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Effect of Various Finishing and Polishing Systems on Surface Roughness of Nanohybrid and Microhybrid Composites

Farnaz Farahat [a], Abdolrahim Davari [b], Alireza Hakimzadeh [c], Marzie Moslehi [d]

[a] Assistant Professor, Dept. of Operative Dentistry, School of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[b] Professor, Dept. of Operative Dentistry, Member of Social Determinant of Oral Health Research Center, School of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.[c]
[c] Postgraduate student, Dept. of Operative Dentistry, school of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[d] Dentist, Yazd, Iran.
Correspondence to Marzie Moslehi (email: moslehi1371@gmail.com).
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Objectives Finishing and polishing systems may affect the surface properties of composite resins. In this in vitro study, we evaluated the surface roughness of two composite resins after polishing with three different polishing systems.
Methods Thirty-six specimens (8 mm diameter × 2 mm thickness) were fabricated from Kalore nanohybrid and Gradia Direct microhybrid composite in a Teflon mold and divided into four groups according to the polishing protocol (n=9): control group, Sof-Lex, Super Snap, and Jiffy. The mean surface roughness (Ra) values were determined using a profilometer and the surface of two samples in each group was observed under a scanning electron microscope (SEM). Data were analyzed using one-way and two-way ANOVA. The significance level was set at 5%.
Results Profilometric evaluation showed that in both composite resins, the smoothest surfaces were obtained with Mylar strip; also Jiffy showed significantly higher Ra values than other polishing systems. Type of composite and polishing technique had significant effects on surface roughness (P=0.0001). SEM observations also showed that surface roughness of Jiffy was more than that of three other groups.
Conclusion After the use of finishing and polishing systems, the surface roughness of Gradia was higher than Kalore in all polishing systems. Sof-Lex and Super Snap were effective on Gradia, and jiffy created the roughest surface.
Keywords Composite Resin; Dental Polishing; surface properties

Introduction

The clinical applications of composite resins have substantially increased over the past few years due to higher esthetic demands of patients, improvements in formulations, and simplification of bonding procedures.[1, 2] One of the most important advances in the last few years was the development of composite resins containing nanoparticles. Regardless of the tooth preparation design and tooth location, the proper finishing and polishing of tooth-colored restorations is essential in restorative dentistry.[2, 3] Therefore, creating the final restoration with a smooth surface is one of the most important factors for its long-term success. Surface roughness is a measure of smoothness of a surface texture, and is measured through vertical changes in the surface. Surface roughness plays an important role in determination of a material's interaction with the environment. Also, the surface texture of dental materials has a major influence on plaque accumulation, which may result in gingival inflammation, increased surface staining, and recurrent caries.[4] A rough surface is generally worn fast and has a higher friction coefficient in comparison with a smooth surface.[4] For composite resins, the smoothest surface is obtained when the materials are polymerized under a Mylar strip.[1, 5, 6] Despite careful placement of matrix bands, removing of excess material and recon touring of restorations are often necessary, which may increase the surface roughness.[7] Finishing refers to the gross contouring or reduction of a restoration to obtain the desired anatomy, and polishing refers to a reduction in roughness and removal of scratches created by the finishing instruments.[8, 9]
A variety of instruments are commonly used to finish and polish composite resins, which include carbide and diamond burs, abrasive discs, strips, abrasive-impregnated rubber cups and points, and finishing and polishing pastes.[10-12] The manufacturers and clinicians aim is to create the smoothest surface in the shortest time.[13] However, it is difficult to obtain a smooth surface by polishing due to different shape, size and load of filler particles and matrix composition.[13]
Various polishing protocols have been tested in vitro to evaluate their effect on the surface roughness of different composite resins, and controversial results have been reported.[14, 15] Ryba et al.[16] reported that larger size of filler particles in composite resins may lead to rougher surface after polishing. They also showed that with a lower matrix to filler ratio, the larger particles might be dislodged during polishing and result in a rougher surface. A recent study investigating the influence of polishing systems on the surface roughness of flow able and regular-viscosity bulk fill composites showed that surface roughness was more closely related to material composition than to the polishing system used.[17]
The aim of this study was to evaluate the effect of three polishing systems on surface roughness of two hybrid

composites.

Materials and Methods

The present in vitro study was approved by the ethics committee of Shahid Sadoughi University of Medical Sciences (IR.SSU.REC.1394,126).

