Original Article

The effect of three polishing systems on surface roughness of flowable, microhybrid, and packable resin composites

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Abstract

Objectives: The aim of this study was to evaluate the effects of three different polishing systems on the surface roughness of three types of resin composite materials. **Materials and Methods:** Three types of resin composites (Heliomolar flow, TPH spectrum, and Tetric Ceram HB) and three polishing systems (Astropol, Enhance, and Soflex) were used. A total number of 40 samples were prepared from each one of the restorative materials and divided randomly into four groups (n = 10) according to the polishing procedure. The first group underwent no treatment and was used as a control group. Each one of the remaining groups was polished with one of the tested polishing systems. After completion of sample preparation, the mean surface roughness (Ra) value was measured using a surface profilometer. Data were analyzed using one-way analysis of variance (ANOVA). **Results:** The control group of each material recorded the lowest Ra value. Among the tested polishing systems, the groups finished with Soflex system exhibited the lowest Ra value. Among the resin composites, Heliomolar flow exhibited the lowest Ra value, regardless of the polishing system used. **Conclusions:** The smoothest surface of all types of resin composite was achieved under Mylar strip.

Key words: *Polishing systems, resin composites, surface roughness*

INTRODUCTION

Dental caries is the most widespread disease, since it affects about 95% of the world population.[1] When teeth are affected by caries, they lose their ability to absorb the load from mechanical impact. Thus, when this natural complex is changed, the restorative material needs to present properties that are able to recover it in an appropriate manner. In order to achieve a satisfactory clinical performance, the composite resin, a hybrid material composed mainly of fillers and organic matrix, is indicated.[2]

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Resin composites are widely used for the direct restoration of both anterior and posterior teeth because of the simple bonding procedures, esthetic demands by the patients, and improved physical and mechanical properties of these materials.[3] Modern microhybrid composites have fine inorganic fillers of a variety of sizes with a mean value of less than 1 μm. Because of their high inorganic filler content, such materials are suited for the stress-bearing situations such as Class IV restorations.[4] However, for the proximal area of posterior teeth where isolation is difficult, the technique sensitivity of the material is more likely to put packable composite at risk. Therefore, flowable composite is used to reduce the marginal leakage and to provide additional release from stress.[5,6]

One of the most challenging tasks related to increasing esthetic demands in dentistry is to achieve a restoration that matches the color and appearance of a natural tooth. The surface properties of these materials are critical for their success because they mediate the interaction of restorative materials with the oral environment.[7] The resin matrix and filler particles have different levels of hardness that cause variations in polishing efficiency. This variability can lead to differences in surface roughness.[8] In restoration procedures, a surface character, such as roughness, can determine the quality and the clinical behavior of the restorative material.[9] Rough surfaces not only increase staining susceptibility but also increase the risk of secondary caries.[10,11]

The finishing procedure may be an important factor for the long-term oral hygiene performance. The oral cavity is constantly contaminated by many diverse microbial species. Most of these microorganisms, especially those which are responsible for caries (e.g. *Streptococcus mutans* and *Lactobacillus* spp.) and periodontitis (e.g. *Actinobacillus actinomycetemcomitans* and *Porphyromonas gingivalis*), can only survive in the mouth when they adhere to rough surfaces.[12] The threshold value of Ra below which no plaque formation is observed (supra- and subgingival) is 0.2 μm.[13] Different polishing procedure systems and different composite resins produce different levels of surface roughness.[11,14] There are many roughness parameters in use, but arithmetic mean roughness is by far the most commonly used. Each roughness parameter is calculated using a formula to describe the surface. Arithmetic mean roughness (Ra) is the arithmetic average of all frames of the profile filtered by measuring the length from the line of the reference profile.[15]

During finishing and polishing procedure, the filler particles of resin composite may be loosened or fractured, and the organic matrix may be removed, exposing the filler particles. Thus, roughness can establish a comparison of the performance of these materials.

The aim of this study was to evaluate the effect of some finishing and polishing systems on the surface roughness of microhybrid, flowable, and packable resin composite materials.

MATERIALS AND METHODS

Three different resin composites were used in this study: A flowable resin composite (Heliomolar flow; Ivoclar Vivadent, Schaan, Liechtenstein), a hybrid resin composite (TPH spectrum; Dentsply, Latin America), and a packable resin composite (Tetric Ceram HB; Ivoclar Vivadent, Liechtenstein) [Table 1]. Stainless steel mold (6 mm in diameter and 3 mm in height) was used to prepare 40 specimens from each one of the restorative materials. To prepare each sample, the mold was placed on a glass slide covered by Mylar strip and the uncured resin composites were then placed in the mold. Another Mylar strip was then placed over the mold and the material was compressed with a glass slide, thus extruding the excess resin composite and forming a flat surface. The samples were polymerized from the top of the mold with a tungsten halogen light (Coltolux 3; Coltene/Whaledent Inc., Cuyahoga falls, OH, USA) for 20 s. Then, each sample received additional light curing for 20 s from the bottom surface to ensure complete polymerization. The intensity of the curing light was 550 mW/cm^2, as verified with a hand-held radiometer (Curing Radiometer Model 100; Demetron/Kerr, Danbury, CT, USA).

