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# IN VITRO COMPARATIVE EVALUATION OF SURFACE ROUGHNESS OF THREE DIFFERENT COMPOSITE RESINS AFTER FINISHING AND POLISHING PROCEDURE - AN ATOMIC FORCE MICROSCOPIC ANALYSIS.

Dental Science

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## ABSTRACT

**Background/Purpose:** The finishing and polishing procedures may affect the surface roughness of composite resins. This study is aimed to evaluate the surface roughness of Nano-hybrid, Micro-hybrid, and Bulk-fil composite resins after the finishing-polishing procedure. **Materials and Methods:** Thirty cylindrical disks of dimension (8mm diameter x 2mm thickness) were prepared. These disks were randomly distributed into 3 different groups (n = 10) based on different composite resins are Nano-hybrid (Filtek Z250 XT), Micro-hybrid (Filtek P-60) and Bulk-fil (Filtek Bulk-Fill) composite resins used. Super snap kit (Sofu, Japan) was used as a finishing/polishing system. Statistical analysis of the data was performed by using one-factor analysis of variance (ANOVA) and Tukey's HSD (honestly significant difference) post hoc test ($\alpha$=2) $P < 0.05$. **Results:** All the tested samples showed surface roughness. Nano-hybrid exhibited the least surface roughness (0.0361 µm,) followed by micro-hybrid (0.0815 µm) and bulk-fill (0.1339µm), which exhibited the highest surface roughness. ($P< 0.001$) **Conclusion:** Filtek Z250 XT exhibited better smooth surface as compared to all groups.

## KEYWORDS

Atomic Force Microscope (AFM), Composite, Finishing/Polishing system, Surface Roughness, restorative materials.

## INTRODUCTION

Aesthetic restorative materials are widely used in dentistry due to their optical and mechanical properties which are comparable to those of enamel and dentin making them more reliable biomimetic replacements.[1]

The introduction of nanoparticle-filled composites with improved mechanical, physical, and optical properties, and clinical performance, makes the use of such material possible for both anterior and posterior restorations.[2]

Finishing and polishing composite resins are important steps in restorative dentistry.[3] A smooth surface enables clinical durability, good aesthetic appearance, and better optical compatibility as well as preventing discolouration and staining of the restoration.[4,5] Therefore, the smoothness of restoration is of utmost importance for its long-term success with acceptable aesthetics.[3]

A variety of rotary instruments and materials are commonly used to achieve a smooth glossy surface which includes carbide finishing burs, diamond finishing points, abrasive-impregnated rubber cups, aluminium oxide-coated abrasive disks, abrasive strips, and polishing pastes.[5] However, aluminium oxide discs are non-destructive which provides adequate surface smoothness as these discs do not displace the composite fillers and promote a homogenous abrasion of the fillers and the resin matrix.[6]

Surface roughness can be measured up to a nanoscale by qualitative methods, such as scanning electron microscopy (SEM), or quantitative methods, such as profilometry. In recent years, atomic force microscopy (AFM) has been used in dentistry to study the various characteristics of different materials. Furthermore, Atomic Force Microscope (AFM) allows three-dimensional (3D) imaging at a nanometric resolution and is also used to map the topography to study the properties of the material on a nanoscale.[7] Green et al (2003), Miles et al (2003), and Seitavuopio et al (2003) also reported in their study that AFM has high precision and sensitivity in detecting details, it also allows 3-D imaging at a Nanometric resolution and does not require any specific environment to work in and for the preparation of the specimen.[8]

This study investigated the surface roughness (Ra, µm), of 3 different composite resins following finishing and polishing with aluminium oxide-coated abrasive discs using an Atomic Force Microscope.

## MATERIALS AND METHODS

### Specimen Preparation

Thirty cylindrical plastic moulds (8 mm inner diameter x 2 mm length) were prepared using plastic tube, which were placed on the glass microscope slide (BEXCO). These moulds were randomly divided into 3 groups with 10 samples (n=10) in each group: Group I (n = 10) — Nano-hybrid composite - Filtek Z250 XT (3M ESPE, USA), Group II (n = 10) — Microhybrid composite- Filtek P-60 (3M ESPE, USA), Group III (n = 10) — filtek Bulk-fill composite (3M ESPE, USA)

The restorative material (8mm diameter x 2mm thickness) was placed directly into the mould in one increment using Teflon coated hand instrument (GDC, INDIA) covered with a polyester strip (SHOFU, Japan). The material was then polymerized for 10 sec from all sides as per manufacturer instructions with Blue phase LED (Light Emitting Diode) Curing Light (Ivoclar-Vivadent, Liechtenstein). All the samples were kept in distilled water until further use.

