

# The Effect of Finishing and Polishing Procedures on the Surface Roughness of Composite Resin Materials

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## Abstract

**Aims:** The aims of this study were to evaluate the effect of various finishing and polishing procedures on the surface roughness of six different composite resin materials (Artemis Enamel, TPH Spectrum, Filtek A-110, Filtek Supreme Enamel, Solitaire 2, and Filtek P-60) as well as to evaluate the effectiveness of the surface sealant application (BisCover) on the surface roughness after finishing and polishing procedures of tested composites.

**Methods and Materials:** Specimens ( $n=168$ ) measuring 5 mm in diameter x 2 mm in thickness were fabricated in a plexiglass well covered with a Mylar strip using six composite resins. A control group of seven specimens of each material received no polishing after being cured under the Mylar strip. Twenty-one specimens for each composite were randomly divided among three finishing and polishing groups ( $n=7$ ). Each group was polished using a different system: Carbide bur/Sof-Lex disc, Carbide bur/Enhance disc with polishing paste, and Carbide bur/Edenta composite finishing kit. The average surface roughness ( $R_a$ ,  $\mu\text{m}$ ) of the control and treated specimens were measured with the Mitutoyo Surftest-402 Surface Roughness tester. After a surface sealant (BisCover) was applied to all treated specimens, according to manufacturer's instructions, the average roughness ( $R_a$ ) was measured again. Results were statistically analyzed using analysis of variance (ANOVA) and the post-hoc Scheffe's test at a  $p<0.05$  significance level.

**Results:** Significant differences were found for the surface roughness ( $p<0.05$ ) with interaction among composite resins and the finishing systems used ( $p<0.05$ ). Enhance/Biscover finishing and polishing procedure surface was not significantly different from the Mylar strip surface groups ( $p>0.05$ ). The Mylar strip group was not significantly different from the Sof-Lex/BisCover and Edenta/BisCover groups.

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The ranking of mean Ra values by materials was as follows: Filtek Supreme Enamel < Filtek A110 < TPH Spectrum < Artemis < Filtek P-60 < Solitaire 2. The ranking of mean Ra values by polishing systems was as follows: Enhance/BisCover < Mylar Strip < Sof-Lex/BisCover < Edenta/BisCover < Sof-Lex < Enhance < Edenta.

**Conclusion:** Smoother surfaces were recorded for the Enhance/BisCover and the Mylar strip-formed surface groups. The composite finishing kit Edenta significantly increased the Ra for all tested composites ( $p < 0.05$ ). But after finishing with Edenta, the use of a surface sealant (BisCover) significantly improved the surface smoothness of all tested composites ( $p < 0.05$ ). Use of BisCover surface sealant on anterior and posterior resin composite restorations after finishing and polishing procedures is recommended.

**Keywords:** Finishing, polishing, surface roughness, composite resin materials

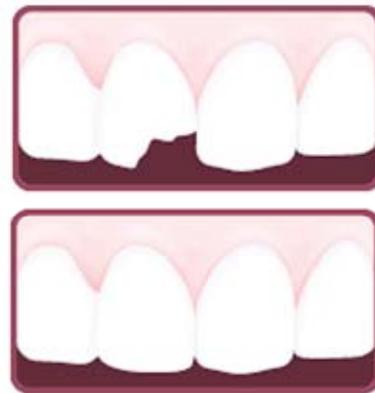
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## Introduction

Composite resins have been widely used as esthetic materials because they are mercury-free, thermally non-conductive, and resist corrosion. These resin materials have progressed from macrofills to microfills and from hybrids to microhybrids, and new materials such as packable and nanofilled composites have been introduced to the dental market.<sup>1-3</sup> Each type of composite resin has certain advantages and limitations. The universal hybrid composites provide the best general blend of good material properties and clinical performance for routine anterior and posterior restorations.<sup>4</sup>

