The effect of six polishing systems on the surface roughness of two packable resin-based composites

ANDRÉ FIGUEIREDO REIS, DDS, MARCELO GIANNINI, DDS, MS, PhD, JOSÉ ROBERTO LOVADINGO, DDS, MS, PhD, CARLOS TADEU DOS SANTOS DIAS, PhD

ABSTRACT: Purpose: To evaluate the surface roughness of two packable composites after finishing and polishing with six different systems. Materials and Methods: Solitaire and Alert composite samples were prepared and polished with Poli I and Poli II aluminum oxide pastes, Ultralap diamond paste, Enhance finishing points, Politip rubber polishers, fine and extra fine diamond burs, and 30-blade tungsten carbide burs according to the manufacturers’ instructions. The polished surfaces were then evaluated with a profilometer and a scanning electron microscope. Results: Solitaire composite resin presented the smoothest surfaces when polished with Poli I and II aluminum oxide pastes, Ultralap diamond paste, Politip finishing points and 30-blade tungsten carbide burs. The smoothest surfaces for Alert composite were evident with the 30-blade tungsten carbide burs. (Am J Dent 2002;15:193-197).

CLINICAL SIGNIFICANCE: Alert displayed a significantly greater surface roughness than Solitaire for most of the agents used. The smoothest surfaces for Solitaire were attained with polishing pastes, 30-blade carbide burs and Politip. Carbide burs provided the best finish for Alert.

CORRESPONDENCE: Dr. André Figueiredo Reis, Department of Restorative Dentistry, Piracicaba School of Dentistry, Campinas State University, Av. Limeira, 901, Piracicaba/SP, Brazil, CEP 13414-018, Fax: 55 19 4305218, E-mail: reisandre@yahoo.com

Introduction

Since resin-based composites were introduced to dentistry,1 no other restorative material has been modified and improved at a similar rate. Despite all initial inherent problems of the composites, many dentists attempted to use these materials to restore posterior teeth, and perhaps the greatest effort to improve composites has been the generation of materials for occlusal surfaces.2,4

Problems with the early composite formulations, such as percentage of filler and particle size leading high wear rates, loss of anatomic form and poor polishability convinced researchers that early composite formulations were unacceptable for restoring posterior teeth.5,7 The increase of the filler loading percentage, the modification and reduction on the particles size, that initially had 12 µm, and their better distribution in the resin matrix, contributed to reduce the wear rates8–10 and to improve the surface smoothness of these restorative materials.8,11,12

Numerous studies have been developed and notable progress has been achieved in the attempt to improve the physical and handling characteristics of posterior composites. New formulations possess packable characteristics similar to amalgam manipulative properties, due to new filler types, which consist of microfilament glass fibers or more coarse and textured fillers than conventional ones.3,13 The use of these composites, in conjunction with bonding agents and following correct clinical techniques, has allowed dentists to place reliable posterior resin-bonded restorations.3,13–15 However, there is no consensus on which finishing and polishing materials provide the smoothest surfaces for packable composites.

Proper finishing and polishing of posterior composite restorations are important steps that enhance both esthetics and longevity of restored teeth.16,17 Surface roughness, associated with improper finishing and polishing can result in excessive surface staining, increased wear rates and plaque accumulation, which compromise the clinical performance of the restoration.18–22

Most investigators agree that the aluminum oxide discs are the finishing and polishing agents that produce the lowest surface roughness average (Ra) on resin-based composites,23–28 however, their use is restricted to anterior teeth. Regarding this limitation, a wide variety of finishing and polishing devices are available to the clinician: multifluted tungsten carbide burs, diamond burs, white stones, rubber points, aluminum oxide pastes, and diamond pastes.16,17

This study compared the effect of six different finishing and polishing agents on the surface roughness of two packable resin-based composites and to observe their polished surfaces with a scanning electron microscope.

Materials and Methods

The packable resin-based composites used in this study were Solitaire and Alert,2 and the polishing systems were aluminum oxide pastes (Poli I and Poli II), diamond paste (Ultralap), rubber polishers (Enhance and Politip), diamond finishing burs (fine and extra fine), and 30-blade tungsten carbide burs. The composition and characteristics of the resins and finishing and polishing systems are listed in Tables 1 and 2, respectively.

