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# Effect of Different Polishing Systems on the Surface Roughness and Gloss of Novel Nanohybrid Resin Composites

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## Abstract

**Objectives** To evaluate the surface roughness and gloss of three nanohybrid resin composites after polishing with three different polishing systems.

**Materials and Methods** A total number of 112 disc specimens (10 × 3 mm) were prepared from nanohybrid—Empress Direct (ID), Grandio (GR), Filtek Z350 (Z350) and a microhybrid resin composite restorative materials—Filtek Z250 (Z250). Following 24-hour storage in 37°C distilled water, each composite group ($n$ = 28) was assigned into four groups ($n$ = 7) according to finishing/polishing (F/P) system: Mylar strip, Optrapol, Politip, and Sof-Lex (SL). The surface roughness (Ra, mm) was measured by a novel three-dimensional method using an image analysis software attached to an environmental scanning electron microscope. A glossometer was used to measure the surface gloss.

**Results** Statistical analysis used was ANOVA test. Two-way Anova test revealed that the “type of composite” and “F/P techniques” had a significant effect on both surface roughness and gloss of the tested resin composite materials ($p < 0.05$). Tukey’s post hoc test showed that ID, GR, and Z350 revealed lower surface roughness and higher surface gloss than Z250 within the same polishing system ($p < 0.05$). Sof-Lex polishing discs produced the lowest surface roughness and highest surface gloss values compared with Optrapol and Politip ($p < 0.05$).

**Conclusion** The tested F/P systems provided comparable surface roughness and gloss for nanohybrid composites. The Sof-Lex system provided the best surface roughness and gloss for nanohybrid composites.

**Keywords**
- ► microhybrid
- ► nanohybrid
- ► roughness
- ► gloss
- ► polish
- ► resin composite restorative material

## Introduction

The durability of restorations is one of the main concerns in restorative dentistry. Due to the growing patient’s esthetic demand, resin composite restorations become the first material of choice in restoring teeth. It has been reported that the surface topography of the restoration significantly affects the clinical success of resin composite restorations.[1,2] Hence,

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for creating successful dental composite restorations, it is mandatory to obtain adequate surface smoothness and gloss.

A rougher surface texture can lead to increased plaque retention, gingival inflammation, irritation of the tongue, lips, and cheeks, and decreased gloss and increased discoloration of the material surface which can affect the restorations' esthetics.[3-5] Smooth surfaces reduce plaque accumulation, recurrent caries, bacterial adhesion, and the discoloration of restored teeth over the long term.[6]

Gloss also plays an important role in the esthetic appearance of composite restorations and their blending to surrounding teeth.[7] High gloss reduces the effect of a color difference between resin composite and surrounding enamel. The color of reflected light is predominant rather than the color of the underlying composite.[8] When different techniques are proposed, not only their efficiency in maintaining a smooth surface but also their ability to obtain a gloss surface have to be considered. Proper contour, smoothness, and high gloss can produce the desired appearance of natural tooth structure desired by patients.[9] Therefore, it is of paramount importance to obtain smooth and glossy surfaces.

The final surface polish of resin composite restorations could be affected by many variables, such as resin composite type, resin monomer type, the load of filler particles, as well as finishing/polishing (F/P) system used.[10,11]

When different techniques are proposed, not only their efficiency in maintaining a smooth surface but also their ability to obtain a gloss surface have to be considered.[12] This study aims to evaluate the effect of three F/P systems on the surface roughness and gloss of three nanohybrid resin composites and one microhybrid resin composite.

## Materials and Methods

Three nanohybrid resin composites and one microhybrid resin composite were used in the current study (►**Table 1**).

### Surface Roughness Measurements

#### Specimen Preparation and Study Design

A total of 112 specimens (28 specimens per each restorative material) were fabricated using a cylindrical Teflon mold (10 mm wide × 2 mm tall) and covered by Mylar strip (SS White, United States). Restorative materials were applied and light cured following the manufacturers' instructions with an LED light-curing unit (Bluephase C8, Ivoclar Vivadent, AG, Schaan, Liechtenstein) with light irradiance 800 mW/cm$^2$. The light irradiance was verified using a digital readout dental radiometer (Bluephase Meter, Ivoclar Vivadent). Each restorative material group was further divided into four subgroups according to the finishing and polishing system used; one control (Mylar strip) and three testing subgroups ($n = 7$).

