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Comparative Evaluation of the Surface Roughness and Surface Polishability of a Ceramopolymer Restoration: A Profilometric Analysis

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ABSTRACT

Objectives: The objective of this study is to analyse and compare the surface roughness and polishability of indirect and direct composite ceramage.

Material and Methods: A total of 60 specimens were divided into four groups: Group I (n = 15): Beautifil II Composite (Shofu Inc.) - Control group, Group II (n = 15): Beautifil II Composite (Shofu Inc.) – Super-Snap X-TREME (Shofu Inc.), Group III (n = 15): Ceramage: microhybrid composite (Shofu Inc.) - Control group, Group IV (n = 15): Ceramage: microhybrid composite (Shofu Inc.) – Ceramage Polishing Kit HP (Shofu Inc.). The prepared samples had a diameter of 6 mm and a height of 2 mm. Group I and II samples were polymerised using light-emitting diode units. While group III and group IV were cured using Solidilite V, a profilometer was used to measure the surface roughness after the finishing and polishing procedures.

Results: The current study's findings show that regardless of the kind of composite utilised, polishing treatment on the surface of the material helped minimise surface roughness. A one way ANOVA showed that there is a significant difference in surface roughness between the four groups.

Conclusion: Given the study's constraints, it can be concluded that the indirect composite Ceramage with the Ceramage Polishing Kit HP can produce a lower surface roughness as compared to the direct composite Beautifil II.

Keywords: Composite, Finishing, Polishing, Profilometer, Surface roughness.

INTRODUCTION

Achieving good surface characteristics is a key objective in composite restorations, driven not only by aesthetic concerns but also oral health considerations. Inadequate finishing and polishing techniques can result in surface irregularities, leading to issues such as staining, plaque retention, gingival irritation, recurrent caries, and altered tactile perception.[1] Secondary caries is a major reason behind the replacement of composite resin restorations.[2] Gingival irritation and subsequent caries may result from biofilm growth and bacterial buildup on these restorations.[3]

In the oral environment, post-polymerisation, the unpolished composite surface may generate a resin-rich surface layer, which exposes the surface to abrasion, revealing rough, inorganic filler material. Maintaining such a finish is challenging; additional contouring and finishing are often required.[4] Although the clinical performance of composite restorations is on par with that of ceramic restorations, composite resin-based indirect restorations are increasingly being used due to their lower cost and intrinsic low brittleness, especially in the posterior region.[5]

Many variables, including filler particle size, filler loading, content of resin, and type of filler, affect the surface quality of composite resin. When the surface roughness surpasses 0.2 µm, it can increase plaque retention, thereby heightening the possibility of periodontal inflammation and cavities. Moreover, surface roughness influences the restoration's natural shine and stain resistance.[6] Polishing is performed to reduce the surface roughness of the restorative material, effectively eliminating any scratches formed during the finishing process. However, the effectiveness of polishing

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systems on composites largely depends on the specific product utilised.

The direct technique involves placing the composite directly into the prepared cavity, providing advantages such as a single, relatively inexpensive appointment. Nevertheless, in terms of resistance to wear and polymerisation shrinkage, the indirect approach outperforms the direct method. This is attributed to the fact that indirect composites are polymerised in laboratory-controlled light, heat, and pressure conditions.[7] When it comes to biofilm growth and compromised composite restorations, surface roughness is a major factor. Numerous investigations have reported lower bacterial adhesion on composites with decreasing surface roughness.[8,9]

Therefore, the rationale for this study was to evaluate and compare direct and indirect composite resins using different polishing systems. To ascertain the difference in surface roughness when choosing to use a direct or indirect composite resin. A straightforward comparison between direct and indirect composites was only performed in a few studies.

MATERIAL AND METHODS

Study setting and sampling criteria

The current research study was conducted in the department of Conservative Dentistry and Endodontics, Attavar Balakrishna Shetty Memorial Institute of Dental Sciences, Mangalore, India. The current study was an experimental *in vitro* investigation, created using the modified Consolidated Standards of Reporting Trials (CONSORT).

The current study primarily emphasises two elements.

1) Type of composite: direct composite and indirect composite.
2) Polishing system: Super-Snap X-TREME. Ceramage Polishing Kit HP

The surface roughness was analysed using the random sampling method. The two composite resins were divided based on the various polishing systems used in the *in vitro* experimental research.

Sample size calculation

The nMaster software (STATA, EpiInfo, nQuery, etc.) version 2.0 was used to determine sample size, with 80% power and alpha error of 0.05, to determine the sample size required for the study.