Packable composites have a high filler load, improved filler technology, and modifications in the organic matrices compared to traditional hybrid composites. These characteristics facilitate the establishment of excellent interproximal contacts and original occlusal anatomy in posterior restorations by condensing the material into the cavity preparations.<sup>5-7</sup>

A new brand of composite resins called "nanofilled composites" has been introduced to the dental market, which has been produced with nanofiller technology and formulated with nanomer and nanocluster filler particles.<sup>8</sup> Nanomers are discrete nanoagglomerated particles of 20-75 nm in size, and nanoclusters are loosely bound agglomerates of nano-sized particles. The manufacturer suggests the combination of nanomer-sized particles and nanocluster formulations reduces the interstitial



spacing of the filler particles and, therefore, provides increased filler loading, better physical properties, and improved polish retention.<sup>8</sup>

Proper finishing and polishing of restorations are desirable not only for esthetic considerations but also for oral health.<sup>9</sup> The marginal finish of a restoration, surface roughness, and surface integrity as well as the physicochemical properties of the material itself can affect plaque retention. This, in turn, plays a significant role in periodontal disease and recurrent decay.<sup>9-12</sup> Therefore, maintaining the smooth surface of a restoration is of utmost importance for its success.<sup>13</sup> Composites are finished and polished in order to establish a functional occlusal relationship and a contour physiologically in harmony with supporting tissues. In addition, proper contour and high gloss give the restoration the appearance of natural tooth structure.<sup>9</sup> Thus, it is important to determine which finishing systems offers the

best results for esthetic restorations. However, it is difficult to obtain a smooth surface on tooth colored materials because they are not all the same.<sup>14</sup> They differ mainly in their inorganic component. The type of inorganic filler, the size of the particles, and the extent of the filler loading vary widely among these materials. These factors influence their polishability.<sup>9,12,14</sup> The difference in hardness between the filler particle and the matrix contributes to a roughened surface in these materials. The advent of visible-light-polymerizing resin and the usage of finer filler particles permits tooth-colored restoratives to be polished to a higher degree.<sup>14</sup>

Various techniques for finishing and polishing esthetic materials have been investigated. These methods include the use of such devices as: tungsten carbide finishing burs, fine to extra-fine diamond finishing burs, stones, impregnated abrasive rubber or silicone discs and wheels, silicone-carbide-coated or aluminum oxide-coated abrasive discs, polishing pastes, and abrasives embedded in resin polishing points.<sup>10,14,15</sup> These finishing and polishing devices are popular among clinicians and have been used for the finishing of composite resins for many years. More recently a liquid polish system (BisCover, Bisco, Inc., Schaumburg, IL, USA) has been introduced with the aim of reducing the need for manual polishing. BisCover is a light-cured resin formulation used to seal restorations while leaving a smooth polished surface without leaving a sticky, air-inhibited layer.

The purpose of this study was to evaluate the effect of various finished and polishing procedures on the surface roughness of six different esthetic restorative materials which included:

- Artemis ( Ivoclar Vivadent AG, Schaan, Liechtenstein)
- TPH Spectrum ( Dentsply Caulk, Milford, DE, USA)
- Filtek A-110 (3M ESPE Dental Products, St. Paul, MN, USA)
- Filtek Supreme Enamel (3M ESPE Dental Products, St. Paul, MN, USA)
- Solitaire 2 (Heraeus Kulzer, Dormagen, Germany)
- Filtek P-60 (3M ESPE Dental Products, St. Paul, MN, USA)

The finishing procedures used are as follows:

1. Diatech Carbide bur (Diatech, Diatech Dental AC, Heerbrugg Switzerland)/Sof-Lex extra thin contouring and polishing discs (3M Dental Products, St Paul, MN, USA)
2. Diatech Carbide bur/Enhance disc with Prisma Gloss polishing paste (Dentsply-DeTrey GmbH D Konstanz, Germany)
3. Diatech Carbide bur/Edenta AG Composite Finishing Kit (Edenta AG, Hauptstrasse 7, Switzerland)

This study also evaluated the effectiveness of the surface sealant application (BisCover) on the surface roughness after finishing and polishing procedures of tested composites.