Thirty cylindrical specimens (3 mm thick and 5 mm in diameter) of each composite were prepared in a polytetrafluoroethylene split mold. The cavity was filled, using an amalgam plunger, and cured for 40 seconds with a visible light-curing unit. The specimens were stored in distilled water at 37°C for 24 hours and then randomly assigned to one of the six test groups (n=5), finished and polished by a single investigator.

The pastes (Ultralap and Poli I/Poli II) and rubber polishers (Enhance and Politip) were applied using a low-speed
Table 1. Packable composites composition.

<table>
<thead>
<tr>
<th>Composite</th>
<th>Particle Size (μm)</th>
<th>Filler type</th>
<th>Filler content (%)</th>
<th>Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solitaire</td>
<td>0.7 to 2.0</td>
<td>Silicon dioxide, fluoride-barium-aluminum-borosilicate glass, fluoride aluminumumisilicate glass</td>
<td>65 (weight) and 66 (volume)</td>
<td>Bis-GMA and multifunctional methacrylic acid ester</td>
</tr>
<tr>
<td>Alert</td>
<td>6 in diameter and 60-80 in length (glass fiber), 0.8 (irregular-shaped filler)</td>
<td>Microfilamentous glass fiber, silicon dioxide, barium-borosilicate glass, microfine silica</td>
<td>84 (weight) and 70 (volume)</td>
<td>Bis-GMA, PCDMA, dimethacrylate groups</td>
</tr>
</tbody>
</table>

Table 2. Finishing and polishing agents composition.

<table>
<thead>
<tr>
<th>Product</th>
<th>Type</th>
<th>Abrasive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poli I and Poli II</td>
<td>Paste</td>
<td>Aluminum oxide</td>
</tr>
<tr>
<td>Ultralap</td>
<td>Paste</td>
<td>Ultrafine diamonds</td>
</tr>
<tr>
<td>Enhance</td>
<td>Rubber point</td>
<td>Aluminum oxide, silanized pyrolytic silica</td>
</tr>
<tr>
<td>Politip</td>
<td>Rubber point</td>
<td>Silicon dioxide</td>
</tr>
<tr>
<td>Diamond bur</td>
<td>Diamond bur</td>
<td>Ultrafine diamonds</td>
</tr>
<tr>
<td>F and FF</td>
<td>Carbine bur</td>
<td>Tungsten carbid</td>
</tr>
</tbody>
</table>

Handpiece for 30 seconds, and felt wheels were used for the application of the pastes. High-speed 30-blade tungsten carbide burs and diamond finishing burs were applied for 15 seconds with water coolant.

After all specimens were polished, they were thoroughly rinsed with water and allowed to dry for 24 hours before measurement of the average surface roughness (Ra). To measure the surface roughness of the specimen a profilometer was used. Three measurements in different directions were recorded for the five specimens in each group, and an overall Ra was determined for the total sample. The results were analyzed statistically by 2 x 6 factorial ANOVA and Duncan’s multiple range test at the 0.05 level of significance (Tables 3, 4).

After the profilometric examination, two samples of each group were prepared for the scanning electron microscope (DSM-940A). Samples were sputter coated with gold to a thickness of approximately 50Å in a vacuum evaporator (MED 010). The samples were observed and photographed of the most representative regions were taken.

Results

The average Ra measurements for combinations of composites and polishing instruments are presented in Fig. 1 and Table 4, respectively. The smoothest surfaces for Solitaire resin were recorded with Poli I and Poli II aluminum oxide pastes, Ultralap diamond paste, Politip finishing point, and 30-blade tungsten carbide bur. No statistically significant differences were observed among them (P>0.05). Regarding Alert composite, the smoothest surfaces were evident with 30-blade tungsten carbide burs (P<0.05). The lowest roughness was obtained for Solitaire composite. However, when Alert composite was polished with the 30-blade carbide bur, it showed better results than Solitaire samples polished with diamond finishing burs and Enhance finishing points (P<0.05).

The Enhance finishing points and the diamond finishing handpiece for 30 seconds, and felt wheels were used for the application of the pastes. High-speed 30-blade tungsten carbide burs and diamond finishing burs were applied for 15 seconds with water coolant.