Specimen preparation

Sixty disc-shaped specimens were produced using nanohybrid composite Beautifil II (Shofu Inc., Kyoto, Japan) and indirect composite ceramage (Shofu Inc., Kyoto, Japan). The composite material was inserted into a 2 mm deep mould that was 6 mm in diameter. The mould was overfilled, and a matrix strip was placed on both sides. To extrude extra material, the sample was then compressed with a glass plate. The direct composite samples were subjected to light curing for 20 seconds. For the indirect composite samples, Sublite V was used for 10s for temporary curing of the ceramage, followed by curing for 3 minutes with Solidilite V.

Grouping and randomisation

Group I (n=15) - indirect composite ceramage (Shofu Inc., Kyoto, Japan)

Group II (n=15) - indirect composite ceramage (Shofu Inc., Kyoto, Japan) with Ceramage Polishing Kit HP (Shofu Inc., Kyoto, Japan)

Group III (n=15) - nanohybrid composite Beautifil II (Shofu Inc., Kyoto, Japan).

Group IV (n=15) - nanohybrid composite Beautifil II (Shofu Inc., Kyoto, Japan) with Super-Snap X-TREME Polishing System (Shofu Inc., Kyoto, Japan)

Polishing procedure

While using the Ceramage Polishing Kit HP on the ceramage indirect composite, the Silicone Point was used for gross contouring, followed by the Pivot Brush with Dura-Polish paste at 10,000 rpm. After this, the Felt Wheel was used with Dura-Polish Dia paste at 10,000 rpm.

For the finishing and polishing, Beautifil II using Super Snap X-TREME Technique kit; the Coarse (black) and Medium (violet) Fine (green) and Super fine (red) polishing discs were used on the composite samples at 15000 rpm for 20s in that order.

The specimens were rinsed with water for 10 seconds to remove any dirt and then air dried for 10 seconds before polishing with a disc of lower grit. To avoid heat accumulation or the formation of surface grooves, mild pressure was exerted using a continuous, repeated stroking motion in one direction. A single individual polished the samples, and the polishing speed was standardised by using an electric handpiece. Using a surface profilometer, the surface roughness was ascertained following finishing and polishing. After analysis, the data was tabulated.

Surface roughness analysis

The surface roughness of all specimens was measured with a surface profilometer (Taylor Hobson Ltd.). In this device, a stylus is linked to an extended leverage arm that traces the surface and monitors the stylus's upward and downward motions. R_a is the mean arithmetic vertical displacement assessed across the linear measure of the specimen. An increased Ra value marks a more uneven surface.

Data management and statistical analysis

The quantitative data were presented as mean and standard deviation. The information was assessed to verify normal distribution and ensure variance equality. One-way ANOVA and Tukey/HSD were done to analyse the level of significance, and a P-value < 0.05 was considered statistically significant. The findings were computed using SPSS Software version 20 (IBM, Armonk, NY, USA).

RESULTS

According to the results of our study, the group with the indirect composite Ceramage showed the lowest surface roughness value when polished using the Ceramage Polishing Kit Hp with a mean value of 0.21 ± 0.15. The highest surface roughness was exhibited by the control group of the direct composite Beautifil II with a mean value of 1.21 ± 0.91. The direct composite group on polishing had a mean value of 0.55 ± 0.16, and the indirect composite control group showed a mean value of 1.13 ± 0.72.

The findings of the present study revealed that additional polishing treatments applied to the surfaces of various composites led to a reduction in surface roughness, regardless of the composite type. One-way ANOVA analysis indicated a statistically significant difference in surface roughness among the four groups, as outlined in Table 1.

Table 1: One-way ANOVA analysis: Comparison of the surface roughness among the four groups.

Group	Mean	N	Std. deviation	F value	Sig between groups
Control indirect	1.13	10	.715	6.525	0.001*
Ceramage Polishing Kit HP	0.21	10	.153		
Control direct	1.21	10	.910		
Super snap X-TREME	0.55	10	.160		
Total	.78	40	.704		

ANOVA: Analysis of variance
*: There was a significant difference between the groups when One-way ANOVA was conducted to compare the surface roughness between the groups.

To further investigate these differences, a Tukey's post hoc test was employed for multiple group comparisons, as detailed in Table 2. The results indicated a statistically significant difference in surface roughness between the indirect composite group, using Ceramage with Ceramage Polishing Kit HP, and the control group employing Beautifil II for direct composite (P value = 0.03), signifying a meaningful distinction. However, no statistically significant differences were observed among the other groups apart from the comparison above.