### Methods and Materials

Table 1 and 2 show the properties of the restorative and finishing-polishing materials tested.

Two packable composites, Solitaire 2 and Filtek P-60; two microhybrid composites, Artemis Enamel and TPH Spectrum; one microfilled composite, Filtek A-110; and one nanofilled composite, Filtek Supreme Enamel were cured according to manufacturers' instructions with a curing light (Hilux 200 Benlioglu Dental, Ankara, Turkey), in plexiglass wells (5 mm in diameter<sup>14-16</sup> x 2 mm in thickness<sup>9,12,14</sup>) against a Mylar strip ( Du Pont Co., Wilmington, DE, USA) in a glass slide configuration. The guide of the curing light was placed perpendicular to the specimen surface at or less than a distance of 1.0 mm. The samples were then cured for 40 seconds through the Mylar strip and glass slide then for an additional 20 seconds without the matrices in place.

The intensity of the light-curing unit was checked before each sample run using a Hilux curing light meter (First Medica, Greensboro, NC, USA). Following light curing, the specimens were placed in 37°C deionized water for 24 hours. A total of 168 specimens were prepared. A control group of seven specimens of each material received no polishing treatment after being cured under the Mylar strip. The remaining 126 specimens were surfaced with a 30-fluted tungsten carbide

Table 1. The composition, manufacturers, and batch numbers of the restorative materials tested.

Type	Commercial name	Manufacturer	Batch number	Filler weight	Particle size Mean ( $\mu\text{m}$ )
Packable composite	Solitaire 2	Heraeus Kulzer D-41538 Dormagen, Germany	070236	75%	0.7-8 $\mu\text{m}$ (2-25 $\mu\text{m}$ max)
Packable composite	Filtek P-60	3M ESPE Dental Products, St Paul, MN, USA	0086	80%	0.6 $\mu\text{m}$ (0.01-3.5)
Nanofilled composite	Filtek Supreme enamel	3M ESPE Dental Products, St Paul, MN, USA	20030127	78.5%	20nm (silica) 20nm (zirconia/silica)
Microfilled composite	Filtek A-110	3M ESPE Dental Products, St Paul, MN, USA	2BP	56%	0.04 $\mu\text{m}$
Microhybrid composite	Artemis (Enamel)	Ivoclar Vivadent AG, Schaan, Liechtenstein	F29911	75-77%	0.6 $\mu\text{m}$
Microhybrid composite	TPH Spectrum	Dentsply Caulk, Milford, DE, USA	0111162	77%	below 1 $\mu\text{m}$

Table 2. The composition, manufacturers, and batch numbers of the finishing and polishing systems investigated.

Finishing and Polishing Systems	Composition	Manufacturers	Batch number
Tungsten Carbide Bur	CF246 Carbide (30-fluted)	Diatech Dental AC, Heerbrugg Switzerland	8324986
Sof-Lex XT Polishing Discs	Coarse, medium, fine, superfine aluminum oxide disc	3M Dental Products, St. Paul, MN 55144 USA	70-2005-2387-9
Enhance Disc with polishing paste	Aluminum oxide disc, Fine aluminum oxide paste Extra-fine aluminum oxide paste	Dentsply-DeTrey GmbH D 78467, Konstanz, Germany	#624075
Edenta Finishing Kit	Extra-fine finishing diamond C850.012, Arkansas stone AS01, Yellow rubber cup 0735	Edenta AG, Hauptstrasse 7, CH-9434 AU/SG Switzerland	LN05.001
BisCover Liquid Polish	Ethoxylated Bisphenol A Diacrylate, Urethane acrylate ester, Polyethyleneglycol Diacrylate	Bisco Inc. 110 W Irving Park Rd., Schaumburg, IL USA	0300012280

finishing bur (Diatech, Diatech Dental AC, Heerbrugg Switzerland) in a rotary motion to simulate initial finishing of the restorative material. A high-speed 30-blade tungsten carbide bur was applied for 15 seconds with water coolant.

