

Influence of Finishing/Polishing Procedures on the Surface Texture of Two Resin Composites

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Abstract: This study compared surface roughness and gloss produced by different finishing/polishing procedures for two resin composites, Clearfil AP-X (AP-X) and Estelite Σ (ES). A total of 70 composite discs (n=35 for each resin composite) were prepared and divided at random into seven finishing/polishing groups (n=5): glass-pressed control; using a super-fine-grit diamond bur (SF); using CompoMaster (CM) after SF-finishing (SF+CM); using White Point (WP) after SF-finishing (SF+WP); using CM after SF+WP-finishing (SF+WP+CM); using Stainbuster (SB) after SF-finishing (SF+SB); and using CM after SF+SB-finishing (SF+SB+CM). After the finishing/polishing procedures, average surface roughness (R_a) and surface gloss ($G_s(60^\circ)$) of all specimens were assessed with a surface profilometer and specimen gloss meter, respectively. Glass-pressed controls for both AP-X and ES composites showed the best surface finish in terms of both R_a and $G_s(60^\circ)$. SF-finishing produced the roughest surface and led to almost complete loss of gloss. While additional polishing with CM reduced R_a and increased $G_s(60^\circ)$, the additional finishing effect of WP or SB between SF-finishing and CM-polishing was not found for either AP-X or ES.

Key Words: Surface roughness, Resin composite, Finishing, Polishing, Surface gloss.

INTRODUCTION

Resin composite restoration currently achieves esthetically pleasing and natural-looking results through the use of nanoparticle-sized small fillers, variations of color, and newly developed restorative techniques such as the layering technique (Peyton PPAD 2002) [1]. To ensure the longevity of these esthetic composite restorations some aspects must be taken in consideration, such as: strong and stable adhesion to teeth, techniques involving gap-free filling, authentic polymerization, functional and anatomical contouring with over-or-less filling, and smooth and glossy polishing (Jung OD 2007) [2].

Finishing and polishing processes, including the removal of excess-filled resin composite, shaping, contouring, and smoothing of the restoration, can affect many aspects of the final restoration, such as surface staining, plaque accumulation, gingival irritation, and wear characteristics of the composite (Murchison Fundamentals of Operative Dentistry 2006) [3] (Shintani DM 1985) [4] (Lu JERD 2005) [5] (Larato JPD 1972) [6]. A wide variety of finishing and polishing instruments are commercially available to the clinician. As initial finishing, it has been advocated the use of a fine-grit diamond or multi-fluted tungsten carbide bur to remove the excess-filled composite and shape the anatomical contouring; and silicone-based points and/or abrasive discs for final polish (Jung OD 2003) [7] (Roeder OD 2000) [8] (Barbosa BDJ 2005) [9]. The additional use of an aluminum-oxide abrasive point may be applied for second finishing between first finishing and final polishing.

The resin composite Estelite Σ (Tokuyama Dental Corp., Tsukuba, Japan), with submicron particles of spherical organic filler produced by the sol-gel method, has recently been developed. Lu *et al.* reported that this composite has similar properties to nano-filled, two micro-filled and two micro-hybrid composites (Lu OD 2006) [10]. However, its surface texture after finishing/polishing has yet to be reported. The present study compared the average surface roughness and surface gloss of one spherical-filled submicron composite (Estelite Σ) and one micro-hybrid composite (Clearfil AP-X, Kuraray Medical, Osaka, Japan) as produced by different finishing/polishing procedures. Furthermore, interactions between the average surface roughness and gloss were also evaluated. The null hypotheses tested in this study were that there is no significant difference in surface texture 1) among the different finishing/polishing procedures, 2) between the two resin composites, and 3) there is no significant interaction between surface roughness and surface gloss.

MATERIALS AND METHODS

The resin composites used in this study were Clearfil AP-X (AP-X) and Estelite Σ (ES; Tokuyama Dental Corp., Tsukuba, Japan), as shown in Table 1. An acrylic ring (9 mm inner hole diameter, 2.5 mm depth) was filled with resin composite and sandwiched between two glass slides. The filled resin composite was polymerized with a quartz-tungsten-halogen light-curing unit (New-Light VL-2, GC, Tokyo, Japan) for 30 s on each side of the specimen. The light-curing unit was adjusted to 700 mW/cm², as measured by the curing radiometer (Model 100, Demetron Research Co., Danbury, CT, USA).