*Group 1*: Specimen maintained without F/P after removal of Mylar strip to act as a control group (seven specimens per each material group).

The remaining 84 specimens were treated with superfine grit finishing diamond bur (25 µm, no. 837 KREF.314.014, Brasseler) attached to a high-speed handpiece with a cooling system for 30 seconds at 200,000 rpm to simulate the clinical procedure of "primary" finishing of resin composite restorations. A slow-speed handpiece (10,000 rpm) with standardized pressure (2 kg) and brushing strokes for 30 seconds (10 seconds per grit) was used for all polishing according to the manufacturer's instructions. A conscious effort was made to standardize the strokes according to previous protocols.[13,14]

*Group 2*: The specimens were finished and polished with an Optrapol lens, a one-step system.

*Group 3*: The specimens were finished with Politip F and then polished with Politip P flames. After each polishing step, the specimen was rinsed with water spray and air dried to produce a smooth "uniform" surface.

**Table 1** Materials used in the study

| Restorative material | Specification | Shade | Manufacture | Matrix | Filler | Average filler size (µm) | Filler loading weight/volume (%) | |
|---|---|---|---|---|---|---|---|---|
| IPS Empress Direct (ID) | Nanohybrid composite | A3 Dentin | Ivoclar Vivadent AG, Schaan, Liechtenstein | Bis GMA, UDMA TEGMA. | Barium glass, Ba-Al-fluorosilicate glass, and mixed oxide | 0.7 | 81.2 | 64.3 |
| Grandio (GR) | Nanohybrid composite | A3 | Voco, Cuxhaven, Germany | Bis-GMA, UDMA, TEGD MA, DMA | Glass–ceramic microfillers Silicon dioxide nanofillers | 1 0.020–0.060 | 87 | 71.4 |
| Filtek Z350 | Nanohybrid composite | A3 | 3M ESPE, St. Paul, Minnesota, United States | Bis-GMA, UDMA, Bis-EMA, TEGM A and PEGDMA | Surface modified zirconia/silica Nonagglomerated/nonaggregated surface-modified silica particles | 0.1–10 0.02 | 81.8 | 67.8 |
| Filtek Z250 | Microhybrid composite | A3 | 3M ESPE, St. Paul, Minnesota, United States | Bis-GMA, UDMA, Bis-EMA, TEGDMA | Zirconia, silica | 0.01–3.5 | 75–85 | 60 |

Abbreviations: Bis-GMA, bisphenol-A glycidyl methacrylate; DMA, dimethacrylate; PEGDMA, polyethylene glycol dimethacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate.

 

**Table 2** Finishing systems used in the study

| Brand names | Specification | Manufacture | Type | Composition | Batch number |
|---|---|---|---|---|---|
| Optrapol | One-step polishing system | Ivoclar Vivadent AG, Schaan, Liechtenstein | Rubber lens | Caoutchouc, silicone, carbide, aluminum oxide, titanium oxide, iron oxide | SL1794 |
| Politip | Two-step polishing system | Ivoclar Vivadent | Rubber flame | Silicone rubber, silicon carbide particles, and titanium oxide | Pl1829 |
| Sof-Lex | Three-step polishing system | 3 M Dental Products ESPE, St. Paul, Minnesota, United States | Silicon disc | Aluminum oxide<br>Medium (40 mm)<br>Fine (24 mm)<br>Superfine (8 mm) | N204788 |

*Group 4*: The specimens were finished and polished with a three-step Sof-Lex aluminum oxide disc system (►**Table 2**). The discs have a small round eyelet that snaps onto the mandrel, which was then mounted on a low-speed handpiece. The specimens were finished/polished with Sof-Lex discs in a descending sequence of abrasiveness, dark blue Sof-Lex disc (medium), fine Sof-Lex (blue), and superfine Sof-Lex (light blue) with uniform light pressure and a planar motion from the bulk of the restoration toward the margins. After each polishing step, the specimen was rinsed with water spray and air dried to produce a smoother, more uniform finish. After completing polishing procedures, specimens were rinsed, cleaned in an ultrasonic cleaner for 3 minutes and air dried.