Twenty-one specimens for each composite were randomly divided among three finishing and polishing procedures.

#### Procedure I

Seven composite samples from each material were polished with coarse, medium, fine, and super-fine grit discs for 15 seconds on

each sample. After each step of polishing, all specimens were thoroughly rinsed with water for ten seconds and air dried for five seconds before proceeding to the next step toward the final polish.

#### Procedure II

Enhance finishing discs were applied 15 seconds for the intermediate finishings and a foam-polishing cup with Prisma Gloss fine and super fine polishing pastes were then applied for 15 seconds. Specimens were rinsed with water for ten seconds and air dried for five seconds between and after polishing paste application.

### Procedure III

Seven composite samples from each material were finished with an Edenta composite finishing kit (extra-fine finishing diamond (C850.012), white Arkansas stone (AS01), and yellow rubber wheel cup 0735). An extra-fine diamond bur was used in a high speed handpiece under constant air/water coolant for 15 seconds. They were then polished for 15 seconds with white stone followed by 15 seconds of polishing with a yellow rubber wheel cup. The white stone followed by the yellow rubber wheel cup was used with a high speed handpiece with water coolant and an air-dried slow speed hand piece, respectively.

All specimen preparation and finishing-polishing procedures were carried out by the same investigator in order to minimize variability. Each step of the finishing-polishing procedures was performed for 15 seconds. Each bur was applied using light pressure in multiple directions. Tungsten carbide burs, extra-fine diamond burs, and white Arkansas stones were used in a high-speed hand-piece with water coolant spray. Enhance discs with polishing paste, Sof-Lex discs, and yellow rubber wheel cups were used in a low-speed hand-piece while being air-dried. The Mylar strips, polishing discs, and polishing cups were discarded after each use, while the tungsten carbide burs, the extra-fine diamond burs, white Arkansas stones, and yellow rubber wheels-cups were changed after every three samples.

The average surface roughness ( $R_a$ ,  $\mu\text{m}$ ) of the control and treated specimens were measured with the Mitutoyo SurfTest-402 Surface Roughness Tester (Mitutoyo Corporation, Tokyo, Japan) (Figure 1).

Five successive measurements in different directions were recorded for each specimen surface. A calibration block was used periodically to check the performance of the profilometer (Mitutoyo Precision Reference Specimen, Mitutoyo Corporation, Tokyo, Japan). The equipment consistently provided an accurate recording of the calibration block ( $R_a = 0.8 \pm 0.10 \mu\text{m}$ ).

After the average surface roughness ( $R_a$ ) was measured, all treated specimens (126) were contoured and acid etchant applied (UNI-ETCH, Bisco Inc., Schaumburg, IL, USA) for 15 seconds



**Figure 1.** Mitutoyo SurfTest-402 Surface Roughness Tester (Mitutoyo Corporation, Tokyo, Japan)

and then rinsed and dried. Then one thin coat of BisCover was applied to all specimens with an applicator tip and light cured for 30 seconds at close range (0-1 mm). The average roughness ( $R_a$ ) was then measured again.

The results were evaluated with using one and two way analysis of variance (ANOVA). A two-way ANOVA was calculated for the differences between the materials and the finishing-polishing methods ( $p < 0.05$ ). The one-way ANOVA and post-hoc Scheffe's test were used to detect specific differences within material groups ( $p < 0.05$ ).

### Results

Means and standard deviations of surface roughness ( $R_a$ ,  $\mu\text{m}$ ) are listed in Table 3 and graphically depicted in Figure 2.

Multiple comparison results for polishing systems and restorative materials tested are reflected in Tables 4 and 5.

A significant difference was observed among the finishing-polishing procedures ( $p < 0.001$ ). The surface group treated with the Enhance/Biscover finishing and polishing procedure was not significantly different from the Mylar strip surface groups ( $p > 0.05$ ) (Table 4). The Mylar strip group was not significantly different from the Sof-Lex/BisCover and Edenta/BisCover groups.

