

COMPARATIVE EVALUATION OF SURFACE ROUGHNESS AND MICROHARDNESS OF TWO COMPOSITE RESINS HAVING DIFFERENT PHOTO-INITIATORS WHEN SUBJECTED TO TWO DIFFERENT POLISHING SYSTEMS: AN IN VITRO STUDY

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ABSTRACT

Background: Surface properties such as roughness and microhardness play a crucial role in the clinical performance and longevity of composite resin restorations. These properties are influenced by the type of photo-initiator system and the finishing and polishing protocols employed. **Aim:** To comparatively evaluate the surface roughness and microhardness of two composite resins with different photo-initiators when subjected to two different polishing systems. **Materials and Methods:** An in vitro study was conducted using two composite resins based on different photoinitiator systems. A total of 60 samples were prepared and divided into groups based on the composite type and polishing system used. Polishing was performed using Shofu One Gloss (Single step) and Astropol (Multi-step) polishing systems. Surface roughness was measured using a profilometer, and microhardness was assessed using a Vickers hardness tester. Statistical analysis was performed using ANOVA and Tukey's post hoc test. **Results:** Composite resin IPS Empress Direct demonstrated significantly lower surface roughness and higher microhardness compared to 3M ESPE Filtek Z250XT. Among polishing systems, multistep polishing system (Astropol) showed superior performance. Statistical significance was observed ($p < 0.05$). **Conclusion:** Both the type of photoinitiator and polishing system significantly influence the surface properties of composite resins. Selection of appropriate materials and finishing systems is essential for optimal clinical outcomes.

KEYWORDS: Composite resin, photoinitiator, surface roughness, microhardness, polishing systems.

INTRODUCTION

Composite resins are widely used restorative materials due to their superior esthetics and adhesive properties. The clinical success of these materials largely depends on their surface characteristics and mechanical strength. Surface roughness plays a crucial role in plaque accumulation, discoloration, and wear resistance. A smoother surface minimizes bacterial adhesion and enhances the longevity of restorations. Microhardness,

on the other hand, reflects the degree of polymerization and resistance to surface deformation.^[1]

Photo-initiators play a crucial role in the polymerization of composite resins by initiating the conversion of monomers into a cross-linked polymer network upon light activation. Traditional composites primarily utilize camphorquinone as a photo-initiator, which absorbs blue light and initiates polymerization. However, newer

composites incorporate alternative photo-initiators to improve polymerization efficiency, reduce curing time, and enhance mechanical properties. Variations in photo-initiator systems can influence the degree of conversion, cross-link density, and ultimately the surface characteristics of the composite. Therefore, evaluating composites with different photo-initiators provides valuable insights into their clinical performance.^[2]

Polishing procedures further influence the final surface quality of composite restorations. Various polishing systems, ranging from multi-step discs to single-step polishers, are available, each differing in effectiveness. Therefore, this study was conducted to evaluate and compare the surface roughness and microhardness of two composite resins with different photoinitiators subjected to two polishing systems.

MATERIALS AND METHODS

Sample Preparation

A total of **60 composite specimens** were fabricated and divided into two groups-

Group A and Group B were further divided into sub-groups-

Group	Subgroup	Polishing Protocol
Group A	A1	Control (Mylar strip finished surface)
	A2	Single-step polishing (Shofu OneGloss)
	A3	Multi-step polishing (Astropol)
Group B	B1	Control (Mylar strip finished surface)
	B2	Single-step polishing (Shofu OneGloss)
	B3	Multi-step polishing (Astropol)

Inclusion Criteria

- Composite resin specimens fabricated using standardized Teflon molds.
- Specimens prepared using two commercially available composite resins with different photo-initiator systems.
- Samples with uniform dimensions and curing protocol.
- Specimens free from surface defects or irregularities.

Exclusion Criteria

- Specimens exhibiting voids, air bubbles, or marginal defects.
- Samples with contamination during fabrication or handling.
- Non-standardized specimens or those deviating from specified dimensions.

Specimens with pre-existing surface irregularities.

FINISHING AND POLISHING PROCEDURE

All finishing and polishing procedures were performed by a single calibrated operator to minimize operator-induced variability.

- **Group A:** Composite resin with [Camphorquinone] – 3M Filtek Z250 XT
- **Group B:** Composite resin with [Camphorquinone and TPO]- Ivoclar IPS Empress Direct

Specimens were prepared using a standardized mold of dimensions 25 mm diameter × 2 mm thickness.