The surface roughness (Ra, mm) was measured by a novel three-dimensional (3D) method using an image analysis software attached to an environmental scanning electron microscope (ESEM) (Quanta 200, FEI Co., Oregon, United States) to provide both qualitative and quantitative assessments of surface roughness. Specimens were photomicrographed at × 1,000 magnification. Those images were then analyzed quantitatively using microscopy installed image analysis software (XT document). The used microscope employed a scanned electron beam and electromagnetic lenses to focus and direct the beam on the specimen surface in an identical way as a conventional SEM. A very small, focused electron spot was scanned over a small specimen area. The beam electrons interacted with the specimen surface layer and produced various signals (information) that were collected with appropriate detectors. The output of these detectors modulated, via appropriate electronics, the screen of a monitor to form an image that corresponded to the information, pixel by pixel, emanating from the specimen surface.[2]

The images were captured, and software data were recorded and represented in an excel spreadsheet.[15]

### Gloss Measurements

The same study design, which previously mentioned in surface roughness test, was followed in surface gloss testing. Surface gloss was measured with a glossometer (PICOGLOSS 560MC, ERICHSEN GmbH & Co. KG, Germany). The measuring principle of this device is based on a light beam that strikes the surface at an angle of 60 degrees.[16] The glossmeter measures the intensity of the reflected light and compares it with a reference value.[17] Measurements were presented in gloss units (GU).

### Statistical Analysis

Statistical analysis was performed using an SPSS (version 17) software program (SPSS; Chicago, Illinois, United States). Initially, the normal distribution of errors and the homogeneity of variances were checked by Shapiro–Wilk's test and Levene's test. Based on these preliminary analyses, data of each test were separately analyzed using the two-way analysis of variance (ANOVA) and Tukey's honestly significant difference post hoc test. A Pearson's test was performed to investigate the correlation between the surface roughness and surface gloss data. All analyses were performed at a significance level of $\alpha = 0.05$.

## Results

### Surface Roughness Results

#### Qualitative Evaluation

Representative 3D images of different F/P procedures were observed with ESEM after scanning the entire surfaces of specimens. Each roughness image revealed three peaks, which are ($X$, $Y$, $Z$) as follows:

$X$-coordinate represents the length of each peak.

$Y$-coordinate represents the width of each peak.

$Z$-coordinate represents the height of each peak.

At the $Z$-axis, the peaks or surface elevations were marked, and the height of each peak was automatically computed. Mean surface roughness values (Ra) were calculated for each specimen. Ra describes the arithmetic mean of all values of the roughness profile (R) over the evaluated length.

For all resin composites (►**Fig. 1**), it was observed relatively uniform surface topography in the control group (Mylar strip). In contrast, irregular surfaces are produced after polishing procedures (one-step Optrapol, two-step Politip, and multistep Sof-Lex). The topographical analysis showed that the smoothest surfaces associated with Sof-Lex, while the highest surface irregularities were observed with Optrapol among finishing techniques.

Among finishing techniques, as illustrated in ►**Fig. 2**, the topographical analysis showed that the smoothest surface