The ranking of mean  $R_a$  values by polishing systems were as follows: Enhance/BisCover < Mylar Strip < Sof-Lex/BisCover < Edenta/

Table 3. Surface roughness (Ra,  $\mu\text{m}$ )  $\pm$  standard deviations of esthetic restorative materials after several finishing and polishing systems.

FINISHING AND POLISHING SYSTEMS							
Restorative Materials	Mylar Strip	Sof-Lex	Enhance	Edenta	Sof-Lex/BisCover	Enhance/BisCover	Edenta/BisCover
Artemis Enamel	0.33 $\pm$ 0.03	0.47 $\pm$ 0.06	0.46 $\pm$ 0.05	1.13 $\pm$ 0.32	0.43 $\pm$ 0.04	0.33 $\pm$ 0.05	0.35 $\pm$ 0.02
TPH Spectrum	0.29 $\pm$ 0.07	0.35 $\pm$ 0.04	0.35 $\pm$ 0.02	1.18 $\pm$ 0.17	0.35 $\pm$ 0.04	0.29 $\pm$ 0.05	0.32 $\pm$ 0.07
Filtek A-110	0.16 $\pm$ 0.03	0.28 $\pm$ 0.03	0.28 $\pm$ 0.02	1.35 $\pm$ 0.29	0.25 $\pm$ 0.04	0.12 $\pm$ 0.03	0.20 $\pm$ 0.02
Supreme Enamel	0.09 $\pm$ 0.02	0.26 $\pm$ 0.03	0.29 $\pm$ 0.06	1.13 $\pm$ 0.17	0.25 $\pm$ 0.04	0.18 $\pm$ 0.05	0.19 $\pm$ 0.01
Filtek P-60	0.51 $\pm$ 0.07	0.63 $\pm$ 0.09	0.65 $\pm$ 0.08	1.27 $\pm$ 0.24	0.53 $\pm$ 0.04	0.49 $\pm$ 0.07	0.61 $\pm$ 0.09
Solitaire 2	0.62 $\pm$ 0.06	0.67 $\pm$ 0.08	0.69 $\pm$ 0.11	1.34 $\pm$ 0.22	0.50 $\pm$ 0.03	0.33 $\pm$ 0.08	0.71 $\pm$ 0.07