### Finishing and Polishing Procedure

All the specimens were subjected to finishing/polishing within the following sequence from black to red (coarse to extra fine): Black (coarse), violet (medium), green (fine), and red (extra-fine) graded series of Super-snap (Shofu, Japan). Finishing/Polishing was carried out at 10,000 rpm for coarse and medium discs and 30,000 rpm for fine and extra fine discs in planar motion. Discs once used were discarded after each polishing step. All the samples were air-dried and stored in distilled water.

### Evaluation

Specimens were then viewed under NT-MDT Atomic Force Microscope, in contact mode with CONT20A-CP tip at 1 Hz scan rate and 256 × 256 resolution to obtain surface topography on a 90 × 90 µm scanning area. Arithmetical mean deviation of surface roughness (Ra) topographic data were processed by Scanning Probe Microscopy (SPM) image processing software called Scanning Probe Image Processor (SPIP 6.0.10)

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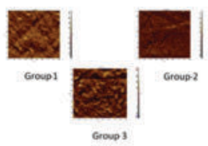
**Statistical Analysis**

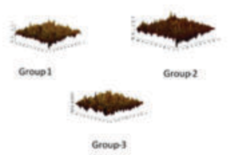
Analysis was performed on SPSS software (Windows version 22.0). Data were analysed by one factor analysis of variance (ANOVA) and the significance of mean difference between (inter) the groups were done by Tukey's HSD (honestly significant difference) post hoc test after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test. A two-tailed ($\alpha$=2) $P < 0.05$ was considered statistically significant.

## RESULTS

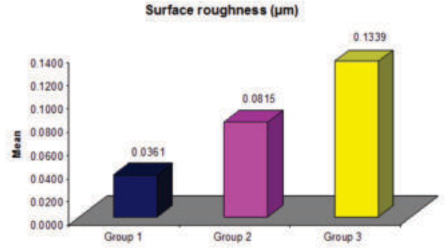
The results showed that amongst all the composites used variables surface roughness was found. The surface roughness of Group I, Group II and Group III ranged from 0.0131-0.0656, 0.01860.1352 and 0.0656-0.1810 µm, respectively with mean (± SD) 0.0361 ± 0.0187, 0.0815 ± 0.0428 and 0.1339 ± 0.0333 µm, respectively and median 0.0378, 0.0806 and 0.1305 µm, respectively. The mean surface roughness of Group I was the minimum followed by Group II and Group III (Group I < Group II < Group III) (Table 1and Graph 1).

Further, on intergroup comparison based on the difference in mean surface roughness, Tukey test showed Group I having least surface roughness as compared to both Group II (0.0361 ± 0.0187 vs. 0.0815 ± 0.0428, mean diff=0.0454, q=4.34, $P < 0.05$) and Group III (0.0361 ± 0.0187 vs. 0.1339 ± 0.0333, mean diff=0.0978, q=9.35, $P < 0.001$) (Table 2 and Graph 2) which was statistically significant. The difference in mean surface roughness was statistically significant ($P < 0.0001$) in all the three experimental groups.

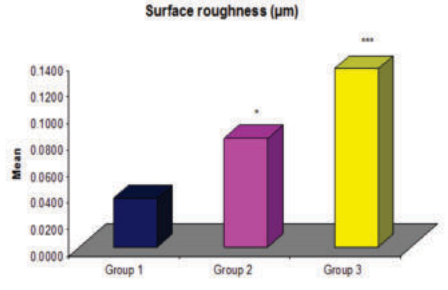



| Figure.1- 2- Dimensional image of sample | Figure.2- 3- Dimensional image of sample |
|---|---|




**Graph 1. Bar Graph Showing Mean Surface Roughness Of Three Groups**




*P < 0.05 or ***P < 0.001 - as compared to Group 1

**Graph 2. Bar Graph Displaying Comparisons Of Difference In Mean Surface Roughness Between Three Groups**

**Table 1: Mean Surface Roughness (µm) Of Three Groups Tested**

| Group | n | Mean ± SD | F value | P value |
|---|---|---|---|---|
| Group I | 10 | 0.0361 ± 0.0187 | 21.88 | < 0.001 |
| Group II | 10 | 0.0815 ± 0.0428 | | |
| Group III | 10 | 0.1339 ± 0.0333 | | |

The surface roughness of three groups were summarized in Mean ± SD and compared by analysis of variance (ANOVA). F value: ANOVA F value.