Each increment was light-cured using an LED curing unit for 40 seconds.

METHODOLOGY

A total of 60 standardized composite resin specimens were fabricated using precision Teflon molds to ensure uniform dimensions and consistency. The samples were equally divided into two primary groups based on the type of composite resin:

- **Group A (n = 30): Filtek Z250 XT (3M ESPE)**
- **Group B (n = 30): IPS Empress Direct (Ivoclar Vivadent)**

Control Group- (A1 and B1)

No finishing or polishing procedures were performed. The surface obtained directly under the Mylar strip was retained as the control.

Subgroups A2 and B2- (Single-Step Polishing – Shofu OneGloss)

Initial finishing was carried out using a tungsten carbide bur to remove superficial irregularities. This was followed by polishing with Shofu OneGloss, a single-step polishing system, applied using a micromotor at standardized speed and pressure in accordance with the manufacturer's instructions.

Subgroups A3 and B3- (Multi Step Polishing – Astropol, Ivoclar)

After initial finishing with a tungsten carbide bur, polishing was performed using the Astropol Composite polishing system, which involves sequential use of abrasives with varying grit sizes to achieve progressive surface refinement.

All procedures were standardized and performed by a single operator to minimize variability.



Fig. 1: Composite A 3M Filtek Z250 XT.



Fig. 2: Composite B IPS Empress Direct Ivoclar.



Fig. 3: Single step polishing kit (One Gloss).

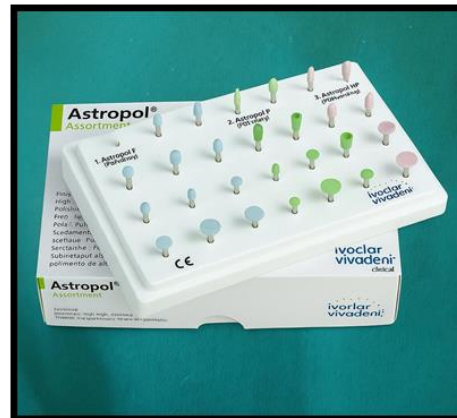


Fig. 4: Multistep polishing kit (Astropol).

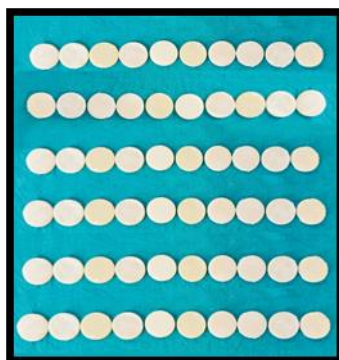


Fig. 5: Composite resin specimens.



Fig. 6: Finishing of specimen with tungsten carbide bur.



Fig.7: Polishing of specimens with Shofu One Gloss polishing kit.

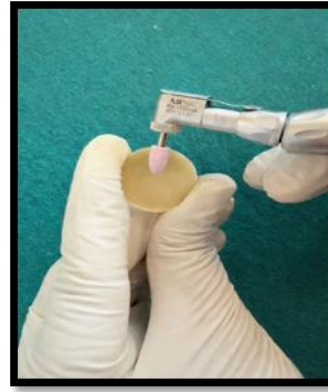


Fig. 8: Polishing of specimens with Astropol polishing kit.



Fig. 9: Evaluation of surface roughness done by Profilometer (Surftest SJ-210) Mitutoyo, Japan,



Fig. 10: Evaluation of microhardness done by Vicker's Hardness Testing Machine (Reichert, Germany).

Evaluation of Surface Characteristics

1. Surface Roughness (Ra)

Surface roughness was measured using a **contact 3D optical profilometer**.

- Three readings were obtained from different regions of each specimen
- The mean value was calculated and recorded in micrometers (μm)

2. Microhardness (Vickers Hardness Test)

Microhardness was evaluated using a **Vickers hardness testing machine**.

- A standardized load was applied for a fixed dwell time.
- Three indentations were made on each specimen.
- The average value was recorded as Vickers Hardness Number (VHN).

RESULTS

Table 1: Mean Surface roughness (Ra μm) of Composite resins.

