Original Article

In-Vitro Comparative Study of the Effect of Four Finishing and Polishing Tools on Surface Roughness of a Microhybrid Resin

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ABSTRACT

Background and Aim: The complications of unwanted surface roughness of composite restorations are highly common due to the increasing use of this restorative material. Therefore, the present study was designed to compare the effect of four finishing and polishing (F&P) tools on surface roughness of microhybrid resin composites.

Materials and Methods: This experimental study was performed on 42 samples of CLEARFIL™ AP-X microhybrid composite, which were divided into four groups of different F&P methods and one control group as follows: control (n=2), Flexi-D discs (n=10), Flexi-D + diamond polishing paste (n=10), Intensive twisted rubber polisher (n=10), and Rubber Polisher Teco (n=10). The samples were examined by profilometry. Surface roughness (Ra) of each specimen was measured at three points, and the mean value was considered as surface roughness. The results were analyzed by analysis of variance (ANOVA) and post hoc statistical tests.

Results: The surface roughness of composite discs in an ascending order was as follows: control (0.048±0.014 µm), Flexi-D disc (0.179±0.132 µm), Intensive twisted rubber polisher (0.233±0.105 µm), Flexi-D disc with diamond polishing paste (0.232±0.141 µm), and Rubber Polisher Teco (0.251±0.087 µm; P=0.001). The difference between the two groups of Flexi-D disc with diamond polishing paste and Rubber Polisher Teco was not statistically significant (P=0.742). The level of surface roughness in Flexi-D samples was significantly lower than that of the other samples (P<0.05).

Conclusion: It seems that the Flexi-D disc is the best F&P tool for microhybrid resin composites.

Keywords: Dental Polishing / Instrumentation, Composite Resin, Surface Properties, Materials Testing

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Introduction:

The surface roughness of restorative materials is one of the problems that can cause plaque and bacteria to accumulate, eventually leading to unhealthy surfaces with consequences such as discoloration and gingival and periodontal inflammation. [1-3]

Also, increased staining of composite restorations will ultimately have a significant effect on their aesthetics. The maximum acceptable roughness is 0.2 µm for restorative materials; at this level, there will be no bacterial adhesion. Higher surface roughness will cause bacterial adhesion and plaque accumulation, increasing the risk of decay and periodontitis.[1-3]

Finishing and polishing (F&P) techniques are used to reduce the surface roughness of restorative materials. Finishing (shaping or reducing restorative materials for ideal anatomy) and polishing (reduction of roughness and scratches created by polishing tools on the restoration) are very important stages of restoration that affect both the aesthetics and the longevity of the final restoration.[2,3]

The final shaping and polishing of resin composites can be accomplished by various means. Diamond burs, carbide burs, various types of rubber point, rubbers, and polishing pastes are among the means of polishing.[1,4-8]

Previous studies have investigated the surface roughness of microhybrid resin composites after F&P with aluminum oxide disc alone or aluminum disc with another F&P method (carbide bur, diamond bur or diamond paste).[9-16]

In these studies, when using aluminum disc (Sof-Lex) alone, the surface roughness of the microhybrid composite was significantly reduced, and the addition of another method to Sof-Lex failed to improve the surface roughness.[9-16]

The effect of new F&P tools, such as Rubber Polisher Teco (silicon composite resin polishing disc), Flexi-D disc (EVE; flexible aluminum oxide disc for composite, gold, and amalgam polishing), and Intensive twisted rubber polisher (composite polishing disc), on the surface roughness of composite resins has been limitedly investigated.[16-21]

In the present study, the effects of four types of F&P tools, including Rubber Polisher Teco, Intensive twisted rubber polisher, Flexi-D disc, and diamond polishing paste, on the surface roughness of microhybrid resin composites were investigated in vitro.

Materials and Methods

In this in-vitro experimental study, 42 samples in four groups of 10 each and one control group of two samples were prepared. The simple randomization method was used for sampling. First, a polyvinyl chloride (PVC) mold with a diameter of 6 mm and a thickness of 3 mm and resistant to deformation was provided. To prepare each specimen, the mold was placed on a glass slab on which a celluloid strip (BP, Iran) was placed. This was done to prevent the adhesion of the composite to the glass slab during the curing of the composite. The CLEARFIL™ AP-X composites (Kuraray Noritake Dental Inc., Okayama, Japan) were then placed in layers of less than 2-mm thickness inside the mold in two steps and cured during two steps. The thickness of the first layer of the composite was 1 mm. For curing the last layer, the celluloid strip was placed on the mold. The glass slide was then placed on the celluloid strip, and the final pressure was applied to the specimen so that the glass slide would be in direct contact with the mold edges and the excess composite would be ejected. Specimens were cured from beyond the glass slide after visual assurance of the absence of any bubbles or incomplete compaction. Overlap curing was performed for 20 seconds at each stage with the intensity of 1000 mW/cm2 (J. Morita Mfg. Corp., Kyoto, Japan) at a distance of 1 mm from the surface of the specimens.[15] The intensity of the light-curing unit was checked at each stage using a radiometer.

