial harmony, cosmetic dentistry has evolved to make it possible to perform direct restorations that are esthetically more desirable and cavity preparations that preserve tooth structures. Improvements on the physical, mechanical and chemical properties of composite resins have enabled their use not only in anterior teeth but also in posterior teeth¹.

However, certain clinical problems associated with the use of direct composite resins have been seen. Among them there is the surface roughness of the restoration^{2,3}. The difficulty in achieving a smooth and shiny surface through finishing and polishing the restoration is of concern. This occurs mainly due to (1) the size, consistency and quantity of the composite applied, and (2) the hardness and grain size of the abrasive used^{3,4}. A rough surface allows dental plaque to stick to it and secondary caries and periodontal disease⁵, and restoration marginal discoloration⁶⁻⁸.

Another critical factor in performing a restoration using the direct technique with composite resins is polymerization shrinkage⁹. This phenomenon induces the formation of marginal gaps, resulting in microleakage. Clinically, postoperative sensitivity may occur¹⁰. It is likely to be worse in large cavities in posterior teeth, which would limit the use of the direct technique. For such cases, the indirect technique seems to provide certain clinical benefits, such as rebuilding the anatomical shape of the tooth, improving the adaptation of the edges of the filling (especially in relation to the gingival wall) and restoring the proximal contacts that had been destroyed by caries¹¹.

In essence, the composites for direct and indirect use have similar compositions, because it is believed that by means of simple technical modifications such as additional heat treatment¹², direct composites may attain levels of mechanical resistance that are similar to those of systems for indirect use, even without the use of special equipment¹³. Secondary polymerization through thermal treatment is a method used to increase the degree of conversion of composites. Scientific evidence indicates that the use of this method improves physical properties of these materials^{9,14-16}.

Considering that there is little information about the effects of heat treatment on composite resins for direct use, the aim of this study was to compare the influence of different finishing/polishing systems on the surface of two commercial heat treated composite resins. The hypothesis to be tested was that there is no difference in surface roughness between the materials when subjected to the different types of surface treatments tested.

2. Material and Methods

2.1. Specimen preparation

Two commercial direct composites microhybrid resin Fill Magic® (Vigodent, Bom Sucesso, Rio de Janeiro, Brazil) and hybrid resin Filtek™ P60 (3M ESPE, St Paul, MN, USA) were used as seen in Table 1.

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Table 1. Composites descriptions used in the study.

Material	Manufacturer	Composition	Batch
Filtek™ P60	3 M ESPE, St Paul, MN, USA	Aluminum oxide, zirconium dioxide and silica 61% by volume, with grain sizes 0.19 to 3.3 µm. Organic matrix composed of BIS-GMA, UDMA and BIS-EMA.	7RR
Fill Magic®	Vigodent S.A. Ind. Com., Bom Sucesso, Rio de Janeiro, Brazil	Metacrylic monomers, pyrogenic silica, barium silicate and aluminum silicate 80% in barium glass, with grain size 0.5 µm. Organic matrix composed of Bis-GMA, TEGDMA, Bis-EMA and UDMA.	187/07

Table 2. Description of the finishing/polishing systems used in the study.

Material	Manufacturer	Grain size	Composition	Batch
Diamond Excel®	FGM Ind. Brasileira, Joinville, SC, Brazil	2-4 µm	Micronized diamond, lubricating substrate, thickener and emulsifier	300707
Diamondflex®	FGM Ind. Brasileira, Joinville, SC, Brazil	–	Natural felt and silicone rubber	823137
Enhance™	Dentsply Indústria e Comércio Ltda.	40 µm aluminum oxide	Tripolymer, silanized pyrolytic silica, urethane dimethacrylate, camphorquinone, N-methyl diethanolamine and aluminum oxide	123/04
Sof-Lex®	3M do Brasil Ltda, Sumaré, SP, Brazil	Medium – 29 µm Fine – 14 µm Ultrafine – 5 µm	Aluminum oxide	19085

The specimens were prepared (n = 40 per group) using a stainless steel matrix (10 mm width × 2 mm height). The resins were inserted into the matrix in two increments. Each increment was light cured using LED laser (Dabi Atlante Ultraled, Ribeirão Preto, São Paulo, Brazil) at 600 mW.cm⁻² for 40 seconds (24 J.cm⁻²). A strip of polyester of thickness 0.005 mm (Labordental Ltda., São Paulo, SP, Brazil) was positioned over the last resin layer and a glass slide was pressed onto this to remove any excess material. Then, the surface of the specimen was light cured again as previously described.

