the Journal of Contemporary Dental Practice at www.thejcdp.com
Volume 8 Number 2 February 1, 2007

The Effect of Different Finishing and Polishing Systems on the Surface Roughness of Different Composite Restorative Materials

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Abstract

Aim: The purpose of this *in vitro* study was to examine the effect of two different finishing systems on the surface roughness of different types of composite restorative materials.

Methods and Materials: Thirty specimens, 8 mm in diameter and 3 mm in depth, were prepared using a microfill composite (Clearfil ST, Kuraray Co. Ltd., Osaka, Japan), a hybrid composite (Clearfil AP-X, Kuraray Co. Ltd., Osaka, Japan), and a packable composite (Clearfil Photo Posterior, Kuraray Co. Ltd., Osaka, Japan) cured against a Mylar matrix strip to create a baseline surface. The average surface roughness was measured using a surface profilometer (Surftest 211, Mitutoyo, Japan) in five different positions on each sample before and after finishing with one of the two finishing systems [Sof-Lex discs (3M) and Po-Go (Dentsply)]. The obtained data were analyzed by two-way analysis of variance (ANOVA) at a p=0.05 significance level.

Results: There were statistically significant differences in the average surface roughness (Ra, µm) between the Mylar matrix strip, Sof-Lex discs, and Po-Go discs ($p<0.05$). For all tested materials, the Mylar matrix strip provided smoother surfaces than both of the finishing systems ($p<0.05$). When the finishing discs were compared, Sof-Lex discs produced a smoother surface than Po-Go discs for all tested materials ($p<0.05$).

Conclusion: The Mylar matrix strip provided a smoother surface than Sof-Lex and Po-Go discs. Furthermore, Sof-Lex discs produced smoother surfaces than Po-Go discs. Sof-Lex and Po-Go systems produced clinically acceptable surface roughness for microfill, hybrid, and packable composite resin materials. The effect of

finishing and polishing systems on surface roughness was dependent on both the system and the composite resin restorative material.

Keywords: Surface roughness, composite restorative materials, finishing, polishing

Citation: Üçtaşli MB, Arisu HD, Ömürlü H, Eligüzeloğlu E, Özcan S, Ergun G. The Effect of Different Finishing and Polishing Systems on the Surface Roughness of Different Composite Restorative Materials. J Contemp Dent Pract 2007 February;(8)2:089-096.

Introduction

Proper finishing and polishing of dental restorations are important aspects of clinical restorative procedures that enhance both esthetics and the longevity of restored teeth.[1-4] Residual surface roughness associated with improper finishing and polishing of dental restorations can result in clinical problems for both the patient and the clinician. These problems include excessive plaque accumulation, gingival irritation, increased surface staining, and poor or less than optimal esthetics of the restored teeth.[4,5]

A well finished and polished surface is difficult to obtain from composite restorations as the resin matrix and the organic filler differ in hardness preventing homogeneous abrasion.[6] As numerous authors have shown in previous studies, the smoothest surfaces were obtained with a clear matrix.[7,8] However, composites polymerized with a clear matrix on the surface will leave a resin rich surface layer that is easily abraded in the oral environment exposing unpolished, rough, and inorganic filler material.[9]

A variety of instruments are commonly used for finishing and polishing tooth-colored restorative materials including: carbide finishing burs (8-12-16 and 30 fluted), 25-50 µm diamond finishing burs, abrasive impregnated rubber cups and points, aluminum oxide coated abrasive discs, abrasive strips, and polishing pastes.[2-4,8-12] Each of these instruments or devices leaves the surface of various restorative materials with varying degrees of surface roughness.[12-15]

Resin composite materials are available with a variety of filler types that affect their handling characteristics and physical properties. Packable composites have been introduced as an alternative to dental amalgam. These composites have packable characteristics by various proprietary manufacturing methods, such as increased viscosity, increasing the level of filler content beyond 80-85% by weight, unique particle morphology, and/or particle size distrubution.[16] Packable composite resins differ mainly in the type of inorganic filler, the size of the filler, size distribution, and the extent of filler loading. Such factors may influence the ability of these materials to be polished. Although packable composites may offer some technical advantages and a more convenient placement, there is no convincing evidence these materials are clinically superior to traditional hybrid composites.[17-19]

Microfilled composites have less inorganic content with a smaller filler particle size than hybrid and packable composites; therefore, they can be finished to a smoother surface than the packable and hybrid composites.[6]

This study evaluated the effect of three different finishing systems on the surface roughness of different types of composite restorative materials.

Materials and Methods

The restorative materials used in this study are listed in Table 1. For each material, ten samples were prepared utilizing a sectional metal mold (8

Table 1. List of materials investigated.