The samples were then randomly divided into five identical groups. All composite specimens were finished and polished in a wet environment for 30 seconds with each tool. [15,21] The groups were as follows:

Control group, which remained intact,Flexi-D group (EVE Ernst Vetter GmbH; Pforzheim, Germany): flexible aluminum oxide discs for composite, gold, and amalgam polishing,

Intensive twisted rubber polisher group (EVE Ernst Vetter GmbH; Pforzheim, Germany): silicone composite polishing discs,

Rubber polisher Teco group (EVE Ernst Vetter GmbH; Pforzheim, Germany): silicone composite polishing discs,

Diamond polishing paste group (DiaPolisher Paste, GC Europe, Leuven, Belgium): the final finishing of composite and ceramic restorations with abrasive particles of 1 to 2 microns.

All samples were stored in distilled water at room temperature. Then, the 42 samples were evaluated by profilometry (SM7, Wetzlar, Germany) to determine the mean surface roughness (Ra).

Surface roughness (Ra) of each specimen was measured at three points, and the mean value was considered as the average surface roughness (Ra).[21] The Ra data were statistically analyzed by analysis of variance (ANOVA) and post hoc supplementary statistical tests. The samples were compared overall and then pairwise.

Result: This study included 42 specimens: 10 in each group and two in the control group. The surface roughness (µm) of each group is presented in Table 1 and Figure 1. As shown in the table, the highest level of surface roughness was detected in the Rubber Polisher Teco group (0.251±0.087 µm), and the lowest, except for the control group, was detected in the Flexi-D (EVE) group (0.179±0.132 µm).
According to ANOVA, the lowest surface roughness in the four groups (regardless of the control group) was observed in the Flexi-D (EVE) group (0.179±0.132 µm). The difference between surface roughness in the four groups was statistically significant according to ANOVA ($P<0.001$).

Table 1: Surface roughness (µm) of the samples of each studied group

Groups	Surface roughness (µm)
Control	0.048±0.014
Flexi-D (EVE) disc	0.179±0.132
Flexi-D (EVE) disc+ diamond polishing paste	0.232±0.141
Rubber Polisher Teco	0.251±0.087
Intensive twisted rubber polisher	0.233±0.105

Least significant difference (LSD) and Tukey's post hoc tests were used for the comparison of the mean surface roughness between each two groups, which showed that the differences between the control group and all four Flexi-D (EVE) ($P=0.01$), Flexi-D (EVE) + diamond polishing paste ($P<0.001$), Rubber Polisher Teco ($P<0.001$), and Intensive twisted rubber polisher ($P<0.001$) groups were statistically significant. Surface roughness was significantly higher in Flexi-D (EVE) samples than in Flexi-D (EVE) + diamond polishing paste ($P=0.036$), Rubber Polisher Teco ($P=0.016$), and Intensive twisted rubber polisher ($P=0.047$) samples. The difference between Flexi-D (EVE) + diamond polishing paste and Rubber Polisher Teco was not statistically significant ($P=0.742$), but the surface roughness in Intensive twisted rubber polisher samples was significantly lower compared to Flexi-D (EVE) + diamond polishing paste and Rubber Polisher Teco samples ($P<0.05$).

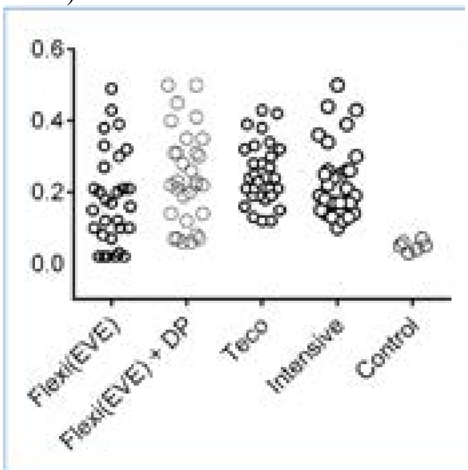

Figure 1. Surface roughness (µm) of each sample in the studied groups

Discussion

The present study showed that the highest levels of surface roughness were related to Rubber Polisher Teco (EVE) and Flexi-D (EVE) + diamond paste groups (without any significant differences). The lowest surface roughness, regardless of the control group, was detected in the Flexi-D (EVE) disc group. In previous studies, the surface roughness of microhybrid resin composites after F&P with aluminum oxide disc (Sof-Lex) alone is ranging from 0.01 to 0.65 µm.[9-16]