All the specimens were dry heated (Ética Equipamentos Científicos SA, São Paulo, Brazil), at a temperature of 170 °C for 10 minutes, with monitoring using a thermometer (Salvterm 1200K; Salcas Ind. Com. Ltda, São Paulo, Brazil), in accordance with a previous studies⁹⁻¹⁴ that determined the heat treatment temperature, by thermogravimetric analysis and differential scanning calorimetry, considering the initial weight loss temperature and glass transition temperature.

Next, the specimens were removed and kept at room temperature until the material had fully cooled down. It was then stored in distilled water at 37 °C for 24 hours.

Thereafter, the specimens in each group were randomly assigned to four subgroups (Sg) according to the finishing/polishing systems (Table 2 and Figure 1).

All the systems were used according to manufacturer's instructions and with a low speed handpiece (5000 to 20000 rpm). The Sof-Lex® discs (3M, Sumaré, SP, Brazil) were used in decreasing order of grain size (29, 14 and 5 µm) for 20 seconds; the Enhance™ silicon tips (Dentsply, Petrópolis, RJ, Brazil) for 30 seconds; and the Diamondflex® felt discs (FGM, Joinville, SC, Brazil) with Diamond Excel® diamond paste (FGM, Joinville, SC, Brazil) for 60 seconds. The finishing/polishing was performed by single operator with low pressure and intermittent movements. The control group consisted of only the use of polyester strip, without finishing / polishing.

2.2. Surface roughness test

Surface roughness was measured using a digital surface roughness tester (Surftest 301; Mitutoyo America Corporation, Suzano, SP, Brazil), which was calibrated through a distance of 0.25 mm on the micrometer scale (µm) according to ISO 4287 (International Standards Organization). Six readings were made on each specimen, in two different directions (three vertical and three horizontal). Mean values for surface roughness (Ra) were obtained in micrometers.

2.3. Statistical analysis

The data obtained were normally distributed (Kolmogorov-Smirnov test) and homoscedastic (Levene test). These data were analyzed by two-way ANOVA and Tukey's post-hoc test at 5% significance level.

3. Results

Two-way ANOVA showed that the means (Ra) obtained from the different surface treatments were statistically different in relation to both resins evaluated (p < 0.05). The means and standard deviations for each subgroup (Sg) of the two experimental groups (G) can be seen in Figure 2. For G1 (Filtek™ P60), in Sg D (Enhance™ tips) the highest mean values (0,12 µm) were observed (p < 0.05). There was no difference between Sg B (0,08 µm, felt disc + diamond paste) and Sg C (0,07 µm) (Sof-Lex® disc). The p value was 0.076. For G2 (Fill Magic®), there were differences among all the Sg (p < 0.05), so that Sg D had the lowest mean value (0,05 µm), followed by Sg C (0,06 µm) and Sg B (0,07 µm), respectively.

4. Discussion

Based on the results from this *in vitro* study, the hypothesis was partially rejected. The finishing/polishing systems tested showed

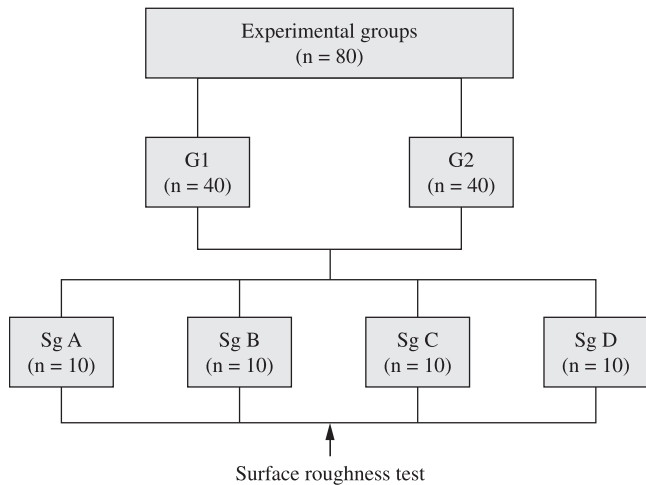


Figure 1. Experimental design. G1 (Group 1 = Filtek™ P60); G2 (Group 2 = Fill Magic®). Subgroups (Sg): Sg A (Control); Sg B (Diamond® felt disc + Diamond Excel® diamond paste); Sg C (Sof-Lex® discs); Sg D (Enhance™ silicon tips).

