Effect of Different Finishing and Polishing Systems on the Surface Roughness of Resin Composite and Enamel: An *In vitro* Profilometric and Scanning Electron Microscopy Study

Abstract

Aim: The aim is to compare and evaluate the different finishing and polishing systems for the change in surface roughness of resin composites and enamel. **Materials and Methods:** To conduct the study, 30 extracted human maxillary central incisors were selected, decoronated, and molded in self-cure acrylic molds. A box-shaped cavity of dimensions 3 mm × 3 mm × 2 mm was prepared in all the teeth. A nanohybrid composite resin (Filtek Z250) was then used to restore the prepared cavities. Thirty samples were divided into two groups, control group (Group A, *n* = 10) and experimental group (Group B, *n* = 20). The samples in Group A were cured through the Mylar matrix. The experimental group, i.e., Group B was divided into two subgroups, i.e., Subgroup BX, *n* = 10 in which Sof-Lex polishing system was used for polishing the tooth surface and Subgroup BF, *n* = 10 in which Shofu composite polishing system was used. The mean surface roughness (Ra in μm) of the composite restoration as well as for the enamel surface of all the samples before and after polishing was measured with a contact profilometer, and the values were correlated with scanning electron microscopy. **Results:** The statistical analysis was carried out using paired t-test. The results exhibited a significant decrease in the surface roughness of the resin composite and enamel surface irrespective of the finishing and polishing system used. The mean surface roughness values demonstrated by Mylar matrix was the lowest followed by Sof-Lex polishing system. Shofu polishing system demonstrated the highest surface roughness values. **Conclusion:** Finishing and polishing of composite restoration can achieve a surface roughness similar to that of enamel. Involvement of marginal enamel in finishing and polishing procedures carried out for composite restoration results in smoother enamel surface.

Keywords: *Nanohybrid composite, profilometer, Shofu, Sof-Lex, surface roughness*

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Introduction

The term restoration signifies replacement of structure and function of the damaged tooth with a restorative material. Restoring a tooth to good form and function requires preparing the tooth for placement of restorative material or materials.[1] Resin composites have become a choice of restorative material because of their unique combination of esthetics, bondability, availability of versatile materials, and conservation of tooth structure.[2]

Surface characteristics of a dental restoration greatly affect the behavior, response, and appearance of the restoration with respect to adjacent soft and hard tissues. Clinically, surface smoothness is essential as irregular surface can lead to

stains, calculus accumulation, gingival swelling, secondary caries, abrasiveness, and disturbed wear kinetics.[3]

The surface roughness of composite resins can be decreased by adopting an acceptable finishing and polishing protocol. Instruments used routinely for finishing and polishing include carbide and diamond (12–30 fluted) burs, strips, rubber cups and points, and abrasive discs smeared with aluminum oxide and pastes.[4] The efficacy of these instruments can be assessed by evaluating the surface roughness of resin composites by a variety of techniques and methodologies which include profilometer,[5] confocal microscopy,[6] and interferometry.[7]

A number of studies[8-10] have been undertaken to evaluate the effectiveness of finishing and polishing systems on the surface roughness of resin composites;

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however, there is a scarcity of literature[11] on their outcome on the surface roughness of marginal enamel which plays an equally important role in the clinical outcome of restoration.

Hence, the present study was conducted to evaluate the effect of different finishing and polishing systems on the surface roughness of resin composite and enamel.

Materials and Methods

Thirty freshly extracted human maxillary central incisors with no cracks, decay, fracture, previous restorations, or structural deformities (extracted for periodontal reasons) were selected. The teeth were thoroughly cleaned immediately after extraction, stored in 0.1% thymol solution for 1 week for disinfection (ISO TS11405:2003 specifications) and then placed in distilled water until they were used to prevent dehydration (storage period < 3 months). Teeth were decoronated, and box-shaped cavities (3 mm × 3 mm × 2 mm) were prepared on the labial surface of coronal parts mounted in autopolymerizing resin. The mounted samples were then randomly assorted into two groups: Group A: ($n = 10$) restoration was done using Mylar matrix. Group B: ($n = 20$) experimental group. Samples in Group B were further randomly assorted into two subgroups based on the polishing system used. Subgroup BX ($n = 10$): restored cavities and marginal enamel were to be polished using Sof-Lex polishing system (3M ESPE, USA). Subgroup BF ($n = 10$): restored cavities and marginal enamel were to be polished using the Shofu composite polishing system (Shofu Dental Corporation, Japan).