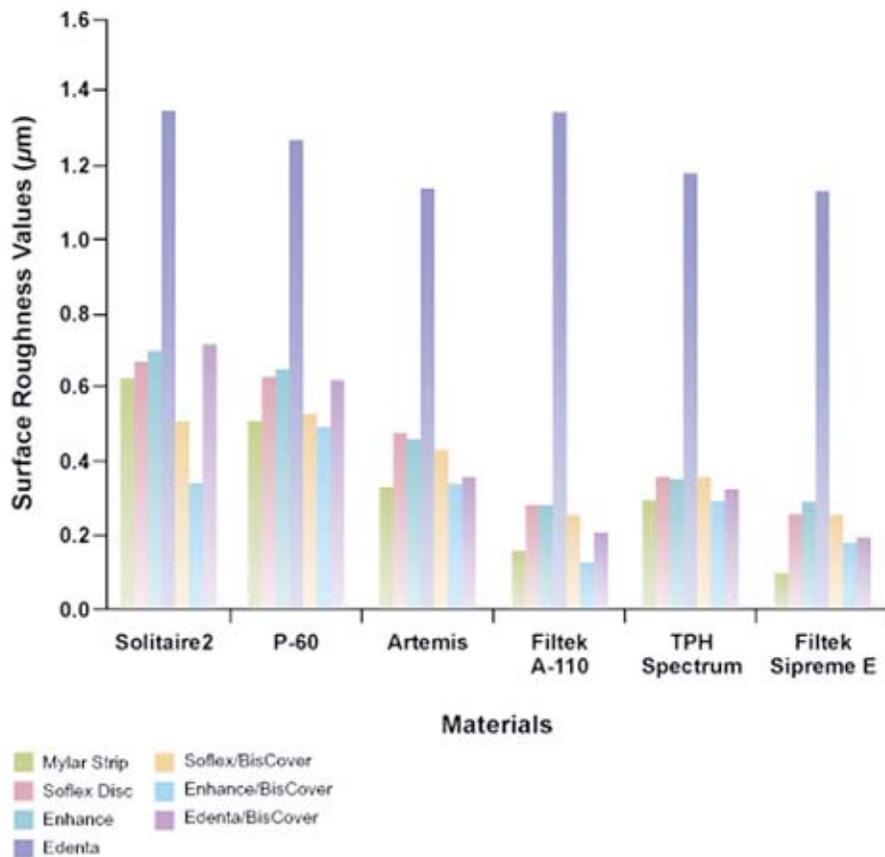


Figure 2. Mean surface roughness values for the resin composite tested.

BisCover < Sof-Lex < Enhance < Edenta (Table 4) (Figure 2).

Smoother surfaces were recorded for the Enhance/BisCover and the Mylar strip-formed surface groups.

Under Mylar strips, packable composite Solitaire 2 showed a statistically rougher surface than Filtek P-60 ( $p < 0.05$ ). Filtek P-60 showed a

statistically rougher surface than microhybrid composites (Artemis and TPH Spectrum) ( $p < 0.05$ ). Artemis and TPH Spectrum showed a rougher surface than microfilled composite (Filtek A110) and nonfilled composite (Filtek Supreme Enamel) ( $p < 0.05$ ).

The smoothest surfaces for Solitaire 2 composite resin were recorded with Enhance/BisCover ( $p < 0.05$ ).

**Table 4. Multiple comparison results for finishing and polishing systems.**

Polishing Systems	Mean Ra Values
Enhance/BisCover	0.29 <sup>a</sup>
Mylar Strip	0.33 <sup>ab</sup>
Sof-Lex/BisCover	0.39 <sup>bc</sup>
Edenta/BisCover	0.40 <sup>bc</sup>
Sof-Lex Disc	0.44 <sup>c</sup>
Enhance	0.45 <sup>c</sup>
Edenta	1.23 <sup>d</sup>

\* Superscript with the same letters indicate statistically homogeneous subsets ( $p>0.05$ )

**Table 5. Multiple comparison results for restorative materials tested.**

Restorative material tested	Mean Ra Values
Filtek Supreme Enamel	0.34 <sup>a</sup>
Filtek A110	0.38 <sup>a</sup>
TPH Spectrum	0.45 <sup>b</sup>
Artemis Enamel	0.50 <sup>b</sup>
Filtek P-60	0.67 <sup>c</sup>
Solitaire 2	0.69 <sup>c</sup>

\* Superscript with the same letters indicate statistically homogeneous subsets ( $p>0.05$ )

For Filtek P-60, Artemis, Filtek A110, and TPH Spectrum resin composites, the smoothest surfaces were evident with Enhance/BisCover, Mylar strip, Sof-Lex/BisCover, Edenta/BisCover, Sof-Lex, and Enhance ( $p<0.05$ ).

For Filtek Supreme Enamel resin composite, the smoothest surfaces were evident with the Mylar strip group. The Mylar strip group was not significantly different from Enhance/BisCover, Edenta/BisCover, and Sof-Lex/BisCover ( $p>0.05$ ).

The roughest surfaces for all the resin composites tested were found when the Edenta composite finishing kit was used ( $p<0.05$ ) (Table 4, Figure 2).

The ranking of mean Ra values by materials was as follows: Filtek Supreme Enamel < Filtek A110 < TPH Spectrum < Artemis < Filtek P-60 < Solitaire2 (Table 5, Figure 2).