For this study, two commercially available composite resins were used: Kalore GC (GC Corporation, Tokyo, Japan) as a nano-hybrid and Gradia Direct (GC Corporation, Tokyo, Japan) as a micro-hybrid composite resin. The properties of the materials are summarized in Tables 1 and 2.

Thirty-six samples were fabricated from each type of composite resin. Fabrication of the samples was performed in a cylindrical metal mold with 8 mm diameter and 2 mm height. A thin Mylar strip and the mold were placed on a glass slab. Afterwards, un-polymerized composite resins were packed in the mold, followed by placement of another Mylar strip and a glass slab over it. Gentle finger pressure was applied to remove the excess material. The samples were then light-cured (Optilux 501, Kerr, Orange, CA, USA) for 40 s at a light intensity of 820 mW/cm2 from both sides of the mold. When preparing the samples, the power of the light cure was measured periodically with a radiometer (Optilux Radiometer, Kerr, Middleton, USA). Immediately after light curing, specimens were removed from the mold and immersed in distilled water at 37°C for 24 h.

Table 1- Characteristics of composite resins investigated in this study

Material	Manufacturer	Shade	Composition			Type	Batch Number
			Resin	**Filler**			
Kalore	GC crop., Tokyo, Japan	A2	UDMA	Prepolymer (SrO2, lanthanoid fluoride), F-A-silicate, Sr-Br-glass, SiO2	1409121	Nanohybrid	1409121
Gradia Direct	GC crop., Tokyo, Japan	A2	UDMA, dimethacrylate Co-monomers	Silica Prepolymerized filler	141021A	Microhybrid	141021A

UDMA: Urethane dimethacrylate

Table 2- Characteristics of the finishing and polishing systems investigated in this study

Finishing and polishing systems	Description	Manufacturer
Sof-Lex discs coarse/medium/fine/super fine	Aluminum oxide disc Grit size 55/29/14/5 µm	3M ESPE, St. Paul, USA
Jiffy polishing disc Medium/Super fine/ fine	Grit 90/70/15 µm	Ultradent Product Inc. South Jordan Utah , USA
05 Super Snap disc Coarse/medium/fine/super fine	Silicon carbide/Aluminum oxide disc Grit size 70/35/20/7 µm	Shufo, Kyoto, Japan

Specimens made from each material were randomly divided into four groups according to the polishing protocol (n=9).

Control group (Mylar strip group): contained specimens that received no finishing or polishing treatment.

Jiffy group: The surface of the samples was polished under water irrigation by use of medium (green), fine (yellow) and superfine (white) discs.

After each polishing step, specimens were thoroughly rinsed with water for 10 s to remove debris, and air-dried for 5 s. In the present study, disc-shaped polishers were used to obtain direct contact with the surface of specimens.

In the Sof-Lex group, specimens were sequentially polished with coarse (black), medium (dark blue), fine (blue), and extra-fine (light blue) aluminum oxide abrasive discs.

In the Super Snap group, specimens were sequentially polished with coarse (black), medium (violet), fine (green), and extra-fine (pink) aluminum oxide abrasive discs.

All samples were prepared by one operator and the handpiece was used in one direction during polishing of the samples. Each disc was used for 10 s and for each specimen, a new polishing disc was used and discarded after the procedure.

After polishing, the surface roughness of each specimen was measured in three points by a contact profilometer (TR 200, Shenzen Laesent Technology Co. Ltd., Beijing China); the mean value of the three points was considered as the mean surface roughness (Ra).

Two specimens of each group were sputter-coated with gold up to 50Aº. Photo micrographs of the represented area were taken by a scanning electron microscope (SEM; Vega3 Tescan, USA) at x1000 magnification.

Data were analyzed using SPSS 21.0 (SPSS Inc., IL, USA). Differences between the groups were analyzed by one-way and two-way ANOVA. The level of statistical significance was set at 0.05.

Results

The Kolmogorov Smirnov test confirmed normal distribution of data. The mean surface roughness of composite resins with different polishing instruments is shown in Table 3.

Table 3- Mean Ra values in different groups (n=9)

Restorative material	Polishing system	Mean ± SD*(nm)
GC Kalore	Mylar (control)	26.416±11.030 Min
	Sof-Lex	43.822±8.955
	Super snap	46.620±7.383
	Jiffy	96.827±9.919
GC Gradia Direct	Mylar (control)	44.311±4.703
	Sof-Lex	46.254±6.848
	Super snap	50.997±6.853
	Jiffy	127.032±7.421 Max

In both composites, the minimum and maximum surface roughness values were observed in the control and Jiffy groups, respectively.