All the cavities were restored with nanohybrid universal composite resin (Filtek Z 2503M ESPE, USA) in a slightly overfilled single increment using specific composite instruments (Hu-Freidy). The restorative material in all the samples of Group B was cured directly (without Mylar strip) for 20 s using LED resin composite curing unit (Denmark, India) (as per manufacturer's instructions). The restorative material in all the samples of the Group A was cured in a similar manner through the Mylar matrix.

Prepolishing surface profilometric analysis was carried out for determining the surface roughness values (Ra) with respect to enamel and composite restoration for all the samples of Subgroups BX and BF using a standard protocol for all samples. The stylus (tip radius of 5 μm) of contact profilometer (Surftest SJ-210, Mitutoyo, Japan) was moved from enamel to the restoration at a speed of 0.25 mm/s and a pressure of 4 mN. Three successive measurements were recorded for each sample in each subgroup, and the average surface roughness (Ra) value was obtained. The readings for enamel and the restoration were recorded separately and tabulated.

After recording the prepolished readings, the samples were finished and polished with graded series of Sof-Lex disks and Shofu polishing agents. The polishing motion was kept constant, unidirectional for both the restoration and

the enamel. Finishing and polishing was done at a speed ranging from 10,000 rpm to 20,000 rpm for graded series of Sof-Lex discs as per manufacturer's instructions. All the specimens were vigorously rinsed with water and air-dried before and after each polishing step.

Post polishing surface, profilometric analysis was carried out for samples of Subgroups BX and BF using the same protocol as before polishing. The Ra values for the polished enamel and composite restoration were noted and arranged for statistical analysis.

After the surface roughness measurement, the samples were prepared for scanning electron microscopy (SEM) to have a visual correlation with the numerical surface roughness (Ra) values.

The specimens were mounted on aluminum stubs, sputter-coated (SCD 050 sputter coater, Polaron SC 7640. U. K.) with gold and palladium and examined under SEM (model Carl Zeiss– EVO-40) with accelerated voltage of 20 kV at a magnification of ×3000.

The analysis was carried out with the Statistical Package for Social Sciences (SPSS, IBM, Armonk, New York, USA.) software version 13 using paired *t*-test.

Results

After tabulation of the surface roughness values and statistical analysis, the following results were obtained [Tables 1 and 2].

The lowest mean surface roughness value (Ra) was shown by Group A (0.089 μm). The mean surface value (Ra) for Subgroups BX and BF before polishing was the same (0.743 μm). The mean Ra value after polishing for Subgroup BF (0.386 μm) was significantly more than the Ra value for Subgroup BX (0.238 μm) [Table 1].

Table 1: Pair-wise comparison of the mean surface roughness values (Ra in μm) for composite restoration between different groups (paired *t*-test)

Paired comparison	*P*
Group A (0.089 μm) versus Subgroup BF (Pr) (0.743 μm)	<0.001
Group A (0.089 μm) versus Subgroup BX (Pr) (0.743 μm)	<0.001
Group A (0.089 μm) versus Subgroup BF (Po) (0.386 μm)	<0.001
Group A (0.089 μm) versus Subgroup BX (Po) (0.238 μm)	<0.001
Subgroup BX (Pr) (0.743 μm) versus Subgroup BX (Po) (0.238 μm)	<0.001
Subgroup BF (Pr) (0.743 μm) versus Subgroup BF (Po) (0.386 μm)	<0.001
Subgroup BX (Po) (0.238 μm) versus Subgroup BF (Po) (0.386 μm)	<0.001

P<0.001 (statistically significant). Pr: Prepolishing; Po: Postpolishing

The mean Ra value of enamel before polishing for Subgroup BX (0.388 μm) was similar to that of Subgroup BF (0.368 μm). The mean Ra value of enamel after polishing for Subgroup BF was more (0.198 μm) than Ra value for Subgroup BX (0.161 μm); however, the difference was not statistically significant [Table 2], and it was seen that the SEM images corroborated with the findings of profilometric analysis [Figures 1 and 2].