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Discussion

Resin-based composites resins cannot be finished to an absolutely smooth surface.29-33 As it is an essential requisite for a successful restoration, the finishing and polishing procedures directly influence the longevity of the restoration and its environment.29,30,34,35

Composite surface roughness is usually dictated by the size, hardness and amount of filler, which influence the mechanical properties of the resin-based composites, and by the flexibility of the backing material, the hardness of the abrasive, and the grit size.36,37 Microfill and microhybrid composites can be finished to a very smooth surface,25,28 with a surface roughness average (Ra) varying from 0.12 to 0.25 μm, due to their small filler particle size and arrangement. The average size of a microfill composite filler particle is 0.04 μm, and a microhybrid contains particles that range between 0.01 and 2.0 μm. Therefore, they can be finished to a smoother surface than the packable composites evaluated in this study.

Means followed by different letters differ among them by Duncan’s multiple range test (P<0.05).

burs recorded the greatest roughness for the Solitaire composite, and the Ultralap diamond paste recorded the greatest roughness for the Alert composite. Among the finishing and polishing agents studied, the smoothest surfaces on both composites were obtained when the 30-blade tungsten carbide burs were applied.

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The differences in surface topography between Solitaire and Alert may be attributed to differences in their interparticle spacing and their filler particle size. Solitaire composite resin, in which particle size varies from 0.7 to 2.0 μm, presented the lowest surface roughness averages, whereas Alert composite, which is composed of bigger particles, varying from 0.8 to 80 μm, recorded the greatest roughness.

For a composite finishing system to be effective, the cutting particles (abrasive) must be relatively harder than the filler materials. Otherwise, the polishing agent will only remove the soft resin matrix and leave the filler particles protruding from the surface. The hardness of aluminum oxide is significantly higher than that of silicon dioxide, and generally, higher than most filler materials used in composite formulations.

The aluminum oxide and diamond pastes produced smooth surfaces on the Solitaire composite. However, the surface roughness of Alert composite was considerably greater when these pastes were used. Thus, polishing pastes were unsatisfactory for polishing the Alert composite, as they caused preferential removal of resin matrix, resulting in exposure of the microfilamentous glass fibers, which have about 6 μm in diameter and 60 to 80 μm in length (Figs. 2, 3).

As expected, the diamond finishing points and the Enhance finishing system produced rough surfaces on both composites. When diamond points were applied, scratches were observed on the surface of the composites. The surfaces polished with the Enhance finishing points presented some pitting, which may have been due to plucking of the filler particles during polishing. The pits were proportional to filler sizes (Fig. 5).

Thirty-fluted tungsten carbide burs are considered to be intermediate finishing devices. Nevertheless, they were the finishing and polishing devices that recorded the best results for Alert (Fig. 6) and were among the best polishers for Solitaire, showing no need of final polishing with any other device. As they are used in high speed, the clinician must be attentive to the pressure applied and to use water cooling not to damage the anatomic form of the restoration nor the adjacent sound enamel.
Silicon dioxide, one of the filler types of the packable composites studied in this paper, is also present on the Politip's composition. According to Tjan & Chan,²⁵ these rubber polishers were found to be effective on microfilled composites and possibly on small-particle hybrid composites, which can explain the good results obtained when they were applied on the Solitaire composite surfaces. When the Alert composite was polished with the Politip rubber polishers, the results were not as good as for the Solitaire composite, probably due to the large filler particle size. However, these rubber polishers recorded the second best surface roughness average for the Alert composite.

The results suggested that each composite requires specific finishing and polishing devices, depending on the size, hardness and amount of filler of the composite used. Carbide burs provided the best finish for the larger particle packable Alert, and, for Solitaire, all were comparable except diamond burs and Enhance, which produced the roughest surface. For most of the polishing techniques a significantly smoother finish was obtained for Solitaire.

Further studies should evaluate the results of different composite polishing systems on different resin-based composites.

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References


Fig. 5. Alert composite and an Enhance-produced surface. The bar denotes 20 μm. (SEM x500.)

Fig. 6. Alert composite and a thirty-fluted tungsten carbide bur-produced surface. The bar denotes 20 μm. (SEM x500.)

Dr. Reis is a Research Assistant. Dr. Giannini is Assistant Professor & Dr. Lovadino is Assistant Professor, Department of Restorative Dentistry, Piracicaba School of Dentistry, Campinas State University, SP, Brazil. Dr. Dias is Assistant Professor, Department of Mathematics and Statistics, ESALQ, University of São Paulo, SP, Brazil.