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Short Communication

Evaluating the Effectiveness of a Synthetic Composite Polishing Paste on the Surface Roughness of Light-Curing Resin Composite: An In Vitro Study

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Abstract

Background: Achieving a smooth and fine surface texture in resin composites is necessary. The study aimed to compare the influence of two polishing pastes on the surface roughness of three composite resins.

Methods: To this end, 90 resin composite specimens (hybrid, micro-hybrid, and nano-hybrid types) were selected for analysis and divided into nine groups of 10. The specimens were polished for 30 seconds with Enamelize and manufactured polishing pastes. Then, surface roughness was assessed using profilometry. Eventually, a two-way analysis of variance with Tukey's post-hoc test was used to analyze the data.

Results: The smoothest surfaces (Ra = 0.37 µm) were achieved with nano-hybrid composites polished using the manufactured paste. Conversely, the roughest surfaces (Ra = 1.78 µm) were observed in the unpolished micro-hybrid group. Nano-hybrid composites demonstrated superior polishability compared to hybrid and micro-hybrid composites. Manufactured paste resulted in less roughness in all three composite groups.

Conclusion: No statistically significant difference in surface roughness was observed between the Enamelize and manufactured polishing groups.

Keywords: Composite, Finishing, Polishing, Surface roughness

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Background

Resin composites remain the most prevalent restorative material in the aesthetic zone. Composites offer excellent tooth structure preservation, durability, and versatility. Their applications range from caries management to cosmetic enhancements, including malalignment, discoloration, and veneer placement (1). However, limitations exist, including polymerization shrinkage, meticulous isolation (2), lower wear resistance compared to ceramics (3), susceptibility to chipping, and suboptimal bonding to dentin and root surfaces. Furthermore, composites lack inherent antimicrobial properties. Various resin composite materials affect the handling and physical properties of restorations (1).

The surface quality of the composite resin is affected by different factors, such as filler particle size, filler loading and resin content, the type of filler used, and particle morphology (4-6). In restorative dentistry, meticulous finishing and polishing are crucial for aesthetic and functional outcomes. Commonly employed instruments include diamond and carbide burs, abrasive discs, and rubber points. Research consistently demonstrates that optimal surface smoothness in composite restorations is achieved through a sequential process, that is, finishing followed by polishing with composite-specific paste (7,8).

The omission of proper finishing and polishing leads to increased surface roughness, resulting in adverse consequences, such as plaque accumulation, reduced surface stability, gingival irritation, compromised aesthetics, and discoloration (9-11). A surface roughness threshold of 200 nm has been identified as the limit below which bacterial adhesion can be effectively inhibited (12). This heightened roughness increases the risk of caries and periodontal disease and negatively impacts stain resistance and light interaction with the restoration (4). While operator skill influences surface quality, standardized finishing and polishing protocols have been developed to minimize this variability and ensure consistent results (13,14). Ultimately, these procedures enhance the physical properties, aesthetics, and longevity of composite restorations while inhibiting bacterial plaque accumulation (15).

Therefore, comprehensive finishing and polishing are essential for optimizing the clinical performance and lifespan of composite restorations and reducing periodontal disease risk. Various finishing and polishing systems are available, including diamond burs, rubber cups, discs, and abrasive pastes (16). Some research has shown that aluminum oxide disks yield smoother surfaces (17), and others have confirmed that diamond burs have better efficacy (18). Nonetheless, Hoelscher et al concluded that finishing tips followed by polishing pastes do not achieve the same level of surface smoothness as aluminum oxide (19).

Few studies have compared the efficacy of polishing pastes on the surface roughness of composites. Thus, the objective of the present in vitro study is to evaluate the influence of manufactured and Enamelize polishing pastes on the surface roughness of three types of resin composites (nano-hybrid, micro-hybrid, and hybrid types).

Materials and Methods

Preparing Polish Paste

A prototype polishing paste was prepared according to internationally patented proportions formulated (Table 1). The material was mixed and tubed as displayed in Figure 1.

