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Surface Roughness of Composite Resins After Finishing and Polishing

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This study evaluated the effect of surface finishing methods on the average surface roughness of resin composites. Seven composites and two polishing systems were used. One hundred and twenty-six conical specimens of each material were prepared in stainless steel molds against a polyester strip. Forty-two of them remained intact and were used as controls. Each half of the remaining samples was polished with either diamond burs or diamond burs + aluminum oxide discs. The results showed no statistical difference in average surface roughness (Ra, µm) between the polyester strip and aluminum oxide discs ($p>0.05$). However, finishing with diamond burs showed a statistically higher average roughness for all composites ($p<0.05$). Statistical differences were detected among materials ($p<0.05$) in the use of diamond burs.

Key Words: composite resin, surface roughness, polishing.

INTRODUCTION

Finishing and polishing of composite resins are important steps in restorative dentistry. A highly polished surface minimizes plaque accumulation, gingival irritation, poor esthetics and color change (1). Therefore, the smoothness of a restoration is of utmost importance for its success (2).

A highly polished surface of composite resin restorations is somewhat difficult to achieve. The resin matrix and the filler particles of composites do not abrade to the same degree due to different hardness. For instance, craters are often formed around hard quartz particles of conventional composites after polishing. As a consequence, irregularities appear on the surface of the restoration (3). The filler content of the composite also affects its roughness, as microfilled composites show smoother surfaces than hybrid composites (4). Similarly, the resin matrix composition may also play a role in the final smoothness of the restoration.

Different methods can be used to finish and polish composite resin restorations (5), and it is well known that few, and possibly, none are as efficient as the polyester strip. However, the use of this strip is limited by the complexity of the tooth anatomy and by diverse restorative procedures. Discs are nondestructive, but their effect on anatomically contoured occlusal surfaces is limited because they cannot access the narrow fissures on the surface for geometric reasons.

This study investigated the average surface roughness (Ra, µm), of 7 composites with different resin types set against polyester strips and either finished with diamond burs or finished with diamond burs and polished with aluminum oxide discs.

MATERIAL AND METHODS

Details of the commercially available resins used in this study are given in Table 1. The materials FI, SP and FM are BISGMA-based, Al and SR are ethoxylate BISGMA-based, and DE and SO are silicon organic-based.

The composite resins were mixed according to manufacturer instructions and placed into a steel matrix

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of 8 mm in diameter and 5 mm deep. After filling each mold, a polyester matrix strip was pressed onto the surface by means of a glass plate. All materials were light cured for 60 s with an Optilux 501 (Demetron, Kerr, Danbury, CT, USA) curing light with an output of 850 mW/cm^2. After polymerization, the specimens were stored in distilled water at 37^{o}C for 24 h.

A total of one hundred and twenty-six specimens were prepared. A control group of 6 specimens of each material received no polishing treatment after being cured under polyester matrix strip (group 1). The remaining specimens were finished by a sequence of instruments: Groups 2 and 3 were finished with diamond burs (KG Sorensen, Barueri, SP, Brazil). The sequence was a fine-grain (gold 2135F) followed by an extra fine-grain bur (silver 2135FF), each applied for 15 s with a low-speed handpiece. All diamond burs were used for 30 s on specimens with intermittent water spray. The preference for diamond burs instead of Arkansas stone was based on recommendations of several authors (6,7). After finishing with diamond burs, group 3 was polished with aluminum oxide disks (Sof-lex, 3M, St. Paul, MN, USA). Three texture abrasives were applied with light pressure in a circular motion in one direction only with continuous water irrigation (Table 2).

A single operator, blinded to which material was being processed, polished all specimens in a randomized order. Polyester matrix strips and abrasive disks were discarded after each use. Diamond burs were

Table 1. Composite resins used in this study.