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Also shown in Table 1 are the details of the rotary polishing instruments used in this study; the Diamond Point FG (SF; Shofu, Kyoto, Japan), the White Point CA (WP; Shofu), the Stainbuster (SB; Danville Materials, CA, USA) and the CompoMaster (CM; Shofu). Thirty-five specimens of each composite (total: 70 specimens) were randomly assigned to one of seven test groups, as shown in Table 2. Surfaces that were pressed by glass slides were considered as control. All other specimens were surfaced with the super-fine-grit finishing diamond bur SF attached to a 1:5 transmitted high-speed contra-angle motor handpiece (KaVo, Biberach, Germany) for 30 s at 200,000 rpm to simulate the initial finishing of the composite materials.

The SF-abraded surfaces were then further abraded with SB or WP attached to a 1:1 contra-angle motor handpiece (KaVo) for 30 s at 9,000 rpm. Each of the five specimens with SB- or WP-abraded surfaces were then further abraded with CM attached to a 1:1 contra-angle motor handpiece (KaVo) for 30 s at 9,000 rpm. Each procedure of finishing and polishing was conducted under a fine water spray.

After the abrasion/polishing procedures, specimens were rinsed under the water spray and air-dried. Surface roughness was measured using a surface profilometer (Handysurf E-30A, Tokyo Seimitsu, Tokyo, Japan), with a standard cutoff of 0.8 mm, a transverse length of 0.8 mm, and a stylus speed of 0.6 mm/s. The surface roughness was measured five times for each specimen, and the average value obtained was defined as R_a (roughness average) of each specimen.

In addition, the surface gloss of each specimen was measured using a precision gloss meter (GM-260, Murakami Color Research Laboratory, Tokyo, Japan) with the light source and detector both set at 60° to normal. Before measurement, the gloss meter was calibrated to a standard gloss board ($G_s(60^\circ) = 92.1\%$). Each specimen was measured five times and the average value determined.

Additionally, the amount of the abrasive reduction of each specimen was calculated as the difference between the weight of before and after the finishing/polishing procedure which was measured by weight analytical balancer (GR-202, A&D Co., Ltd., Tokyo, Japan).

Table 1. Resin Composite Materials and Finishing/polishing Instruments Tested in this Study

Resin Composite					
Code	Resin Composite	Shade	Lot #	Type (Filler Size)	Manufacturer
AP-X	Clearfil AP-X	A3	1115AB	3.0 μm (hybrid)	Kuraray Medical
ES	Estelite Σ	A3	J22116S	0.2 μm (submicron)	Tokuyama Dental
Finishing and Polishing Instrument					
Code	Material	Shade	Lot #	Type	Manufacturer
SF	Diamond Point FG	SF114	30610	25 μm diamond	Shofu
WP	White Point CA	No. 44	0206534	20 μm aluminum oxide	Shofu
SB	Stainbuster	2504	7640	17 μm zircon oxide fiber	Danville Materials
CM	Compomaster CA	13S	0106133	6 μm diamond	Shofu

Table 2. Effect of Finishing/Polishing Procedures on Surface Roughness (R_a) of Each Resin Composites (Mean and SD, μm)

Composite/Finishing/Polishing Group*	AP-X	Statistics**	ES
Control	0.08 (0.02)C	NS	0.06 (0.01) c
SF	0.25 (0.01) A	NS	0.58 (0.10) a
SF+CM	0.39 (0.02) AB	S	0.22 (0.01) b
SF+WP	0.47 (0.07) AB	NS	0.51 (0.06) a
SF+WP+CM	0.42 (0.09) AB	NS	0.43 (0.08) a
SF+SB	0.36 (0.02) B	NS	0.51 (0.17) a
SF+SB+CM	0.41 (0.07) AB	S	0.25 (0.04) b

*SF: superfine diamond bur, CM: CompoMaster, WP: White Point CA, SB: Stainbuster.
 ** Statistically analysis between AP-X and ES ($p=0.05$).
 S: significantly different, NS: no statistically different.
 Values with the same letter are not significantly different in same composite ($p<0.05$).

The obtained data were used to calculate the mean and standard deviation (SD) for each group, and were statistically analyzed using two-way analysis of variance (ANOVA), with statistical significance set at a p -value of 0.05. The strength of the association between pairs of variables was obtained by the use of Pearson's correlation coefficient. All statistical analyses were performed using Stat-View 5.0J (SAS Institute, Cary, NC, USA).