Forty samples were prepared from each one of the tested materials. Each group was then divided into four groups (n = 10) according to the polishing procedure as follows:

Group A: Control group that received no polishing procedures after being cured under Mylar strip

Group B: Polished with Astropol system (Ivoclar Vivadent, Liechtenstein)

Group C: Polished with Enhance system (Dentsply, Latin America)

Group D: Polished with Soflex system (3M ESPE, St. Paul, USA).

The tested polishing systems have been presented in Table 2.

Before the polishing procedures, except for the control group, finishing was performed with 30 μm diamond finishing burs (Diatech; Diatech Dental AC, Heerbrugg, Switzerland) using a high-speed handpiece at 40,000 rpm under three-way water cooling for 10 s. The finishing bur was changed every five samples. Then, the polishing procedures were carried out with a slow-speed handpiece (NSK Ti-Max Electric Handpiece; NSK, Chiyoda, Tokyo, japan). Except for the control group, finishing and polishing procedures

Table 1: The resin composite materials used in the study

Restorative material	Type	Composition	Filler volume % by weight	Average filler particle size (μm)	Manufacturer
Heliomolar flow	Flowable resin composite	Bis-GMA UDMA Decanediol dimethacrylate	51	0.04-0.2	Ivoclar Vivadent, Liechtenstein
TPH spectrum	Microhybrid resin composite	Bis-GMA TEGDMA	77	0.04-5.0	Dentsply, Latin America
Tetric ceram HB	Packable resin composite	Bis-GMA UDMA Decanediol dimethacrylate	81	0.04-3.0	Ivoclar Vivadent, Liechtenstein

Bis-GMA= Bisphenylglycidyl dimethacrylate, GMA= Glycidyl dimethacrylate, UDMA= Urithan dimethacrylate, TEGDMA= Triethylene glycol dimethacrylate

Table 2: The polishing systems used in this study

Polishing system	Composition	Manufacturer
Astropol	Rubber polishers impregnated with silicon carbide, aluminum oxide, and iron oxide	Ivoclar Vivadent, Liechtenstein
Enhance	Aluminum oxide impregnated cured urethane dimethacrylate resin finishers	Dentsply, Latin America
Soflex	Aluminum oxide coated disk medium (40 μm), fine (24 μm), ultra-fine (8 μm)	3M ESPE, USA

were carried out immediately after curing of the samples, resembling the clinical condition.

Finishing of the samples

For samples finished with Astropol system, the speed of the handpiece was set at 10,000 rpm with water coolant, as per the manufacturer's instructions. The polishing procedures were started with gray followed by green and finally the pink rubber cup, each for 15 s. For samples finished with Enhance system, the speed of the handpiece was set at 10,0 00rpm without water coolant, as per the manufacturer's instructions. The samples were polished for 15 s with the disks, followed by 10 s of polishing using fine polishing paste and additional 10 s using extra-fine polishing paste (Prima-Gloss; Dentsply, Latin America). The samples were rinsed with water for 10 s and air dried for 5 s between polishing paste application and after completion of the polishing procedure. The samples finished with Soflex system were polished with the medium disks at 1000 rpm for 10 s and then with the fine and extra-fine disks each for 15 s at 30,000 rpm in a dry field.

Each sample was subjected to polishing procedure according to the manufacturer's instructions concerning the speed of the handpiece and the time of application, not the number of strokes. As all samples have a flat surface, the motion of the polishing system was a simple straight motion from left to right. All finishing and polishing procedures were done by a single author to eliminate inter-individual variation and to exert the same pressure as possible for all samples.

Measurement of surface roughness

Before any measurement of the mean surface roughness (Ra), all samples were rinsed with water for 10 s and air dried for 5 s. The Ra of each sample was measured with a profilometer (MarSurf PS1; Mahr GmbH, Gottingen, Germany). Each sample was measured three times to record the Ra. The sample was rotated 120° after each measurement. After recording the Ra value of each sample, the collected data were used to calculate the Ra value of each group.

Statistical analysis

The observed data were subjected to statistical analysis. One-way analysis of variance (ANOVA) at a significance level of $\alpha = 0.05$ was used.

RESULTS

The mean surface roughness values and standard deviations of all groups are listed in Table 3. There was no significant difference ($P > 0.05$) between all groups. Of all tested resin composite materials, the control group (Mylar strip) exhibited the lowest Ra values. Soflex system recorded the lowest Ra values among the all tested polishing systems, while Astropol system recorded the highest Ra values. Comparing the resin composite materials, the lowest Ra value was recorded for the flowable composite, while the highest Ra value was recorded for the packable composite. Among all groups, the lowest Ra value was recorded for the control group of the flowable composite, while the highest Ra value was recorded for packable resin composite when finished with Astropol system.