Material	Category	Particle Size (µm)	Filler Content (wt%)	Manufacturer
Clearfil ST	Microfill composite	0.04/ 0.2/ 10	81.6	Kuraray Medical Tokyo, Japan
Clearfil AP-X	Microfill composite	0.04- 15	86	Kuraray Medical Tokyo, Japan
Clearfil Photo Posterior	Microfill composite	0.04- 20	86	Kuraray Medical Tokyo, Japan

mm diameter x 3 mm deep). The cavities were slightly over filled with material, covered with a Mylar matrix strip (Hawe-Neos Dental, Bioggio, Switzerland), and placed between two glass slides. The specimens were light polymerized for a 40s exposure using a quartz tungsten halogen Hilux light (Benlioğlu Dental A.Ş., Ankara, Turkey). The intensity of the light curing unit was checked using a Hilux curing light meter (Benlioğlu Dental A.Ş., Ankara, Turkey) before starting the polymerization. The mean output was 600 mW/cm^2. After light polymerization, the matrix strips were discarded. The samples were then stored in distilled water at 37ºC for 24 hours.

Following the storage period, the average surface roughness of the matrix-created surface was measured in five different positions on each sample using a surface profilometer (Surftest 211, Mitutoya, Tokyo, Japan). The cut-off value for surface roughness was 0.8 mm, and the traversing distance of the stylus was 4.0 mm. The radius of the tracing diamond tip was 5 µm and measuring force and speed were 4µN (0.4 gf) and 0.5 µ/s, respectively. The average roughness value (Ra, µm) of an individual disc was taken as the mean of the Ra values measured in five different positions.

The specimens were then subdivided into two treatment groups of five specimens from each of the three restorative materials. The first group was finished with coarse, medium, fine, and superfine aluminum-oxide abrasive Sof-Lex discs (3M-ESPE Dental Products, St. Paul, MN, USA), and the other group was finished with diamond coated Po-Go micro-polishers (Dentsply, Konstanz, Germany). The discs were mounted on a slow speed handpiece rotating at approximately 20,000 rpm. All specimen preparation, finishing, and polishing procedures were carried out by the same investigator in order to reduce variability.

After the finishing procedure was completed, surface roughness was again measured on the samples using the surface profilometer. Statistical analysis was performed using two-way analysis of variance (ANOVA) and post hoc paired group Scheffe's tests at a $p=0.05$ significance level.

Additionally, after finishing one specimen of the tested groups, they were prepared for scanning electron microscopy (ISM-840 A, Joel, Tokyo, Japan). Samples were sputter coated and evaluated with a magnification of x2500 at an accelerating voltage of 20 kV.

Results

Means and standard deviations of the surface roughness values (Ra, µm) are shown in Table 2. The smoothest surface was created against Mylar matrix strips, and results showed a statistically significant difference in mean surface roughness between the Mylar matrix strip, Sof-Lex discs, and Po-Go discs ($p<0.05$). When the composite surfaces created against the Mylar matrix strips were compared, there was no statistically significant difference between microfill and hybrid ($p>0.05$), but the difference was significant between microfill-packable and hybrid-packable ($p<0.05$) composite resin materials.

The mean surface roughness of hybrid resin composite revealed no significant difference with microfill composite resin for both finishing systems ($p>0.05$).

No significant differences between the average Ra values were observed between all tested composite materials finished with Sof-Lex discs (p>0.05). However, when the hybrid and microfill composite resins were finished with Po-Go discs, the surfaces were smoother than those produced by the packable composite resin (p<0.05).

When the finishing systems were compared, Sof-Lex discs produced a smoother surface than Po-Go discs for all tested materials (p<0.05). SEM observations support the findings that the Mylar matrix strip produced the smoothest surface and the Sof-Lex discs produced a smoother surface than the Po-Go discs (Figures 1, 2, and 3).

Discussion

Surface quality is an important parameter that influences the clinical behavior of dental restorations. Inadequate surface texture of a restoration can cause gingival irritation, surface staining, plaque accumulation, and secondary caries.[5,20-23] A variety of materials and techniques have been introduced for contouring, finishing, and polishing[2,24] but there is not a universally accepted method for finishing procedures.

In this study for all tested materials the Mylar matrix strip provided smoother surfaces than

Table 2. Effect of finishing with Sof-Lex and Po-Go discs on surface roughness (Ra, µm) of microfill, hybrid, and packable resin composites. (Capitals letters represent the differences between composite resin materials and lower case letters represent the differences between finishing systems.)

Material	Surface Roughness (Ra, µm)		
	Mylar Strip	Sof-Lex	Po-Go
Clearfil ST	0,063±0,022 Aa	0,248±0,090 Ab	0,560±0,090 Ac
Clearfil AP-X	0,088±0,042 Aa	0,300±0,075 Ab	0,590±0,080 Ac
Clearfil Photo Posterior	0,122±0,063 Ba	0,320±0,083 Ab	0,830±0,178 Bc