RESULTS

Values for R_a , $G_s(60^\circ)$ and the amount of abrasive reduction for each test group are summarized in Tables 2-4, respectively. Two-way ANOVA revealed that all of the finishing methods had a significant effect on R_a ($F=52.021$, $p<0.0001$) and $G_s(60^\circ)$ ($F=99.303$, $p<0.0001$). The composite material had a significant effect on $G_s(60^\circ)$ ($F=210.552$, $p<0.0001$) but not on R_a ($F=0.698$, $p=0.4071$). An interaction was found between 'finishing methods' and 'composite material' in terms of both R_a ($F=6.804$, $p<0.0001$) and $G_s(60^\circ)$ ($F=16.879$, $p<0.0001$). Therefore, one-way ANOVA and *post-hoc* Tukey's test was additionally performed in both R_a and $G_s(60^\circ)$ at the 5% level, respectively.

The glass-pressed controls significantly found the lowest R_a values ($p<0.05$) and highest gloss values ($p<0.05$) among

all groups in terms of both AP-X and ES. On the other hand, the SF-abraded groups were the highest R_a values in both AP-X and ES.

For AP-X, SF+SB significantly reduced R_a compared to SF only ($p<0.05$), while no significant difference was noted between SF and SF+WP ($p>0.05$). On the other hand, for ES, significant differences were not observed between the SF, SF+WP, and SF+SB groups ($p>0.05$).

On comparison of WP and SB, no significant difference in R_a was found for either the AP-X or ES composite ($p>0.05$). A tendency toward the reduction of R_a on additional polishing with CM was noted, but a significant difference was found only with the SF+SB+CM procedure for ES ($p<0.05$).

The glass-pressed controls in both AP-X and ES significantly found the highest gloss values ($p<0.05$) among all groups. The SF-abrasion significantly reduced the gloss values in terms of both AP-X and ES. In AP-X, there is no significant difference among six groups except for the control ($p>0.05$). On the other hand, CM-polishing significantly increased the gloss value ($p<0.05$).

Overall, the smoother specimen showed a significantly higher gloss value ($r=-0.724$, $p<0.001$). Comparing the two

Table 3. Effect of Finishing/Polishing Procedures on Gloss Value ($G_s(60^\circ)$) of Each Resin Composites (Mean and SD, %)

Composite/Finishing/Polishing Group*	AP-X	Statistics**	ES
Control	88.9 (3.5) A	NS	81.4 (4.0) a
SF	2.3 (0.1) B	NS	7.7 (1.7) e
SF+CM	2.7 (0.3) B	S	48.5 (15.9) bcd
SF+WP	11.6 (2.0) B	S	32.0 (8.3) d
SF+WP+CM	11.5 (18.8) B	S	53.6 (9.5) bc
SF+SB	5.9 (1.3) B	S	38.6 (9.4) cd
SF+SB+CM	3.7 (1.3) B	S	60.6 (8.6) b

*SF: superfine diamond bur, CM: CompoMaster, WP: White Point CA, SB: Stainbuster.

** Statistically analysis between AP-X and ES ($p=0.05$).

S: significantly different, NS: no statistically different.

Values with the same letter are not significantly different in same composite ($p<0.05$).

Table 4. Effect of Finishing/Polishing Procedures on Abrasive Reduction of Each Resin Composites (Mean and SD, mg)

Composite/Finishing/Polishing Group*	AP-X	Statistics**	ES
Control	0.0 (0.0)	NS	0.0 (0.0)
SF	8.6 (1.6)	NS	14.1 (6.1)
SF+CM	18.6 (0.6)	NS	15.9 (3.0)
SF+WP	11.1 (1.7)	NS	16.9 (1.7)
SF+WP+CM	15.2 (2.9)	NS	19.1 (2.2)
SF+SB	11.7 (3.3)	S	18.7 (2.9)
SF+SB+CM	14.6 (2.1)	NS	16.7 (1.6)

*SF: superfine diamond bur, CM: CompoMaster, WP: White Point CA, SB: Stainbuster.

** Statistically analysis between AP-X and ES ($p=0.05$).

S: significantly different, NS: no statistically different.

resin composites, ES tended to have a glossier surface than that of AP-X (AP-X: correlation coefficient $r=-0.887$, $p<0.001$, ES: correlation coefficient $r=-0.804$, $p<0.001$).