However, the surface roughness of microhybrid composites after F&P by Sof-Lex with another F&P method ranged from 0.074 to 0.23 µm.[16-19] In these studies, when using Sof-Lex alone, the surface roughness of the microhybrid composite was significantly reduced, and the addition of another method to Sof-Lex failed to improve surface roughness. In a 2015 study by Ferriera et al, Sof-Lex alone produced surface roughness equal to 0.01 µm, while Sof-Lex together with diamond paste produced surface roughness equal to 0.1 µm.[15] A study performed by Botta et al showed that the surface roughness after the use of Diamond flex with diamond paste was 0.074 µm while adding Diamond pro to the above composition caused surface roughness to increase to 0.079 µm. (19) The results of other methods of F&P used in the present study (two groups of Rubber polisher Teco and Intensive twisted rubber polisher) are consistent with previous studies.[20,21]

CLEARFIL™ AP-X composite consists of Bis-GMA, TEGDMA, silanized barium glass filler, silanized silica filler, silanized colloidal silica, camphorquinone, accelerators, catalysts, and pigments. Filler particle size is 0.3 µm, 86% by weight and 70% by volume.

In F&P, if abrasive components are not harder than the filler inside the composite, the polisher only removes the matrix and soft parts, while the fillers remain on the surface. Therefore, unlike silicone discs, aluminum discs are capable of better polishing of CLEARFIL™ AP-X composite, which includes barium glass and silica fillers.[9] In the present study (except for the control group due to its small sample size), the lowest surface roughness was related to Flexi-D disc (aluminum oxide). In previous studies on microfilled composites, Sof-Lex discs (aluminum oxide) produced the lowest surface roughness compared to other samples.[8,9]

The surface morphology of composite resins after F&P is affected by various factors such as the size, hardness, and amount of filler particles.[22] In polishing, if the filler particles are hard, bumps are created on the surface of hybrid composites while the soft matrix resin disappears. Filler particles must be close together to protect the resin matrix. The smaller the filler particles, the lower is the polymerization, the higher is the shrinkage and the more are mechanical problems.[22,23]

Compared to microfilled and hybrid composites, nanofilled composites have the highest polishability. In previous studies, hybrid composites (Filtek Z250) showed the lowest surface smoothness, which can be attributed to the formation of large glass filler particles that, when compressed, leave bubbles and rough surfaces after polishing.[22-25] Hybrid composites have larger filler particles than nanofilled and microfilled composites, which is why their surface roughness is even greater. Because of the different types of filler particles and resin, it is important to use a polishing system that is compatible with the resin composite.[11,25]

In our study and many previous studies, only surface roughness was measured, which is only one of several parameters that affect the quality of restorative surfaces in the clinical setting. Other effective factors, such as the amount of pressure applied during polishing, the direction of the surface, the time taken during the F&P process, and the abrasives used for polishing, affect surface roughness.[26,27] In the present study, we tried to prevent these confounders from affecting the results; however, some of these factors are inevitable. Future studies with better control of these confounders are suggested.

In the present study, Flexi-D disc produced the lowest surface roughness in CLEARFIL™ AP-X light-cure composite. It can, therefore, be of good quality in clinical practice. However, since the present research has been done on flat surfaces and in a laboratory environment, its application in clinical practice depends on the position of the tooth and the polishing area; F&P on prominent surfaces, especially in the posterior teeth, can alter the results. Also, in this study, only surface roughness was investigated, and other aspects including composite color, aesthetics, thickness, biofilm and microorganism accumulation, resistance, and other characteristics need further investigation.

Conclusion:

In the present study, Flexi-D (EVE) disc produced the lowest surface roughness in CLEARFIL™ AP-X microhybrid resin composite. The lowest levels of surface roughness were noted with Intensive twisted rubber polisher followed by Flexi-D disc with diamond paste and Rubber Polisher Teco, respectively. Confirmation of the above results requires further in-vivo studies in clinical settings.

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