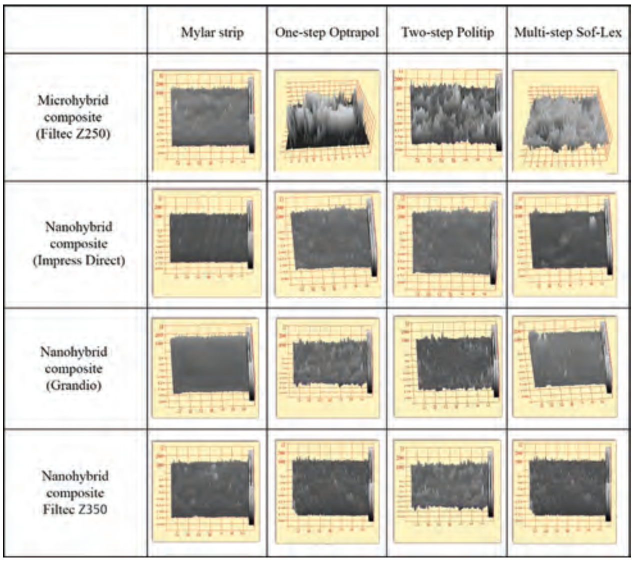


**Fig. 1** Comparison between Filtek Z250, IPS Empress Direct, Grandio (GR), and Filtek Z350 in Mylar strip, one-step Optrapol, two-step Politip, and multistep Sof-Lex polishing systems.

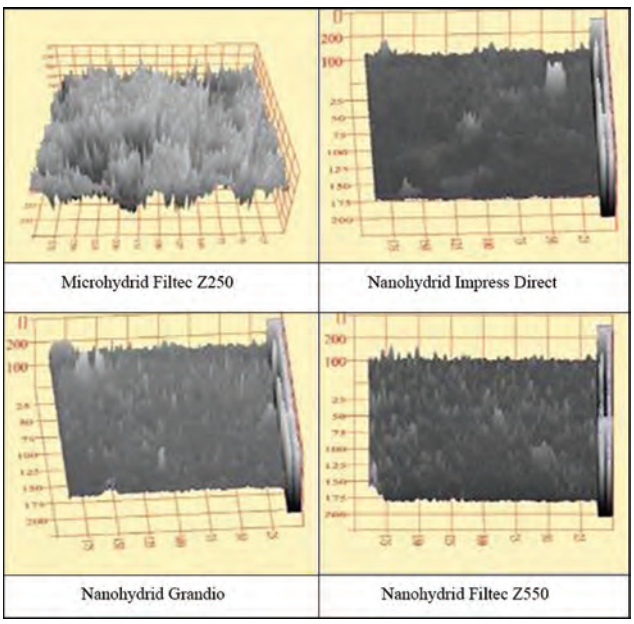


**Fig. 2** Comparisons between composite materials after finishing/polishing with Sof-Lex.

associated with Sof-Lex. For microhybrid composite (Z250) specimens, more irregularities were detected on the surface in comparison with nanohybrid (Impress Direct, Grandio, and Filtek Z350).

### Quantitative Evaluation

A 3D surface roughness profile was automatically plotted. At the *Z*-axis, the peaks or surface elevations were marked and automatically computed. Mean surface roughness values (Ra) were calculated for each specimen. Ra describes the arithmetic mean of all values of the roughness profile (R) over the evaluated length.

The results of a two-way ANOVA test revealed that "type of composite" and "F/P techniques" significantly affect the surface roughness values ($p > 0.0001$). The interaction of both variables was also significant ($p > 0\ 0.0001$). Mean Ra and standard deviation values of the four composite materials (IPS Empress Direct [ID], Grandio [GR], Filtek Z350 [Z350], and Filtek Z250 [Z250]) after different surface treatments are shown in ►**Table 3**.

### Surface Gloss Test

The results of the two-way ANOVA test revealed that "type of composite" and "F/P techniques" significantly affect the surface gloss values ($p = 0.0001$). Gloss values (GU) of the tested groups are shown in ►**Table 4**.

## Discussion

Successful restoration should replicate surface smoothness and gloss of human enamel. The present study compared the surface roughness and surface gloss of four different composite resin restorative materials: three nanohybrid (Empress Direct, Grandio, and Filtek Z350) and one microhybrid resin composites (Filtek Z250) before and after F/P with different systems. These restorative materials were selected based on filler size. Additionally, the polishing systems investigated in this study were selected according to the number of application steps to compare and evaluate the effectiveness of one-step polishers compared with two and multistep polishers.