DISCUSSION

One of the purposes of this study was to evaluate the effect of seven different procedures on the surface texture of two resin composites. Several previous studies have measured the polyester matrix strip-produced surface as a control, such as the Mylar strip, followed by clinical application (Roeder OD 2000) [8] (Ozgunaltay JOR 2003) [11] (Türkün OD 2004) [12] (Yap JOR 1998) [13]. Almost all of these procedures resulted in a smoother finish than any polished surfaces. Our study also identified the smoothest and shiniest surfaces to be the glass-pressed controls for both the AP-X and ES resin composites. However, these surfaces result in a reduction in hardness or surface discoloration due to insufficient polymerization or a rich content of organic resin binder (Park JOR 2000) [14] (Park JOR 2004) [15] (Baseren JBA 2004) [16]. Therefore, the removal of the outermost composite by finishing/polishing procedures is necessary to produce a wear-resistant, harder, and color stabilized restoration.

In general, finishing procedures are performed with rigid rotary instruments, such as super-fine-grit diamond burs or tungsten carbide finishing burs. The present study used super-fine-grit diamond burs with an average of 30 μm diameter diamond particles. These surfaces were visibly very rough, with a loss of shininess, and numerous scratches. These results were similar to those of previous reports (Jung OD 2007) [2] (Roeder OD 2000) [8] (Reis AJD 2002) [17].

We used an abrasive point with aluminum oxide (WP) as one of the secondary finishing instruments. Our results did not reveal an effect of WP on R_a ($p>0.05$). However, the effect of WP on glossiness was found only in ES ($p<0.05$). These findings suggest that the abrasion of rough surfaces created by super-fine-grit diamond bur would reduce the roughness, but would not contribute to the removal of scratches.

We also evaluated the effect of SB in comparison with WP. This newly-developed and unique rotary instrument is based on zircon fiber and binding resin. It is mainly used for the removal of stained tooth surfaces, smoothing after scaling, and the abrasion of adhesive resin from enamel surface on removal of an orthodontic bracket. According to the manufacturer's instruction, this instrument can be used for the finishing of a composite surface. Although a significant decrease in R_a was found for AP-X, no significant difference was noted for ES between the SF and SF+SB procedures. This result might be due to the surface undulation, caused by extensive removal by SF in ES, where the rigid SB instrument could not evenly contact the surface, thus leading to the difference of R_a . The larger standard deviation (SD) may support this suggestion.

This study also evaluated the influence of second finishing on final polishing by the use of CM. In terms of R_a , there was no difference for the same composite between the three finishing groups SF+WP+CM, SF+SB+CM, and SF+CM, but for ES, a difference was observed between SF+WP+CM and SF+SB+CM. $G_s(60^\circ)$ also did not show a significant difference between the three finishing groups. Miyazaki *et*

al. reported that R_a/R_{max} of WP-finished composite surfaces was equal to the #400-#600 SiC paper-ground composite surface (Miyazaki JJCD 2000) [18]. In clinical situations, second finishing with WP or SB should be used only in the anatomical formation as a backup for diamond/carbide finishing. The first hypothesis, there is no significant difference in surface texture among the different finishing/polishing procedures, was therefore rejected.

Although two-way ANOVA clearly found the significant effect of composite material on surface gloss, no significant effect was found on surface roughness. Therefore, the second hypothesis, there is no significant difference in surface texture, was partially accepted. ES tended to be glossier than AP-X when each R_a was the same. These results are probably due to the difference in filler shape. Composed fillers in almost composites are ground glass particles whose morphology is irregular (Lu OD 2006) [10]. On the other hand, the filler shape of ES was spherical, with a narrow range of 0.1 to 0.3 μm -sized particles. Therefore, ES might reflect the light uniformly with lower diffusion/absorbance than AP-X (Lu OD 2006) [10].

To evaluate the polishing effect, the measurement of surface gloss is effective as an additional parameter to R_a (Miyazaki JJCD 2000) [18] (Stanford JADA 1985) [19] (Ohmura JJCD 1996) [20] (Watanabe QI 2006) [21] (Da Costa JERD 2007) [22]. Therefore, we also evaluated the effect of each finishing/polishing procedure on gloss value, and interactions between the average surface roughness and gloss. A clear relationship was found between R_a and $G_s(60^\circ)$ in each composite. Therefore, the last hypothesis, there is no significant interaction between surface roughness and surface gloss, was rejected.

CONCLUSIONS

This study compared the average surface roughness and surface gloss of two composites as produced by different finishing/polishing procedures. Furthermore, interactions between the average surface roughness and gloss were also evaluated, and concluded as follows:

1. The effect of finishing/polishing procedures on surface roughness and gloss were found.
2. While no significant difference in surface roughness was found between two composites, the Estelite Σ provided the glossier surface than Clearfil AP-X.
3. A clear relationship was found between average roughness and gloss in each composite.

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