Composite	Code	Manufacturer	Resin type	Filler	W%
Filtek Z250	FI	3M St. Paul, MN USA	BISGMA BISEMA UDMA	Zirconia/SiO_2	78
Solitaire	SO	Heraeus/Kulzer & Co. GmbH, Bad Homburg Germany	Silicon tetra-acrylate BISGA / HPMA ETMA	$BoFBaASiO_4$ Porous SiO_2 SiO_2	66
Alert	AL	Jeneric/Pentron Inc. Wallingford, CT USA	Ethoxylate BISGMA	$(BaAl)_2$ SiO_4 SiO_2-MgO_2 Al_2 O_3-Si	84
Suprafill	SP	SS White Rio de Janeiro, RJ Brazil	BISGMA TEDMA UDMA	Ba_2SiO_4	76
Fill Magic	FM	Vigodent Rio de Janeiro, RJ Brazil	BISGMA TEGMA BISEMA UDMA	Ba_2 SiO_4 Sr_2 SiO_4 SiO_2 Fluoride	81
Surefil	SR	Dentsply Eatontown, NJ USA	Ethoxylate BISGMA TEGMA UDMA	$BoFBaASiO_4$ SiO_2	82
Definite	DE	Degussa Dental Centrum Hanau, Germany	Silicon dimethacrylate (Omorcer) Dimethacrylates	Ba_2 SiO_4 SiO_2 Modified apatite	77

W%: weight percentage of inorganic filler.

reused in random order.

The average roughness (Ra) of a surface is defined as the average value of the height of the surface profile above and below a centerline throughout a prescribed sampling length. To eliminate the effects of waviness, roughness of each disc surface was calculated with Surtronic 3+ roughness instrument (Taylor-Hobson, Leicester, England) using five intervals within each stylus transverse to calculate Ra. In this study, resolution was 0.01 µm, the interval (cutoff length) was 0.8 mm, transverse length 4.0 mm and stylus speed 1 mm/s. A diamond stylus with a radius of 5 µm was used.

Three traces were recorded for each specimen at three different locations in each direction (parallel, perpendicular and oblique to the finishing and polishing scratch directions) giving nine tracings per sample The average of these nine mean surface roughness measurements was used as the score for each sample.

Data were analyzed by two-way analysis of variance (ANOVA). Surface treatments and products were compared by Tukey-Kramer intervals at a 0.5 significance level.

Table 2. Methods of finishing and polishing of composite resin surface.

Group	Time
Group 1 (control)	
Polyester matrix strip	60 s
Group 2	
Finishing	
Diamond burs (gold 2135F)	15 s
Diamond burs (silver 2135FF)	15 s
Group 3	
Finishing	
Diamond burs (gold 2135F)	15 s
Diamond burs (silver 2135FF)	15 s
Polishing	
Aluminum oxide disk medium	10 s
Aluminum oxide disk fine	20 s
Aluminum oxide disk extra fine	20 s

RESULTS

The testing procedure for surface roughness showed significant differences between the material/polishing procedure combinations used. A two-factor ANOVA showed significant material and diamond bur polishing procedure effects. Significant interactions were also found indicating that the different materials did not behave uniformly to the different polishing procedures used. Polyester matrix strips, as expected, produced the smoothest surface with a roughness of 0.483 (Surefil), 0.616 (Alert). Although polyester matrix strip finishing is a surface treatment of choice, most clinical situations require bulk removal of excess composite. Burs or Arkansas stones are always necessary in these cases. The X-fine diamond (15 µm) performed considerably better than the fine diamond burs (25 µm). Both produced a rougher surface than the polyester matrix strip, but composite resins were not disrupted. Fractured particles, dislodgment and fissures were not observed.

Table 3 provides the Ra values for each material after the surface treatments. Tukey-Kramer intervals for comparisons between material and surface treatment were 0.250 and 0.198 µm. The Tukey comparisons demonstrate that different compositions of particles and matrix of resins are not important in determining surface roughness of resin with diamond burs. Z250 resins with 78% inorganic particles had a rougher surface than Surefil, also with 78% inorganic particles. This indicates that composites reacted very sensitively to the treatment with diamond burs. More pressure caused a significantly rougher surface of resin removing the grains and leaving deep scratches. When finished with diamond burs under the

Table 3. Means and standard deviation of surface roughness (Ra, µm).