Surface roughness can be measured by ESEM, which provides both qualitative and quantitative data of surface roughness.[18] In the present study, surface roughness was measured by an ESEM, which can capture an image for the tested specimens with magnification up to × 100,000. The main advantage of ESEM is that the specimens could be observed inside its low-vacuum chamber in a relatively wet condition. Moreover, it can examine the nonconducting, contaminated, hydrated, and even living samples without "long" tedious dehydration procedures, which may affect the integrity of the biological specimens.[19] In comparison with SEM, ESEM provides a reliable idea about the material behavior in relatively humid environment.[19]

Nevertheless, the outcome of the roughness test of the current laboratory study revealed that the smoothest composite surfaces were obtained with Mylar strips; it is not applicable in a true clinical scenario. Mylar strips were used as a control group according to previous studies.[20,21] Several previous studies supported that unpolished surfaces that obtained under Mylar strip of all tested composites were significantly smoother than polished specimens.[22-24] However, the removal of the outermost composite layer by F/P procedures is necessary to produce a wear-resistant, harder, and color stabilized restoration.[25]

The current study shows that the multiple-step system (Sof-Lex) is the most effective polishing method in the creation of a smooth surface for tested composites compared with the one- and two-step system. The superiority of this

**Table 3** Roughness values (μm) of the tested groups

| Polishing systems | Z250 | ID | GR | Z350 |
|---|---|---|---|---|
| Group 1 | | | | |
| Mylar strip | $0.299 \pm 0.03^{d,A}$ | $0.216 \pm 0.05^{c,B}$ | $0.214 \pm 0.05^{d,B}$ | $0.246 \pm 0.06^{d,B}$ |
| Group 2 | | | | |
| One-step Optrapol system | $1.606 \pm 0.03^{a,A}$ | $0.84 \pm 0.05^{a,D}$ | $0.953 \pm 0.09^{a,C}$ | $1.203 \pm 0.04^{a,B}$ |
| Group 3 | | | | |
| Two-step Politip system | $1.53 \pm 0.03^{b,A}$ | $0.72 \pm 0.06^{b,D}$ | $0.85 \pm 0.04^{b,C}$ | $0.917 \pm 0.04^{b,B}$ |
| Group 4 | | | | |
| Multistep Sof-Lex system | $1.323 \pm 0.03^{c,A}$ | $0.67 \pm 0.03^{b,D}$ | $0.72 \pm 0.05^{c,C}$ | $0.819 \pm 0.05^{c,B}$ |

Note: Values are means ± standard deviation. Groups identified by different superscripts were significantly different ($p < 0.05$). The same superscript letters (A–D) in the same row indicate no significant difference (Tukey's honestly significant difference [HSD] test; $p < 0.05$). The same superscript letters (a–d) in the same column indicate no significant difference (Tukey's HSD test; $p < 0.05$).

**Table 4** Two-way analysis of variance of surface gloss values factor

| Polishing systems | Z250 | ID | GR | Z350 |
|---|---|---|---|---|
| Group 1 | | | | |
| Mylar strip | $51.57 \pm 4.2^{a,B}$ | $75.93 \pm 5.2^{a,A}$ | $76.57 \pm 4.7^{a,A}$ | $73.93 \pm 4.97^{a,A}$ |
| Group 2 | | | | |
| One-step Optrapol system | $32.14 \pm 1.8^{d,B}$ | $42.9 \pm 1.1^{d,A}$ | $42 \pm 2.02^{d,A}$ | $42 \pm 1.19^{c,A}$ |
| Group 3 | | | | |
| Two-step Politip system | $36.9 \pm 1.49^{c,B}$ | $46.79 \pm 2.6^{c,A}$ | $46.79 \pm 3.3^{c,A}$ | $45.7 \pm 3.98^{c,A}$ |
| Group 4 | | | | |
| Multistep Sof-Lex system | $41.9 \pm 1.5^{d,B}$ | $55.6 \pm 3.3^{b,A}$ | $55.86 \pm 2.6^{b,A}$ | $53.7 \pm 3.67^{b,A}$ |