In Kalore, control group exhibited significantly lower Ra, and Jiffy showed significantly higher Ra than other finishing and polishing systems (P=0.0001). There were no statistically significant differences between Sof-Lex and Super Snap (P=1.000).

In Gradia Direct, there was no statistically significant difference between the surface roughness created by Mylar, Sof-Lex and Super Snap (p=1.000). Jiffy showed significantly higher Ra than other finishing and polishing systems (P=0.0001). In the control and Jiffy groups, Kalore showed lower surface roughness values compared with Gradia Direct (P=0.0001). But in the Sof-Lex and Super Snap groups, there were no statistically significant differences between Kalore and Gradia Direct (P=1.000).

A comparison between two composites and finishing and polishing systems showed that the amount of surface roughness difference between the control and Jiffy groups was significant (P=0.0001). Also in these groups, the surface roughness of Gradia Direct was significantly higher than Kalore (P=0.0001).

Two-way ANOVA showed that the surface roughness of Gradia Direct was significantly higher than Kalore (P=0.0001). Also, type of finishing and polishing system had a significant effect on surface roughness (P=0.0001).

SEM micrographs are shown in Figures 1 and 2.

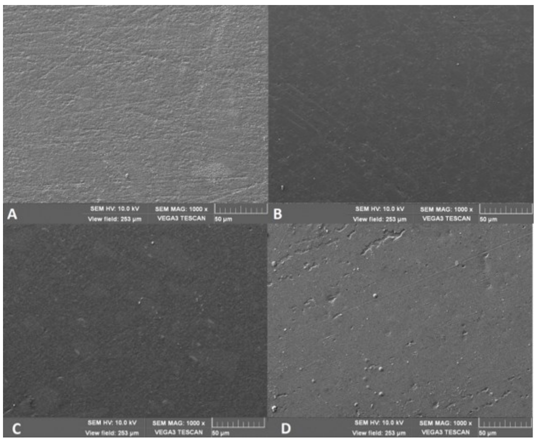

Figure 1- SEM micrograph of Kalore Surface polished with different finishing and polishing systems (x1000 magnification). (A) Control surface (Mylar); (B) Polished with Sof-Lex; (C) Polished with Super Snap; (D) Polished with Jiffy

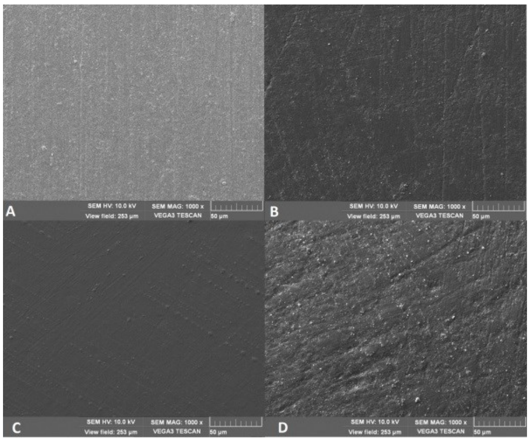

Figure 2- SEM micrograph of Gradia Direct surface polished with different finishing and polishing systems (x1000 magnification). (A) Control (Mylar); (B) Polished with Sof-Lex; (C) Polished with Super Snap; (D) Polished with Jiffy

These images showed that surface roughness of Jiffy was more than the three other groups. Also, surface of control groups was slightly rougher than Super Snap and Sof-Lex groups.

Discussion

The present study assessed the surface roughness of Gradia Direct microhybrid and Kalore nanohybrid composites after polishing with various multi-stage polishing systems. The results showed that there was a significant difference in surface roughness in Kalore between the control group and other groups. The difference in surface roughness of Sof-Lex and Super Snap groups and the control group in Gradia was not statistically significant.