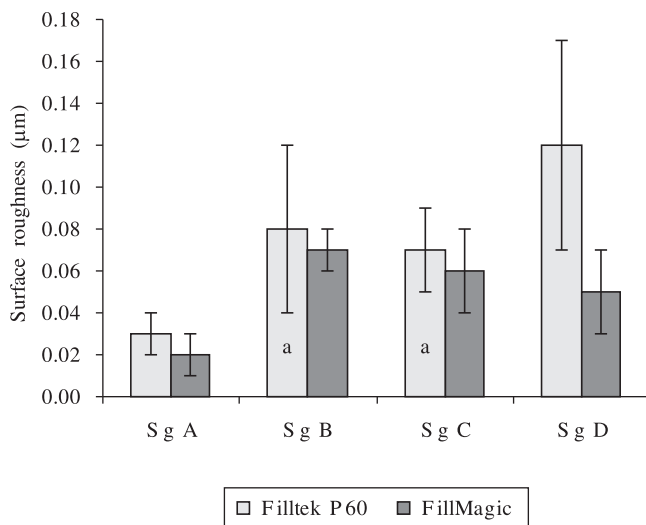


Figure 2. Means and standard deviations for surface roughness obtained using the four finishing/polishing systems on the two resins tested. The same letter inside the bars indicates statistically similar results ($p > 0.05$).

changes in the smoothness of the surface when compared to the two composites (Filtek™ P60 and Fill Magic®). The control groups (polyester matrix) for both resins (G1 Sg A and G2 Sg A) (Figure 2) achieved the lowest mean values for Ra and differed significantly from all the other finishing/polishing systems tested ($p < 0.05$). These findings were consistent with other studies that also showed lowest mean values for Ra when used polyester matrix^{6,17-21}.

In G1 (Filtek™ P60) (Figure 2), Sg D (Enhance™ tips, 0.12 µm) presented the highest mean values for Ra compared with Sg C (Sof-Lex® discs, 0.07 µm) and Sg B (felt disc + diamond paste, 0.08 µm), respectively ($p < 0.05$). Curiously, in G2 (Fill Magic®) (Figure 2), Sg D demonstrated the lowest mean values for Ra (0.05 µm), compared to Sg C and Sg B (0.06 and 0.07 µm), respectively ($p < 0.05$). Lu et al.¹⁸ (2003) suggested that the interaction between the Filtek™ P60 resin and the finishing/polishing system might have been harmed by two factors: 1) the flexibility of the

Enhance™ tips; and 2) the composition of the inorganic matrix of the resin, formed by larger particles (0.19 to 3.3 µm) that were harder and more irregular.

On the other hand, Reis et al.³ (2003) and Scheibe et al.²² (2009) evaluated the effectiveness of finishing/polishing systems on the surface of some composite resins, and concluded that the best polishing was achieved using the felt disc + diamond paste. Nevertheless, in this study, the results did not agree with theirs, since the felt disc + diamond paste system showed higher mean values for Ra to the Filtek™ P60 resin (0.08 µm, G1 Sg B) (Figure 2) than to the Fill Magic® resin (0.07 µm, G2 Sg B) (Figure 2). This fact might be explained by different composites resins and finishing/polishing systems used.

Smaller mean values for Ra were obtained using Sof-Lex® discs on the Filtek™ P60 resin (0.07 µm, G1 Sg C) (Figure 2) than on the Fill Magic® resin (0.06 µm, G2 Sg C) (Figure 2). This result can be also explained because aluminum oxide discs do not displace the composite fillers and the malleability of the discs promotes a homogeneous abrasion of the fillers and resin matrix²³.

Ferracane et al.²⁴ (1995) suggested that Sof-Lex® discs should be used in the proximal surface because of their thinness, and that the felt disc + diamond paste system would be a good choice for the occlusal surfaces of direct composite resin. In this research, the mean values for Ra from Sg B (0.08 µm) and Sg C (0.07 µm) on G1 (Filtek™ P60) did not presented any significant differences ($p = 0.076$).

Additional thermal treatment on direct composite resins is already greatly used due to the observed improvement on physical properties in these resins^{9,14-16}. This has made it possible to use them as indirect restorations. The possibility of polishing outside of the oral cavity that indirect restorations improves the proximal contact, reduces the strain on the tooth and decrease to polymerization contraction stress, thereby enabling greater control of marginal microleakage and recurrent caries¹⁶.

Therefore, considering the possibility of offering rehabilitation for posterior teeth to low-income communities at lower cost, which would enable greater social coverage of oral rehabilitation and oral health promotion, it is believed that these laboratory results could be extrapolated for clinical application. However, further studies are needed to evaluate other parameters, such as anatomical shape, marginal integrity and discoloration, which might influence the longevity of these dental restorations.

5. Conclusion

This study demonstrated that the finishing/polishing technique with silicon tips produced smoothness surfaces on the microhybrid composite. For hybrid composite, formed by hard and irregular particles, the highest polishing was obtained using aluminum oxide discs.

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