Note: Values are means ± standard deviation. Groups identified by different superscripts were significantly different ($p < 0.05$). The same superscript letters (A–D) in the same row indicate no significant difference (Tukey's honestly significant difference [HSD] test; $p < 0.05$). The same superscript letters (a–d) in the same column indicate no significant difference (Tukey's HSD test; $p < 0.05$).

method could be explained by the sequential order of using decreased abrasiveness, which enhances the final surface texture. This result is not achieved with one-step polishing systems.[26] The results of the current study were in agreement with the study by Venturini et al,[27] who reported that the effective finishing system (abrasive) must incorporate relatively harder abrasives than the resin composite's filler particles. Otherwise, the polishing agent would only remove the soft resin matrix and leave the filler particles protruding from the surface.[17] Moreover, the aluminum oxide cutting particles of Sof-Lex disc (which is higher than silicon particles of Politip and Optrapol) are harder than most filler particles of the resin composite used.[28] This property allows removing of both fillers and soft resin matrix during finishing procedures. Also, Sof-Lex discs can remove both fillers particles as well as the matrix.[15]

A recent study by Rodrigues-Junior et al[29] confirmed that the multistep systems produced lower surface roughness and higher gloss than the one-step system. Surface gloss is another factor playing an essential role in the longevity of resin composite restorations.[16]

In the present study, the highest gloss values were obtained with Mylar strips followed by the three-step polishing system, then the two-step polishing system, while the least gloss values were recorded with the one-step polishing system. These findings were in agreement with Lopes et al[30] who reported that finishing and polishing procedures require sequential use of instrumentation with gradually smaller grained abrasives to achieve the desired glossy surface ultimately. Conversely, the outcome of this study disagreed with Da Costa et al (2007),[17] who reported that one-step systems have the highest gloss values.

The results of this study showed that the surface roughness values of unpolished specimens were not exceeding 0.3 μm. Studies reported that patients could not detect rough surface when the Ra is 0.5 μm.[31] In contrast, a previous study reported that dental plaque may accumulate on resin composite surfaces when the Ra is below 0.5 μm.[32] The mean roughness value of three nanohybrid resin composites (ID, GR, and Z350) produced values below the maximum limit (0.7–1.44 μm) at which dental plaque cannot accumulate on composite specimens.

In the present study, nanohybrid composites (ID, GR, and Z350) exhibited lower surface roughness than Z250. This finding can be attributed to their nanotechnology manufacturing techniques. The outcome of this study was in total agreement with several previous studies.[9,33] The study by Mitra et al[34] attributed this difference to the high filler content, the reduction of filler size, and an even filler distribution within the resin matrix. In addition to the strong chemical integration of nanoparticles into the resin matrix, the filler particles become situated as close together as possible to protect the resin matrix from abrasives. Thus, nanocomposites wear by breaking off individual primary particles rather than by breaking off larger particles, as in hybrid composites.[11,34] The outcome of this study was in total agreement of several previous studies which stated that the nanohybrid material can be referred to as a "nanofiller loaded resin composite."[35-37]

The current study showed that the highest gloss values were recorded with nanofilled resin composite specimens. This result was in accordance with Heintze et al,[38] who stated that gloss was material dependent. In the present study, there was a significant inverse linear relationship between roughness and gloss, which is reported previously in several studies.[39,40] This relationship was previously reported by Watanabe et al,[15] who stated that when the surface roughness is increased, the degree of random reflection of light will increase, consequently resulting in decreased gloss. Conversely, Heintze et al[38] disagreed with this relationship and reported that correlations between gloss and roughness were in general absent.

## Conclusion

In light of the results of the current study, it can be concluded that:

- Both surface roughness and gloss were significantly influenced by the F/P systems and the composite resin filler particle size.
- A multistep F/P system (Sof-Lex) exhibits the most efficient F/P protocol of resin composite restorations.
- There was an inverse relationship between surface roughness and surface gloss.

## Recommendation

Further studies are needed to invent a new F/P system that can obtain a surface topography similar to those which can be obtained by Mylar strips.

**Conflict of Interest**

None declared.

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