Group	Description	Mean \pm SD (μm)	ANOVA
A1	Composite 1–No finishing and polishing	0.53 \pm 0.13	0.04*
A2	Composite 1 – Single-step polishing	0.57 \pm 0.30	
A3	Composite 1 – Multi-step polishing	0.30 \pm 0.12	
B1	Composite 2 – Control (Mylar strip)	0.33 \pm 0.10	
B2	Composite 2 Single-step polishing	0.32 \pm 0.14	
B3	Composite 2 – Multi-step polishing	0.28 \pm 0.06	

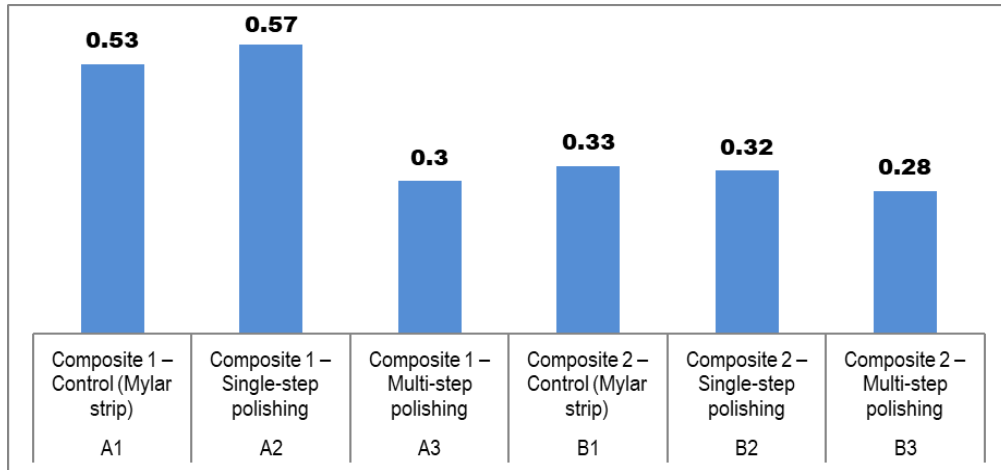


Fig 11. Bar graph showing mean surface roughness (Ra μm) for each group.

Table 2: Mean \pm SD Micro-Hardness of Composite Resins.

Group	Description	Mean \pm SD (HV)	ANOVA
A1	Composite 1 – No finishing and polishing	53.95 \pm 4.39	0.02*
A2	Composite 1 – Single-step polishing	57.32 \pm 2.00	
A3	Composite 1 – Multi-step polishing	58.67 \pm 1.22	
B1	Composite 2 – No finishing and polishing	61.25 \pm 4.41	
B2	Composite 2 – Single-step polishing	63.83 \pm 0.53	
B3	Composite 2 – Multi-step polishing	66.28 \pm 2.86	

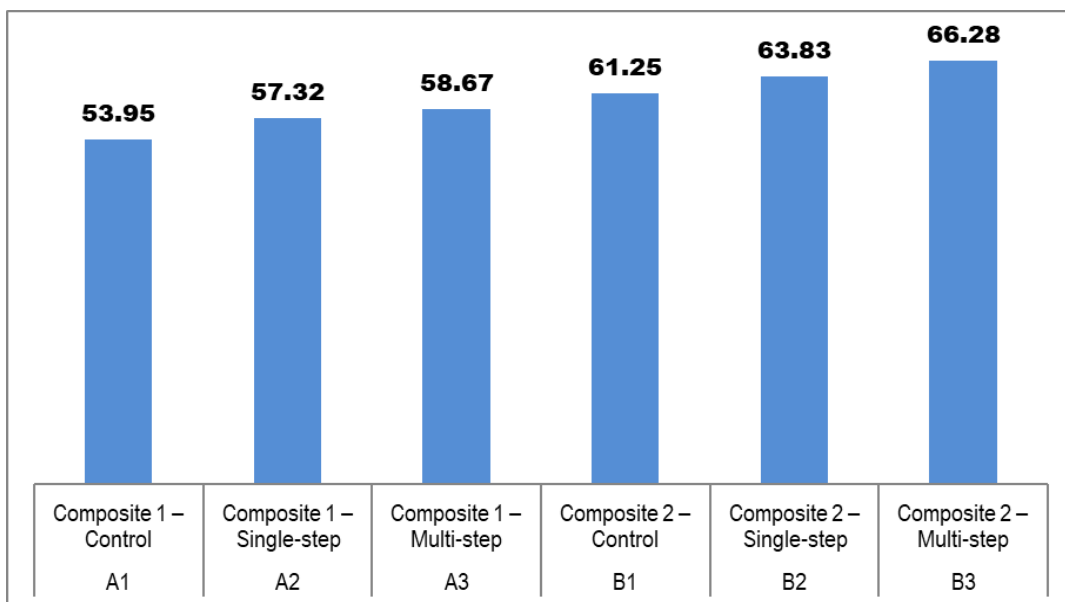


Fig 12: Bar graph showing Mean \pm SD Micro-Hardness of each group.