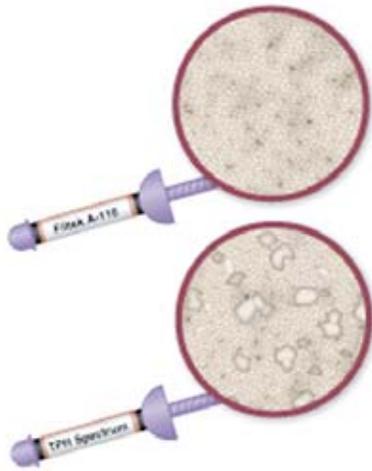
The Edenta composite finishing kit significantly increased the Ra for all tested composites

( $p<0.05$ ). But after finishing with Edenta, the use of surface sealant (BisCover) significantly improved the surface smoothness of all tested composites ( $p<0.05$ ).

### Discussion

High-quality finishing and polishing of composites are important steps to enhance both the esthetics and longevity of restored teeth.<sup>9,14,16</sup> Unfortunately, polishing is complicated by the heterogeneous nature of these dental materials, i.e., hard filler particles embedded in a relatively soft matrix. Composite surface roughness is basically dictated by the size, hardness, and amount of filler which influences the mechanical properties of the resin composites. It is also influenced by the flexibility of the finishing material, the hardness of the abrasive, and the grit size.<sup>9,12,14,16-18</sup>

Microfilled and microhybrid composites can be finished to a very smooth surface, due to their small filler particle size and arrangement.<sup>12,19</sup> The average size of filler particles in a microfilled composite is 0.04  $\mu$ m, and a microhybrid



contains particles ranging in size between 0.01 and 2 mm which allows them to be polished to a smoother surface than the conventional composites containing large filler particles.<sup>12,19</sup> The size of the aggregated filler particles of nano-filled composite was 0.6–1.4  $\mu\text{m}$  clustered with 5–20  $\mu\text{m}$  and 75  $\mu\text{m}$  primary particles which is similar to the filler size of microhybrid resin composites.<sup>8,12</sup>

The main differences between conventional and packable resin composites are due to modifications of the filler or resin components.<sup>16</sup> They are characterized by a high-filler load and a filler distribution that gives them a different consistency compared to hybrid composites. The differences in surface topography between the composite resins tested in this study may be attributed to differences in their interparticle spacing and their filler particle size. Composite resin fillers appear to play an intrinsic role in how well a composite can be finished.<sup>16,17,20</sup>

In this study, under Mylar strips, packable composite Solitaire 2 showed a statistically rougher surface than packable composite Filtek P-60 ( $p < 0.05$ ). Filtek P-60 showed a statistically rougher surface than microhybrid composites (Artemis and TPH Spectrum) ( $p < 0.05$ ). Artemis and TPH Spectrum showed a rougher surface than microfilled composite (Filtek A110) and nonfilled composite (Filtek Supreme Enamel) ( $p < 0.05$ ). Although dissimilarity in surface roughness of composite resin materials may be primarily attributable to differences in the size and content of filler particles, these restorative materials differ in many other ways such as the

type of filler, degree of conversion of the polymer matrix and silane coupler which may influence the final polish.<sup>21</sup>

It is well known the Mylar strip-formed surface was the smoothest composite surface produced because of the resin rich layer at the surface.<sup>14,22,23</sup> Mori et al.<sup>24</sup> evaluated the surface roughness of four packable composites and found all non-treated materials finished with a Mylar strip showed lower roughness values than those finished and polished with Sof-Lex discs.

Choi et al.<sup>12</sup> investigated the effects of three different polishing methods on four brands of resin composites and found no significant difference in the surface roughness before and after polishing except for Filtek Supreme A2 polished with Super-Snap.

Hergott et al.<sup>25</sup> found the surface roughness values produced by the Sof-Lex disc system were statistically similar to those produced by Mylar strips.