Table 3: Mean surface roughness (Ra) values and standard deviations for all tested groups

	Mylar (control) (µm)	Soflex (µm)	Enhance (µm)	Astropol (µm)
Flowable composite	0.208±0.022	0.211±0.040	0.322±0.010	0.442±0.053
Microhybrid composite	0.275±0.033	0.319±0.054	0.383±0.020	0.525±0.034
Packable composite	0.425±0.017	0.429±0.034	0.527±0.060	0.530±0.024

DISCUSSION

Recently, the necessity for tooth-colored restorations has greatly increased, while application of metallic restoration has become unpopular from an esthetic perspective.[16] Opdam *et al*. reported that resin composites have been increasingly used in posterior teeth since 1991 and they have become the first choice in case of primary caries.[17] Packable resin composite has been introduced to the market as an alternative to amalgam with high expectations. It is characterized by a high filler load that gives it a different consistency compared with hybrid resin composite.[18] Flowable resin composite is placed under packable composite, particularly in Class II, to improve the marginal integrity, as it is characterized by low viscosity.[19] Surface quality is an important parameter that influences the behavior of the dental restoration in different ways. Finishing and polishing are the final steps after completion of the restoration. Finishing includes the gross removal of the overhangs, anatomical contouring, and initial smoothing of the surfaces, while polishing aims to reduce surface roughness to the least possible level.[20]

In this study, we investigated the effects of three different polishing systems (Astropol, Enhance, and Soflex) on the surface roughness of three resin composites (flowable, microhybrid, and packable). Under the conditions of this study, the control group of all resin composites which were cured against Mylar strip exhibited the lowest Ra value. This may be related to the absolute smooth surface of the Mylar strip. Also, resin composite surface untouched with any cutting instruments or any finishing and polishing systems had filler particles that were not abraded away from the resin matrix, which finally led to the creation of the smoothest surface of the tested resin composites.[21-23] However, the smoothest surface of resin composite is achieved under Mylar strip, but this surface cannot be maintained clinically because no flat tooth surface exists; otherwise, the complex tooth morphology will necessitate the clinician to make finishing and polishing for the restoration to reassemble the tooth complex morphology.

In our study, among the tested finishing and polishing systems, groups finished with Soflex system recorded the lowest Ra value. This is in agreement with other studies.[18,20,24,25] Many factors were responsible for this result. Ozgünaltay *et al*.[18] suggested the ability of Soflex system to remove the surface scratches created by the burs, while Jung *et al*.[20] attributed this result to the ability of Soflex system to abrade the filler particles and the resin matrix at equal rates. Neme *et al*. attributed this result to the two bodies wear process associated with Soflex systems; there is no free abrasive that could erode away the relatively soft resin matrix between the harder filler particles.[24] Another explanation for this observation is the composition and way in which the aluminum disks were used. As they were used in decreasing the abrasiveness level, they promoted uniform wear and whatever polishing of the surface, regardless to the type of composite resin.[11] On the other hand, the results of Marigo *et al*. are in disagreement with our study result.[26] They mentioned that Soflex system gave rougher surfaces of resin composite than Enhance system. This disagreement may be due to the use of different types of resin composite than those used in our study. Another recent study is also in disagreement with our result.[27] The authors found that the smoothest surfaces were obtained with Enhance polishing system. They reported that the reasons for this could be attributed to the following factors. This polishing system comprises the following: Aluminum oxide impregnated polishing disks and points, prisma gloss, and prisma gloss extra-fine aluminum oxide pastes. The aluminum oxide paste causes finer abrasion in comparison to impregnated disks or points used alone. In our study, the highest Ra value was recorded for groups finished with Astropol system. This result is in line with another study.[28] This result may be due to the coarser abrasive particles in the Astropol system than in Soflex system. On the other hand, Sapra *et al*. found that the smoothest surface was recorded with Astropol system for some tested groups.[29] This disagreement may be attributed to either the difference in the tested materials or the sample preparation techniques.

When comparing the resin composites, the flowable composite (Heliomolar flow) exhibited the lowest Ra value, followed by the microhybrid composite (TPH spectrum), while the packable composite (Tetric Ceram

HB) recorded the highest Ra value. This result is in accordance with other studies.[2,7] They suggested that the filler particle size affects the surface roughness. The larger the filler particle size, the rougher would be the resin composite surface. Gonçalves *et al*. attributed the smoothest surface of flowable resin composite to the lower degree of polymerization and viscosity of the urithan dimethacrylate (UDMA) monomer.[30]

Unfortunately, there are some limitations in this study such as the flat surface of the sample (a condition that does not exist clinically) and also, the study was performed *in vitro*, so the effect of oral environment was neglected. These limitations can be improved by preparing the sample in the tooth itself to follow the tooth morphology. Also, *in vivo* studies are required to investigate the possible effect of oral environment on the surface roughness of such restorations.

CONCLUSIONS

Considering the limitations of this study, we can conclude that the smoothest surface of resin composite was achieved under Mylar strip. The difference in mean surface roughness among the tested polishing systems was insignificant; so selection among them will depend on individual preference and anatomy of the tooth.

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