Table 3: Overall Comparison of Surface Parameters.

Parameter	Best-Performing Group	Interpretation
Surface Roughness	Multi-step (A3, B3)	Lowest Ra values, smoother surfaces
Micro-Hardness	Multi-step (B3)	Highest VHN, statistically significant

IPS Empress direct exhibited the least surface roughness values and smoother surfaces as compared to the control group and Filtek Z250 XT. One way ANOVA show significant difference in comparison of surface roughness values.

IPS Empress Direct shows statistically significant difference in micro-hardness values in comparison to 3M ESPE filtek Z250 XT.

DISCUSSION

The present in vitro study was designed to evaluate and compare the influence of different polishing systems on surface roughness and microhardness of two composite resins with different photo-initiator systems. The findings clearly demonstrate that both the type of polishing protocol and the composite material significantly influence the final surface properties, with a notable interaction between these factors. The results of this study are consistent with a substantial body of literature emphasizing that finishing and polishing procedures are critical determinants of the clinical performance, esthetics, and longevity of composite restorations.

Surface roughness is one of the most critical parameters influencing plaque accumulation, wear resistance, and esthetic longevity of composite restorations. In the present study, a clear and progressive reduction in surface roughness was observed with increasing complexity of polishing systems, following the pattern: control (Mylar strip) > single-step > two-step > multi-step polishing. This trend was highly significant for IPS Empress Direct ($p < 0.001$) and also evident, though less pronounced, for Filtek Z250 XT.

These findings are in strong agreement with Jaramillo-Cartagena *et al.*^[3], who reported in their systematic review that multistep polishing systems consistently produce smoother surfaces compared to simplified polishing protocols. Similarly, Indhira Melo *et al.*^[2] and Rodrigues-Junior *et al.*^[4] demonstrated that multi-step polishing systems yield significantly lower roughness values than one-step systems, attributing this to the sequential reduction in abrasive particle size, which allows gradual refinement of the composite surface. The superiority of multi-step polishing was further corroborated by Büyükpolat *et al.*^[5], who reported that advanced polishing systems significantly reduce surface irregularities and improve surface uniformity.

Microhardness is a key indicator of the mechanical integrity and wear resistance of composite restorations. In the present study, a significant increase in microhardness was observed with the use of more advanced polishing systems, with the highest values recorded in the multi-step polishing groups for both composites. This trend was statistically highly significant ($p < 0.001$), indicating that polishing protocol plays a crucial role in enhancing surface hardness.

These findings are in agreement with Fidan *et al.*^[6] who reported that polishing procedures significantly improve the microhardness of composite resins by removing the superficial resin-rich layer and exposing the more densely polymerized sub-surface. Similarly, Nithya *et al.*^[7] demonstrated that multi-step polishing systems resulted in higher microhardness values compared to single-step systems, highlighting the importance of sequential abrasion in improving mechanical properties. The clinical implication of these findings highlights the importance of selecting appropriate composite materials and polishing protocols to achieve optimal surface characteristics and longevity.

The present study clearly demonstrates that both polishing protocol and composite material significantly influence surface characteristics of composite restorations. While multi-step polishing systems consistently produce superior outcomes in terms of surface smoothness and hardness, intrinsic material properties continue to play a dominant role, particularly in determining mechanical performance.

Advanced polishing techniques can effectively minimize differences in surface roughness and gloss between materials; however, they cannot completely override inherent material characteristics such as filler composition and degree of polymerization. Therefore, optimal clinical outcomes require a combination of appropriate material selection and meticulous finishing and polishing procedures.

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that both the polishing protocol and composite material significantly influence the surface characteristics of composite restorations. Multi-step polishing systems demonstrated superior performance in reducing surface roughness while enhancing microhardness and gloss, thereby providing optimal surface quality. Although single-step system offered moderate improvements, they were less effective compared to multi-step protocols. IPS Empress Direct exhibited better overall surface properties than Filtek Z250XT, indicating the influence of intrinsic material composition on polishing outcomes. However, advanced polishing techniques were able to minimize differences in surface roughness and hardness between the materials, though variations in microhardness persisted. These findings emphasize that while material selection is important, meticulous finishing and polishing play a crucial role in achieving clinically acceptable restorations with improved esthetics, durability, and resistance to plaque accumulation.

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