Preparing Samples

A sample size of 10 per group was determined ($\alpha = 0.05$ and 90% power). Ninety specimens (7 mm diameter × 2 mm height) were fabricated from hybrid, micro-hybrid, and nano-hybrid resin composites (Table 2). Specimens were prepared in Teflon molds lined with Mylar strips and light-cured using a DTE lux E unit (Woodpecker, Guilin, China) at 980 mW/cm² (420–480 nm), according to the manufacturer's instructions. All materials were obtained from Prime Dental Manufacturing (IL, USA). Prior to testing, specimens were stored in distilled water at 37 °C for 24 hours (20).

Specimens were finished using Sof-Lex Pop-On aluminum oxide discs (3M ESPE, St. Paul, MN, USA) for 30 seconds at 10 000 rpm with a low-speed handpiece (NSK, Tokyo, Japan), applying light pressure in a unidirectional manner from the restoration toward the margin to avoid creating a white line at the margin. The procedure was performed dry. Following finishing, the specimens were washed and air-dried (8). Subsequently, they were polished for 30 seconds at low speed using circular motions with either Enamelize (Cosmedent, IL, USA) or the manufactured polishing paste. Nine experimental groups (three composite types × two polishing pastes; n = 10/group) were established.

Surface roughness (Ra) was assessed using a contact profilometer (TR-200 PLUS, TESTECH, Barandal, Philippines) at three locations per specimen (sides and center), employing a tracing speed of 0.5 mm/s, a tracing length of 2 mm, and a cutoff length of 0.25 mm. The surface roughness value (Ra), representing the arithmetic average of the roughness profile, was the most common parameter used for this purpose. All measurements were performed by a single operator. Surface roughness (Ra) was measured for each specimen in three different directions, and the average was recorded. The mean Ra for each group (n = 10) was calculated using these average values.

Table 1. Composition of the Polishing Paste

Material	Weight Percentage (W/W)
Abrasive agent [aluminum oxide (3 μm) and diamond abrasive particles (4-8 μm)]	52
Moisture retention agent	21
Water	10
Silica gel	9
Glycerin	5
Gelling agent	2
Flavor	1

Figure 1. Manufactured and Enamelize Polishing Pastes

Statistical Analysis

Descriptive statistics were computed, and two-way analysis of variance with a Tukey's post hoc test ($P < 0.05$) was used to analyze the data by SPSS, version 23 (IBM, Armonk, New York, USA).

Results

Table 3 presents the mean surface roughness (Ra) values obtained with profilometry. Polishing with the manufactured paste resulted in a significant reduction in surface roughness (Figure 2). The mean Ra value for unpolished composites was 1.17 μm compared to 0.58 μm for those polished with the manufactured paste, representing approximately a twofold increase in surface smoothness. The highest roughness was found in the unpolished micro-hybrid composite, while the lowest roughness was observed in the nano-hybrid composite polished with the manufactured paste.

Figure 3 depicts the stock chart of roughness values of three composite groups. In each composite group, the highest roughness value was observed in the unpolished

Table 2. Composition and Characteristics of Composites and Abrasive Disks

Material	Composition	Producer
Nano-hybrid composite	Bis-GMA - Filler (average particle size = 0.70 µm)	Prime Dental Manufacturing, IL, USA
Micro-hybrid composite	Bis-GMA - Filler (average particle size = 10 µm)	Prime Dental Manufacturing, IL, USA
Hybrid composite	Bis-GMA - Filler (average particle size = 20-40 µm)	Prime Dental Manufacturing, IL, USA
Sof-lex middle-grain abrasive discs	Oxide alloy	3M ESPE, St. Paul, MN, USA

Table 3. Average Surface Roughness (Ra) and SD

Process	Composite	Ra (µm)	SD (µm)
No polishing	Hybrid	1.15	0.58
	Nano-hybrid	0.57	0.22
	Micro-hybrid	1.78	0.65
Polish with Enamelize paste	Hybrid	0.77	0.26
	Nano-hybrid	0.43	0.12
	Micro-hybrid	0.86	0.23
Polish with manufactured paste	Hybrid	0.64	0.18
	Nano-hybrid	0.37	0.09
	Micro-hybrid	0.74	0.17

Note. SD: Standard deviation.