DISCUSSION

It has been shown that the size, hardness, and number of filler particles affect the surface micromorphology of composites after they are finished and polished. It is vital to keep in mind that through the polishing process, the polishing armamentarium must be able to have the resin matrix and filler particles of composites together be consistently removed.[10] The diamond particles within the polishing paste may provide smoother surfaces on composites compared to the aluminium oxide particles present on the polishing discs due to their higher hardness.[11]

Within the current study, two distinct types of composites were assessed concerning their surface properties after

Table 2: Tukey's post hoc test: Multiple group comparisons of the mean surface roughness between groups.

Multiple comparisons
Dependent variable: Surface roughness
Tukey HSD

(I) Group	(J) Group	Mean difference (I-J)	Std. error	Sig.
Control indirect	HP	.917*	.264	.007
	Control direct	-.076	.264	.992
	Super snap	.584	.264	.138
Ceramage Polishing Kit HP	Control indirect	-.917*	.264	.007
	Control direct	-.993*	.264	.003*
	Super snap	-.333	.264	.593
Control direct	Control indirect	.076	.264	.992
	HP	.993*	.264	.003*
	Super snap	.660	.264	.076
Super snap X-TREME	Control indirect	-.584	.264	.138
	HP	.333	.264	.593
	Control direct	-.660	.264	.076

*Significance difference
Tukey HSD: Tukey's honestly significant difference, HP: Ceramage Polishing Kit HP, Sig: Significance. I and J are the group names given in the table for comparing the 1st group with the 2nd group to do multiple comparisons.

employing different polishing materials. The control groups underwent no polishing, while the experimental groups for Ceramage and Beautifil II were subjected to polishing using the Ceramage Polishing Kit HP and Super-Snap X-Treme, respectively.

According to the results, the smoother surface is produced by the Ceramage Polishing Kit HP polishing system. This result could be attributed to the use of diamond polishing paste (Dura-Polish Dia), which produces a smoother surface in the indirect composite Ceramage despite being a microhybrid composite containing zirconium silicate filler particles. Our results suggest that the material of the surface plays a more significant role in determining its final smoothness than the specific steps involved in the polishing process. For an effective polishing system, the abrasive particles need to possess higher degrees of hardness than the fillers used.[12] Suppose the abrasive particles lack sufficient hardness compared to the fillers; in that case, they may selectively remove the softer resin matrix, leaving behind protruding filler particles on the surface, resulting in a rougher finish.[13]

As per the manufacturer's specifications, the direct composite utilised in this study was composed of nanohybrid fillers, while the indirect composite featured microhybrid fillers. This distinction may explain why the indirect composite, despite being composed of zirconium disilicate and polished with diamond polishing paste, did not exhibit a superior surface roughness compared to the direct composite. The latter was polished using aluminium oxide polishing discs across more comparison groups. This observation aligns with findings from other studies that suggest that nanohybrid resin composites tend to result in smoother surfaces than their microhybrid counterparts following various polishing procedures.[14] It can also be taken into consideration that the flexibility of the aluminium oxide discs of the Super Snap X-TREME polishing kit helped maintain a uniformly smooth surface.[15] While the Ceramage Polishing Kit HP used a silicone point for gross reduction followed by a pivot brush and Felt Wheel for polishing, which may have caused the indirect composite, which is composed of a microhybrid fillers not to produce as smooth a surface as could have been produced had the indirect composite used was one containing nanohybrid fillers. In clinical scenarios necessitating intraoral adjustments for both direct and indirect composites, the use of diamond paste for polishing appears to be a favourable option. This technique has shown superior results in terms of improving surface characteristics and decreasing the production of biofilms.[16]

Interestingly, none of the materials achieved the desired surface smoothness of 0.2 μm despite undergoing polishing procedures. This finding highlights the crucial role of polishing duration in influencing the outcome. For resin-based composites specifically, Jones et al. suggest using the Super-snap aluminum polishing disc system for 25 seconds per step to achieve optimal results.[17] The present study employed a 20-second application time for each polishing disc, as recommended by the manufacturers. This relatively short duration might be a contributing factor to the observed surface roughness exceeding the clinical standard of 0.2 mm for all materials.[18]

Within the constraints of this study, the findings may imply that indirect resin composites are more suitable for restorations requiring adjustments after cementation, particularly in achieving a smoother final surface compared to direct resin composites.

CONCLUSION

Considering the limitations of the study, it can be deduced that the finishing and polishing procedures applied to the indirect composite Ceramage, specifically using the Ceramage Polishing Kit HP, result in a lower surface roughness when compared to the direct composite Beautifil II.

Ethical approval: Institutional Review Board approval is not required. As this study involved composite pellets and did not include human or animal subjects, ethical approval is not required.
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