**Table 2: Comparison Of Difference In Mean Surface Roughness (µm) Among The Groups.**

| Comparison | Mean diff. | q value | P value | 95% CI of diff. |
|---|---|---|---|---|
| Group I vs. Group II | 0.0454 | 4.34 | P< 0.05 | 0.0087 to 0.0821 |
| Group I vs. Group III | 0.0978 | 9.35 | P< 0.001 | 0.0611 to 0.1345 |
| Group II vs. Group III | 0.0524 | 5.01 | P< 0.01 | 0.0157 to 0.0891 |

diff: difference, q value: Tukey test value, CI: confidence interval

## DISCUSSION

In search of aesthetically acceptable adhesive restorative material with adequate physical and mechanical properties, there were various tooth-coloured restorative materials have been developed. Amongst these recently developed composites based on nanoparticle filler technology which can be used in areas of high aesthetic demand as well as in stress-bearing areas. However, the literature reveals that the type of restorative material as well as the finishing and polishing procedures influence the surface geometry and aesthetic appearance of tooth-coloured restorations.[6]

In the present study, on comparing the mean surface roughness, it was found that Group I had the least surface roughness as compared to the corresponding Groups of Group II and Group III. This can be attributed to their small filler particle size (less than 100 nm). Because the amalgamation of nanoparticles and nanocluster formulation minimizes the interstitial spacing of filler particles and hence it provides increased filler loading, improved mechanical properties and polish retention. These results are supported by Rai et al., (2003) Lu et al., (2003) also suggests better surface smoothness of nanocomposites as compared to Microhybrid composite and Resin modified GIC.[6] Also supporting the same result by Ryba et al., (2002) and Costa et al., (2010) suggested that resin composite with smaller particle sizes obtain a higher gloss and lower surface roughness.[9]

Group III which is Bulk Fill Composite exhibits the highest surface roughness as compared to Group I and II. This can be due to large irregular filler particles in their structure that create an interstitial spacing which in turn renders a significantly rough surface which suggests poor polishability. The possible reason for surface roughness could be related to the resin components, which differ in the fusion of BisEMA. BisEMA has a high molecular weight and fewer double bonds resulting in a softer matrix. Therefore, in the present study surface roughness of the Bulk Fill Composite is maximum as compared to the other Groups. [10] These results are also supported by Kumari et al., (2016) in which they found that the bulk-fill composite showed higher surface roughness. They suggested that the possible reason for higher surface roughness could be lower filler loading and polymerization modulators that are chemically embedded in the centre of the polymerizable resin. [7] And Ehrmann et al., (2019), Ishii et al., (2020), Yap et al., (2019) and Venturini et al., (2006) also stated that Bulk fill composite materials have large and irregular filler particles in its composition, which can attribute to its poor polishability. [10]

Furthermore, Group II (micro-hybrid) resulted in less surface roughness as compared to Group III. The micro-hybrid composite contains UDMA and high-molecular-weight Bis-EMA (ethoxylated bisphenolA glycol dimethacrylate) which forms fewer double bonds resulting in a slightly softer matrix. It also contains large glass particles which can be plucked away, leaving voids or rougher surfaces, due to which allows the flaking of some filler particles and the weak resin matrix would worsen during the finishing and polishing of restoration. The result of the present study is in accordance with a study conducted by Tjan et al., (1989) and Koh et al., (2008) reported that Micro hybrid composites contain particles that range from 0.01-2 µm; therefore, these materials can be polished to a smoother surface.[5]

Various studies on the polishing of composite resins have been introduced and the most used parameter to describe surface roughness is Ra.[11] Atomic force microscope (AFM) is considered to be an important and applicable method for Ra assessment.[12]

There are various studies to investigate the finishing and polishing of composite materials.All esthetic restorations need maintenance, and regular repolish to enhance their esthetics and increase their longevity.[13]

## CONCLUSION

Owing to the findings of the present in-vitro study it can be concluded that smaller filler particle size allowed higher filler load in the resin matrix which in turn improved the mechanical properties of composite resin as well as bestowing a smoother and glossier surface.

### Conflicts Of Interest

They have no financial affiliation (e.g., employment, direct payment, stock holdings, retainers, consultantships, patent licensing arrangements or honoraria), or involvement with any commercial organization with direct financial interest in the subject or materials discussed in this manuscript, nor have any such arrangements existed in the past three years. There are no conflicts of interest.

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