In the current study the smoothest surface was not produced with Mylar strips in all the materials tested. Enhance/Biscover finishing and polishing procedure surface was not significantly different from the Mylar strip surface groups ( $p > 0.05$ ). The Mylar strip group was not significantly different from Sof-Lex/BisCover and Edenta/BisCover ( $p > 0.05$ ) groups. The use of BisCover surface sealant significantly improved the surface smoothness of all tested composites. Rebonding of composite restorations with unfilled resin has been recommended for penetration of the subsurface micro-cracks and interfacial gaps generated during finishing and polishing procedures as well as decreasing wear.<sup>10,26,27</sup> Studies show surface sealing improves the initial wear rates of posterior composites and can decrease microleakage around Class V restorations.<sup>10</sup> But composite surfaces should be completely contoured, finished, and polished before surface sealing because the surface sealant will not adequately compensate for surface irregularities produced by finishing and polishing instruments.<sup>28</sup> In this study surface sealing with BisCover after finishing and polishing procedures had a positive effect on surface roughness.



Despite the careful placement of matrices, the removal of excess material or recountouring of restorations is often necessary.<sup>14,23</sup> For contouring anatomic features in teeth, diamond and carbide burs are necessary. The Edenta composite finishing kit (extra-fine finishing diamond/white Arkansas stone/yellow rubber wheels-cup) produced rough surfaces on all composites. It was reported composite surfaces treated by the finishing diamond were significantly rough compared with those treated by tungsten carbide finishing burs.<sup>29</sup> Jung<sup>29</sup> suggested finishing diamonds were best suited for gross removal and contouring because of their high cutting efficiency on composite surfaces, while carbide finishing burs would be best suited for smoothing and finishing as a result of their low cutting efficiency. In this study 30-fluted tungsten carbide burs were used to finish the surface of the restorations followed by the use of Sof-Lex discs, an Enhance disc with polishing paste, and an Edenta finishing kit to polish the restorations. All finished and polished specimens were covered with surface sealant BisCover.

According to the results of this study, the composite finishing kit Edenta (extra-fine finishing diamond, white Arkansas stone, and yellow rubber wheels-cup) produced rougher surfaces for all tested composites regardless of differences in organic and inorganic phases.

Profilometers are a widely used method for the evaluation of roughness. They provide limited two-dimensional information, but an arithmetic average roughness can be calculated and used to represent various material/polishing surface combinations that can assist clinicians in their composite finishing decisions.<sup>9,14,30</sup> 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 is due to the impossibility of measuring the homogeneity in the maximum profile valley height and depth. For this reason, Ra was preferred in this study to evaluate the surface roughness.

The question as to the degree of smoothness a surface must be finished is difficult to answer, although achieving the roughness of occluding enamel surfaces or achieving profile irregularities smaller than the average size of bacteria is discussed as possible thresholds. Weitman and Eames<sup>31</sup> and Shintani et al.<sup>32</sup> have reported no appreciable difference in plaque accumulation between the surfaces polished by different methods resulting in Ra values within a 0.7-1  $\mu\text{m}$  range. According to Chung,<sup>33</sup> restorations appear optically smooth when their surface roughness is smaller than 1  $\mu\text{m}$ . In this study, except for the Edenta Finishing Kit system, all the other systems were found to be effective in polishing the resin composite tested.

The results from this *in vitro* study only correlate to the clinical situations where there are accessible and relatively flat surfaces. Further studies are needed to determine which finishing technique is best suited to clinical situations where access is limited and restoration surfaces are not flat.

### Conclusions

There is a significant relationship between the methods used for the finishing and polishing procedures and the content of the material itself with regard to the achieved surface finish. The roughest surfaces for all the resin composites tested were found when an Edenta composite finishing kit was used. Smoother surfaces were recorded for the Enhance/BisCover and the Mylar strip-formed surface groups.

Considering application time and achievement of a Mylar strip-like surface, the BisCover surface sealant system should be used in anterior and posterior resin composite restorations following finishing and polishing procedures. The results would be valid clinically for readily accessible and flat surfaces but not for all areas in the mouth.

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