Figure 2. Applying the Polishing Pastes to the Samples

samples. Across all three groups, polishing with the manufactured paste led to lower roughness values compared to the Enamelize paste.

Based on the results (Table 4), there was a statistically significant difference in surface roughness between unpolished and manufactured paste-polished specimens for all three composite types. Furthermore, statistically significant differences in polishability were found among the three composite types.

Discussion

This study evaluated the surface roughness of three resin composite types polished with two different pastes using profilometry and statistical analyses. The resulting surface roughness was influenced by both the composite type and the polishing procedure, which includes factors such as polymerization, finishing, and polishing techniques, as well as operator skill (21-23).

The optimal timing for finishing and polishing composite restorations remains debated, with some advocating immediate post-cure processing (within 5 minutes) while others recommend a 24-hour delay to minimize marginal damage from thermal effects (24). Several factors influence the quality of the finish, including the abrasive material's hardness, geometry, and flexibility, as well as the applied speed (25,26). Operator skill has also been identified as a contributing factor (27). In this study, finishing and polishing were performed 24 hours post-cure, with a single operator to minimize inter-operator variability.

The polish of hybrid composites tends to lack durability (28). This limitation has led to the development of nanocomposites, which provide superior polish and gloss retention compared to hybrid options (29), as supported by some studies (26,30,31). In addition to enhanced surface smoothness, nanocomposites also exhibit reduced polymerization shrinkage, improved color stability, and better aesthetics (32,33).

Optimal surface smoothness was achieved in resin composite restorations in this study. Inadequate finishing and polishing can lead to undesirable outcomes, such as staining, biofilm accumulation, gingival inflammation, and secondary caries (34,35). While the ideal surface roughness remains undefined (with proposed ranges of 0.7–1.44 µm, 0.25–0.50 µm, and 0.2 µm), minimizing surface roughness is expected to reduce bacterial adhesion and staining, thereby mitigating plaque accumulation and the risk of caries and periodontal disease (7).

These findings are consistent with previous research. De Fátima Alves da Costa et al (36) demonstrated that using a felt disc with polishing paste following disc finishing (e.g., Sof-Lex) reduced surface roughness in nano-filled and nano-hybrid composites. Similarly, Ferreira et al (37) reported superior surface smoothness using felt discs and diamond paste compared to aluminum oxide discs, improving the surface finish of the Z350XT nanocomposite and Z250 micro-hybrid composite. Pietrokovski et al (18) also found significantly lower surface roughness with diamond-coated burs compared to disc polishing. Finally, Bansal et al (34) observed the lowest surface roughness with Mylar matrix polishing, followed by the Sof-Lex system.

Pettini et al confirmed the significant impact of finishing and polishing on composite surface quality (8), observing approximately twice the surface roughness (Ra) in unpolished specimens compared to those finished with medium Sof-Lex discs, tungsten carbide milling cutters (Q and UF series), and approximately 20% greater roughness compared to those finished with flame-shaped diamond milling cutters. AlJazairy et al (38) found the