Evidence shows that the surface roughness of composite resins is affected by various factors such as the type, shape, size, and distribution of filler particles, the type of resin matrix, surface hardness, the effectiveness of the bond between the filler and the matrix, and the curing intensity.[18]

In the present study, the efficacy of Sof-Lex and Super Snap for reducing the surface roughness of Gradia was more than that in Kalore and there was no significant difference in Ra between the control, Sof-Lex and Super Snap in Gradia group. Lainović et al.[19] showed that Filtek Z550 nanohybrid composite polished by Super Snap had higher Ra than Gradia. They found that presence of nanometer- and micrometer-scale filler particles in Z550 and the exposure of micrometer particles during the polishing procedure may lead to a rougher surface than Gradia.[19] Also, in a study by Erdemir et al.[20] Gradia microhybrid had a smoother surface than Filtek Supreme nanofilled composite after polishing by Sof-Lex discs. They found that despite the larger filler particles, the higher filler volume resulted in smoother surface in Gradia.

Furthermore, Giacomelli et al.[21] found that after polishing with multi-stage Venus Supra, Gradia showed smoother surface than Tetric Evo Ceram and Venus Diamond nanohybrid composite due to the efficient abrasion of both matrix and filler. But St-Pierre et al.[22] showed that initial surface roughness of micro-filled Durafill VS was more than that of Grandio SO nanohybrid composite. They also found that there was an interaction between the composite resin and the polishing system that affected the final surface roughness. It means that some polishers cause excellent finish on some composite resins but have lower effect on others.[22] In the present study, comparison of Ra values between the two composite types showed that in use of all finishing and polishing systems, the Ra value in Gradia was higher than Kalore (this difference was significant only in the Jiffy polishing system). This result can be attributed to the smaller size and higher content of filler particles in Kalore. Composite resins that have a larger mean particle size tend to have significantly higher abrasion wear. This is due to the preferential wear of resin between the fillers, which causes the fillers to become loose and ultimately fallout from the resin matrix, leading to three-body wear and generalized loss of material.[23]

Other factors affecting the surface roughness of composite resins are the type of finishing and polishing instruments, hardness of the abrasive particles, and discs' flexibility. Previous studies have shown the ability of Sof-Lex discs to create the smoothest surface.[19, 20, 24] The hardness of aluminum oxide particles used in some finishing and polishing discs is significantly higher than most composite resin fillers.[25] Therefore, it has been reported that flexible aluminum oxide discs produce the smoothest surface due to the concurrent removal of filler and matrix from the composite surface.[26] In the present study, no significant difference was found in Ra between Sof-Lex and Super Snap systems in both composite resins. It seems to be due to the approximately similar size of abrasive particles of the last disc in these systems, which is 5 µm in sof-Lex and 7 µm in Super Snap systems. However, the abrasive particle size of most soft discs in the Jiffy system is 15 µm; therefore, this polishing system provides significantly rougher surface than the other two types.

Although significant differences were found between the study groups of the present study, it seems that surface roughness of the two composites was clinically acceptable. Jones et al.[27] found that when the surface roughness of the polished restoration was 500 nm, it could not be distinguished by the patient. Also, in another study, it was found that in Ra values less than 200 nm, the bacteria are unable to bind to the surface.[28] In the present study, Ra in all groups was lower than 200 nm, which provides clinically acceptable results for surface roughness.

In the present study, profilometer and SEM were used to evaluate the surface roughness. Consistent with the profilometry results, SEM showed that surface roughness of Gradia was more than Kalore. In both composite resins, SEM evaluation showed smoother surface with Sof-Lex and Super Snap discs than Mylar strip, which was inconsistent with the results obtained from the profilometer. Evidence shows that the surface roughness observed with SEM is fully consistent with the profilometric findings.[20] But some studies showed that there was an inconsistency between SEM and profilometric evaluations.[25, 26, 29] This difference is probably attributed to the fact that profilometry has been limited to only 3 points of the sample surface, which may not reflect the entire surface properties.

In this study, only the surface roughness of the composite resins after polishing was evaluated, which was one of the several factors affecting the surface properties of the restorations. Other factors having influence on the results of polishing include polishing time, the amount of force applied to the restoration surfaces during polishing, and the time interval between composite application and polishing[30], all of which should be considered to evaluate the performance of the available polishing systems.

Conclusion

Considering the limitations of the present study, it was found that Ra of all groups was clinically acceptable but surface roughness of Kalore nanohybrid composite was lower than that of Gradia microhybrid composite. Moreover, the effect of Sof-Lex and Super Snap on reducing surface roughness of Gradia was more than their effect on Kalore; also Jiffy created the roughest surface.

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Conflict of Interest

None Declared ■

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