Composite	GI	GII	GIII
Alert	0.616 ± 0.0051 A,a	2.076 ± 0.2068 B,bc	0.590 ± 0.0629 A,a
Definite	0.390 ± 0.0126 A,a	2.086 ± 0.1853 B,bc	0.561 ± 0.0530 A,a
Fill Magic	0.615 ± 0.0054 A,a	1.976 ± 0.2537 B,bc	0.613 ± 0.0393 A,a
Solitaire	0.503 ± 0.0789 A,a	1.770 ± 0.1938 B,a	0.540 ± 0.0565 A,a
Suprafill	0.488 ± 0.0990 A,a	2.090 ± 0.4100 B,bc	0.533 ± 0.0765 A,a
Surefill	0.483 ± 0.9130 A,a	1.866 ± 0.1300 B,ab	0.501 ± 0.0538 A,a
Z250	0.490 ± 0.1013 A,a	2.203 ± 0.1141 B,c	0.473 ± 0.0628 A,a

Means followed by the same letter were not statistically different ($p>0.05$). Capital letters for horizontal comparison. Small letters for vertical comparison.

same circumstances, Alert, Definite, FillMagic and Suprafill composites did not have a significantly different roughness, even though they have different organic and inorganic components, although Solitaire and Surefil had significantly different roughness and compositions.

DISCUSSION

The flexibility of the backing material in which the abrasive is embedded, the hardness of the abrasive, and the grit size determine surface roughness. An extra-fine diamond bur produces a surface smoothness equal to or better than that achieved with a fine diamond bur (8).

Overall, the diamond burs (GII) were less effective than the polyester strips (GI) and the Sof-lex discs (GIII) for finishing the composites. These findings are in accordance with Hoelscher et al. (9) and Jung (10), who reported higher values of surface roughness for polishing with diamond burs. In addition, contrary to the superiority of polyester strips over other methods in achieving very smooth surfaces, as reported by Germain Jr. and Meiers (11) and Geiger et al. (12), the polyester strip (GI) and the Sof-lex discs (GIII) produced the same roughness in this study ($p>0.05$).

The rougher surfaces produced by the diamond burs might be related to their grain sizes. The fine grain and extra-fine grain burs used have an average grain size of 25 and 15 µm. Scratches created by particles of such dimensions may be larger than the wavelength range of visible light and may be perceived by the normal unaided human eye (13).

There are differences in roughness for the different resins using the same treatment with the same instrument (4). In this study, the burs produced roughness in all composites effectively, regardless of differences in organic and inorganic phases. This is perhaps due to the pressure used with the burs on resin surfaces. In groups 2 and 3, the diamond burs are reusable finishing instruments and with continuous use could damage the uniform wear. Abrasion irregularities are dependent on the composition and hardness of the particles and also on the pressure used with the diamond burs on the resin surface.

Although dissimilarity in surface roughness of materials may mainly be attributable to the differences in the size and content of filler particles, these restorative materials differ in many other ways, i.e., type of filler, degree of conversion of the polymer matrix and silane coupler, which may also influence polishing (14-15). However, the durability of the smoothness is difficult to predict and may be influenced by factors related both to the clinical restorative procedure and to the composition of the material, especially the filling particle size (17).

This study demonstrated that the polishing technique with aluminum oxide discs and water was an effective method for the materials evaluated. Besides drawing off heat, the water leaches the eroded particles, which must be removed immediately from the surface of the restoration. These results are in agreement with those reported by Bouvier et al. (18). Also, the scratches produced on the resin surface by the particles of the extra fine discs may be thinner than the visible light wavelength, accounting for the final smoothness observed.

RESUMO

Este estudo avaliou o efeito de diferentes métodos de acabamento e polimento sobre a rugosidade superficial de resinas compostas. Dois sistemas para polimento, e sete marcas comerciais de resinas compostas foram avaliados e comparados. Um total de 126 espécimes confeccionados em uma matriz de aço inoxidável foram divididos em três grupos. No grupo 1, seis amostras de cada material foram polimerizadas sob a pressão de uma tira de poliéster. Os demais espécimes receberam acabamento seqüencial de pontas diamantadas finas e extrafinas. Após o acabamento, as amostras do grupo 3, foram polidas com os discos de óxido de alumínio, de abrasividades média, fina e extra-fina e jatos de água intermitentes. Os resultados mostraram não haver diferença estatisticamente significante nos valores médios de rugosidade de superfície (Ra, µm) entre o grupo 1 (tira de poliéster) e o grupo 2 submetido ao acabamento com as pontas diamantadas e o grupo 3 com pontas diamantadas e polidos com discos de óxido de alumínio ($p>0.05$). A análise estatística revelou diferenças de níveis de rugosidade entre as superfícies resinosas quando receberam somente o acabamento com as pontas diamantadas. As tiras de poliéster, como era esperado, produziram as superfícies mais lisas em todas as resinas, embora os resultados não têm estatisticamente diferenças daqueles encontrados nas superfícies polidas com os discos de óxido de alumínio.

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