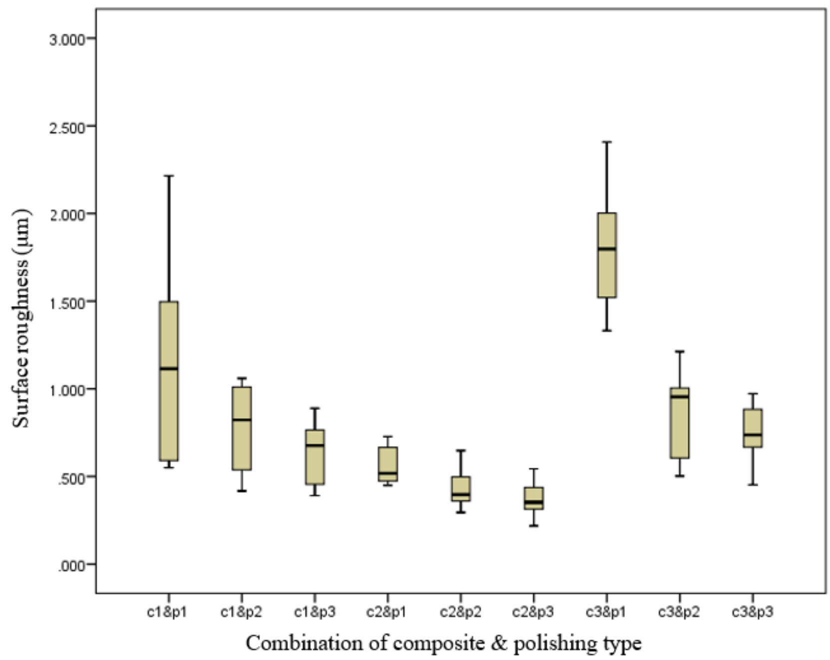

Figure 3. Stock Chart of Roughness Values Determined for Different Groups of Tested Samples: **(C1)** Hybrid Composite, **(C2)** Nano-Hybrid Composite, **(C3)** Micro-Hybrid Composite, **(P1)** No Polishing, **(P2)** Polishing With Enamelize Paste, and **(P3)** Polishing With Manufactured Paste

Table 4. Comparison of Each Polishing Process (No Polishing, Enamelize Polishing Paste, and Manufactured Polishing Paste) on Polishability of Each Composite

Composite	Polish		Mean Difference (µm)	Standard Deviation (µm)	*P*-value (95% Confidence Interval)
Hybrid	No polishing	Enamelize paste	0.38	0.17	<0.01*
		Manufactured paste	0.51	0.17	0.02*
	Enamelize paste	Manufactured paste	0.13	0.17	0.85
Nano-hybrid	No polishing	Enamelize paste	0.13	0.07	0.18
		Manufactured paste	0.19	0.07	0.03*
	Enamelize paste	Manufactured paste	0.06	0.07	0.76
Micro-hybrid	No polishing	Enamelize paste	0.92	0.18	<0.01*
		Manufactured paste	1.05	0.18	<0.01*
	Enamelize paste	Manufactured paste	0.12	0.18	0.88

* Statistically significantly different.

lowest surface roughness values using the PoGo polishing system, with mean Ra values of 0.060 µm and 0.108 µm for nano-hybrid and micro-hybrid composites, respectively.

Kaminedi et al (26) investigated the effect of finishing and polishing time on the surface roughness and microhardness of two composite resins and concluded that all finishing and polishing methods resulted in improved surface smoothness due to the removal of a superficial resin layer.

Consistent with the results of a number of studies (39-41), nano-hybrid composites exhibited the highest polishability with both manufactured and Enamelize pastes. The analysis of variance revealed that the manufactured paste yielded approximately a 100% reduction in surface roughness compared to the unpolished control group. No statistically significant difference in polishing efficacy was observed between the manufactured and Enamelize pastes, highlighting the effectiveness of the manufactured polishing paste in reducing surface roughness across all composite types evaluated in this study.

This study had limitations. First, profilometric roughness measurements were limited to linear profiles, whereas optical techniques could provide a more comprehensive surface area analysis. Second, a single experienced operator performed all procedures. While a standardized protocol was followed, inherent human variability (e.g., attention and tremor) may have influenced the results. Finally, clinicians should consider that composite filler characteristics (hardness, size, and composition) will influence the appropriate finishing and polishing system (17).

Conclusion

The main findings of this study are as follows:

1. The nano-hybrid composite showed more polishability compared to hybrid and micro-hybrid composites.
2. Both polishing pastes influenced the surface

roughness of tested resin composites.

3. The manufactured paste (non-significantly) led to more reduction in surface roughness in all three composite groups compared to the Enamelize paste.

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Authors' Contribution

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Competing Interests

The authors declare that they have no conflict of interests.

Ethical Approval

The study protocol was approved by the Ethics Committee of Hamadan University of Medical Sciences (No. IR.UMSHA.REC.1397.909).

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