Discussion

A resin composite restoration can be indiscernible to the bare eye when its surface closely resembles the surrounding enamel surface. Thus, restorations should be polished to attain an enamel-like surface topography and shine.[12] Clinically, surface roughness is important for the esthetic appearance of the restoration, the biological consequences regarding periodontal health, and the development of secondary caries due to increased plaque accumulation.[13]

The methodology of cavity preparation and restoration adopted here was undertaken for ease and feasibility of profilometric analysis as it provided a chance for the study of the effect of finishing and polishing on the

Table 2: Pair-wise comparison of the mean surface roughness values (Ra in μM) of enamel for samples in Group B (paired *t*-test)

Paired comparison	*P*
Subgroup BX (Pr) (0.388 μm) versus Subgroup BX (Po) (0.161 μm)	<0.001
Subgroup BF (Pr) (0.368 μm) versus Subgroup BF (Po) (0.198 μm)	<0.001
Subgroup BX (Po) (0.161 μm) versus Subgroup BF (Po) (0.198 μm)	>0.001

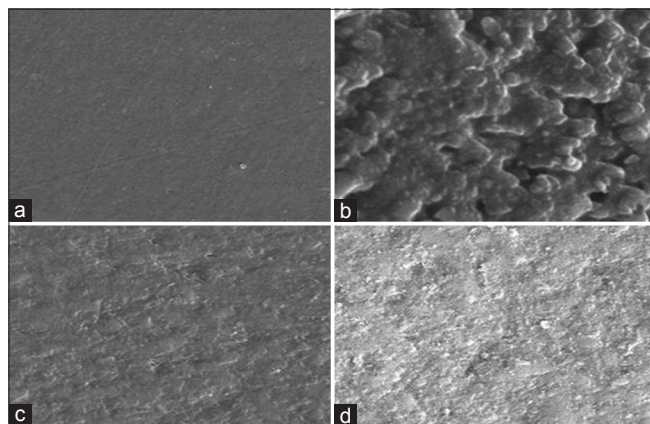$P<0.001$ (statistically significant); $P>0.001$ (statistically nonsignificant). Pr: Prepolishing; Po: Postpolishing

Figure 1: Scanning electron microscopy images of composite surface at ×3000. (a) Scanning electron microscopy image of composite surface with Mylar matrix (Ra = 0.088). (b) Scanning electron microscopy image of unpolished composite surface matrix (Ra = 0.767). (c) Scanning electron microscopy image of composite surface polished with Sof-Lex polishing system (Ra = 0.241). (d) Scanning electron microscopy image of composite surface polished with Shofu composite polishing system (Ra = 0.388)

surface roughness of composite and marginal enamel simultaneously.

Resin composites were originally classified into a conventional composite resin, small particle composite resin, hybrid composite resin, and microfilled composite resin, with a wide variation between the composite materials in terms of their average filler particle size.[14] However, with the introduction of nanotechnology, a new generation of nanocomposites has emerged which is being favored vastly due to its versatility and ease of use.[15] The incorporation of smaller filler particles makes them more wear resistant as they leave less interparticle distance, thus providing more protection to resin matrix against wear.

Filtek Z250 Nano Hybrid Universal Restorative is a visible light-activated nanohybrid composite suited for the use in both anterior and posterior restorations. The fillers are integrated in a unique way that makes them easy to polish with good polish retention within the class of hybrids, providing pleasing results.[16] Many studies unanimously have proved that the smoothest surface of a resin composite restoration is attained when it is polymerized against an appropriate Mylar matrix.[10,17] However, for adequate contouring of restoration, the steps of finishing and polishing become mandatory.

Finishing refers to the contouring, shaping, and smoothing of the restoration to give anatomical contours and to remove excess material at the interface while polishing is the process carried out to remove minute scratches from the surface of a restoration and obtain a smooth, light-reflective luster.[3] The efficacy of finishing and polishing systems depends on the substrate material, kind of abrasive used, time spent with each abrasive, amount of strokes, magnitude of pressure applied, alignment of abrading surfaces and geometry of abrasive instruments, and the presence or absence of lubrication.[18]

In the present study, two types of polishing systems, Sof-Lex (3M ESPE) and Shofu (Shofu Dental Corporation) were used. The polishing motion was kept constant and unidirectional covering enamel and restoration for both the systems and was carried out for 15 s with each instrument under running water to simulate the clinical situation.[19]

In the present study, the samples were evaluated for the surface roughness before and after polishing. According to the results obtained here, restorations fabricated under Mylar matrix presented with significantly lower surface roughness values as compared to unpolished and polished restorations in samples of Group B [Table 1]. These results conform to the findings of other similar work in the literature.[5] The use of Mylar matrix on the top surface of a resin composite prevents the generation of oxygen-inhibited layer on the surface of the composite during polymerization resulting in a smooth, nonsticky surface thereby giving it a smoother appearance.[20]
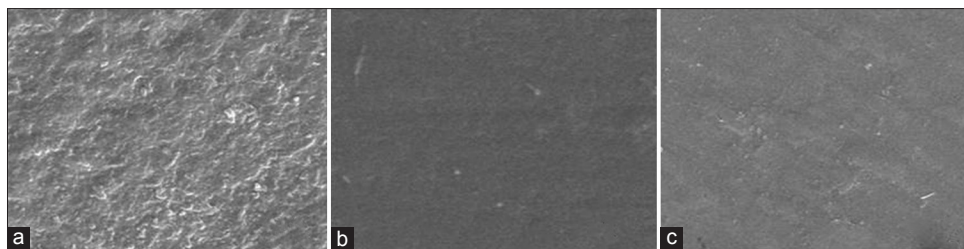
Figure 2: Scanning electron microscopy images of enamel surface at ×3000. (a) Scanning electron microscopy image of unpolished enamel (Ra = 0.366). (b) Scanning electron microscopy image of enamel polished with Sof-Lex polishing system (Ra = 0.164). (c) Scanning electron microscopy image of enamel polished with Shofu composite polishing system (Ra = 0.198)

In the present study, surface polishing of the restorations in both the subgroups (BX and BF) resulted in significantly lower surface roughness values as compared to those of unpolished restorations [Table 1]. This finding is in corroboration with other studies in literature, thus concluding that polishing results in lower surface roughness values.

Regarding the two polishing systems used in the present study, polishing of the restorations with the Sof-Lex polishing system (Subgroup BX) resulted in significantly lower surface roughness values as compared with the Shofu composite polishing system [Table 1].

This observation agrees with other-related studies. LS Turkun and M Turkun stated that the large aluminum oxide abrasive particles embedded in Sof-Lex discs tend to rip through the surface of resin composite. The discs tend to abrade filler particles and resin matrix equally, resulting in a smooth surface. Sof-Lex discs provide a slightly smoother surface with the aluminum oxide abrasive on the rigid matrix as this has the ability to flatten the filler particles and abrade the softer resin matrix at an equal rate.[21]

Furthermore, the smoother surface obtained through Sof-Lex polishing system may be due to the abrasive particle used. A composite finishing system is effective if the abrading particles are relatively harder than the filler materials; otherwise, the polishing agent will only remove a soft resin matrix but leave the filler particles protruding from the surface. The hardness of aluminum oxide abrasive particle (2100 KHN) is lower than silicon carbide particle (2500 KHN).[19] Also as the filler particles in Filtek Z250 are composed of zirconia and silica with hardness of around 1600 KHN for zirconia and 820 KHN for silica,[22] so this hardness difference between silicon carbide and the silica filler particles might have led to relatively more aggressive finishing and polishing with the Shofu composite polishing system than the Sof-Lex polishing system resulting in a significantly rougher surface. Another reason that may have contributed to the lower surface roughness values for the Sof-Lex polishing subgroup is that the Sof-Lex discs are flexible and adapt better to the surface contour during planar motion as compared to the rigid points of Shofu composite polishing subgroup used in rotary motion which might have led to nonuniform type of polishing.[23]

Unpolished enamel in the samples of Group B (Subgroups BX and BF) presented with significantly higher surface roughness values as compared to enamel polished using Sof-Lex polishing system and Shofu composite polishing system [Table 2]. This finding may be ascribed to the abrasion of the softer enamel (hardness = 340–431 KHN) by the harder abrasive particles in the two polishing systems.[19]

Furthermore, there was no statistically significant difference between the mean surface roughness values of enamel surfaces finished and polished with the Sof-Lex polishing system and the Shofu composite polishing system [Table 2]. No study with a similar methodology to study the effect of finishing and polishing systems on enamel was found in the literature to corroborate or contradict the findings in the present study.

In our study, both Sof-Lex polishing system and Shofu composite polishing system when used on the nanohybrid composite resin (Filtek Z250) resulted in surface roughness values similar to that of enamel. This finding validates the choice of resin composite, polishing system, and the methodology undertaken in the present study.

In the present study, SEM of the samples in different groups and subgroups before and after profilometry was carried out to observe whether or not a correlation can be established with profilometric observations and surface visualization at higher magnifications, and it was seen that the SEM images corroborated with the findings of profilometric analysis [Figures 1 and 2].

Conclusion

Within the limitations of the present study, it can be concluded that finishing and polishing decreased the surface roughness of the nanohybrid composite resin. (Filtek Z250) Resin composite restorations using Mylar matrix exhibited the smoothest surface. Moreover, Sof-Lex polishing system performed better than Shofu composite polishing system with respect to surface smoothness of Filtek Z250, and during finishing and polishing of resin composites, a smoother margin enamel surface was obtained.

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Conflicts of interest

There are no conflicts of interest.

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