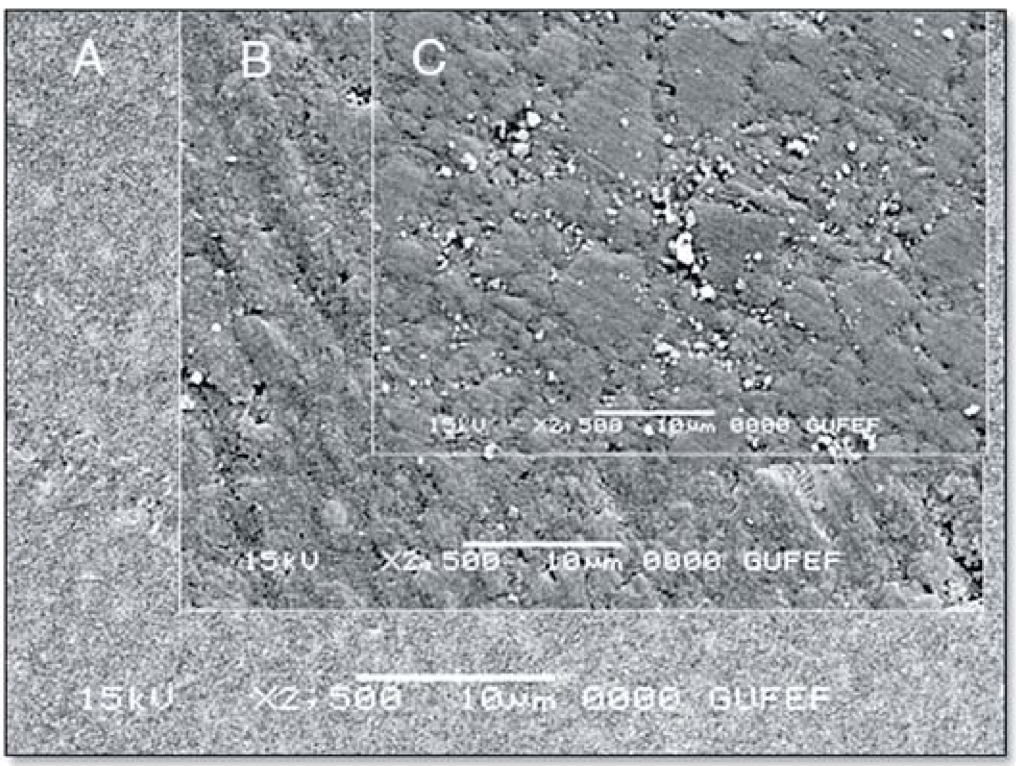

Figure 1. SEM photographs of Clearfil APX at 2500X magnification finished with: **A.** Mylar matrix strip, **B.** Sof-Lex discs, and **C.** Po-Go discs.

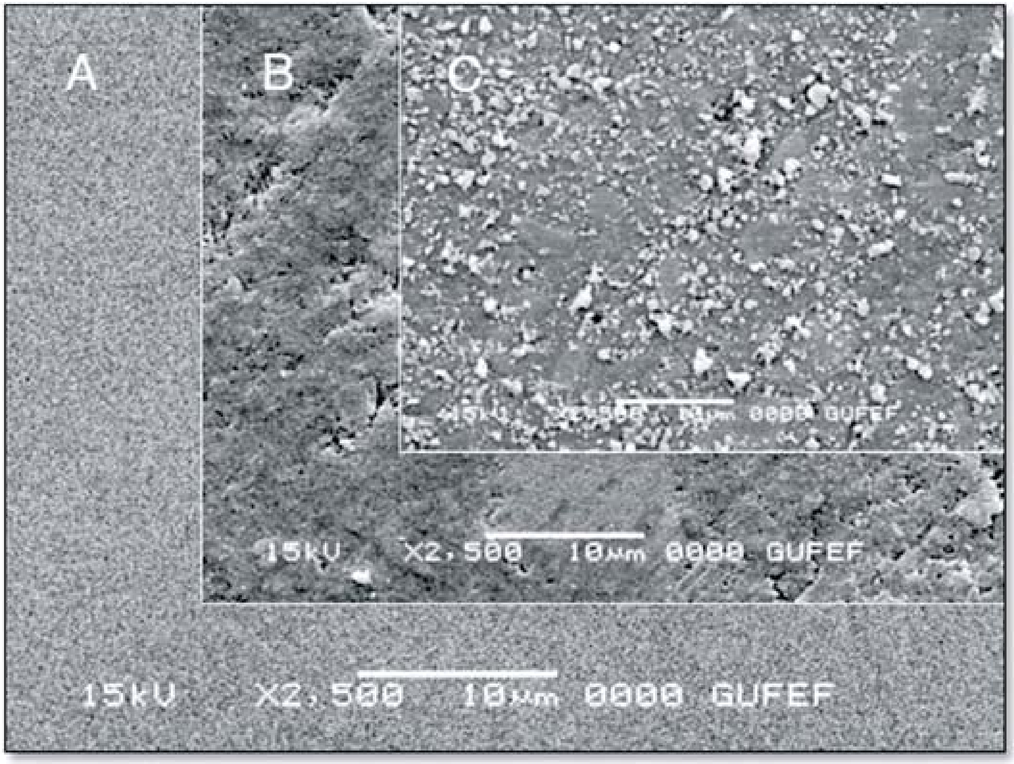

Figure 2. SEM photographs of Clearfil Photo Posterior at 2500X magnification finished with: **A.** Mylar matrix strip, **B.** Sof-Lex discs, and **C.** Po-Go discs.

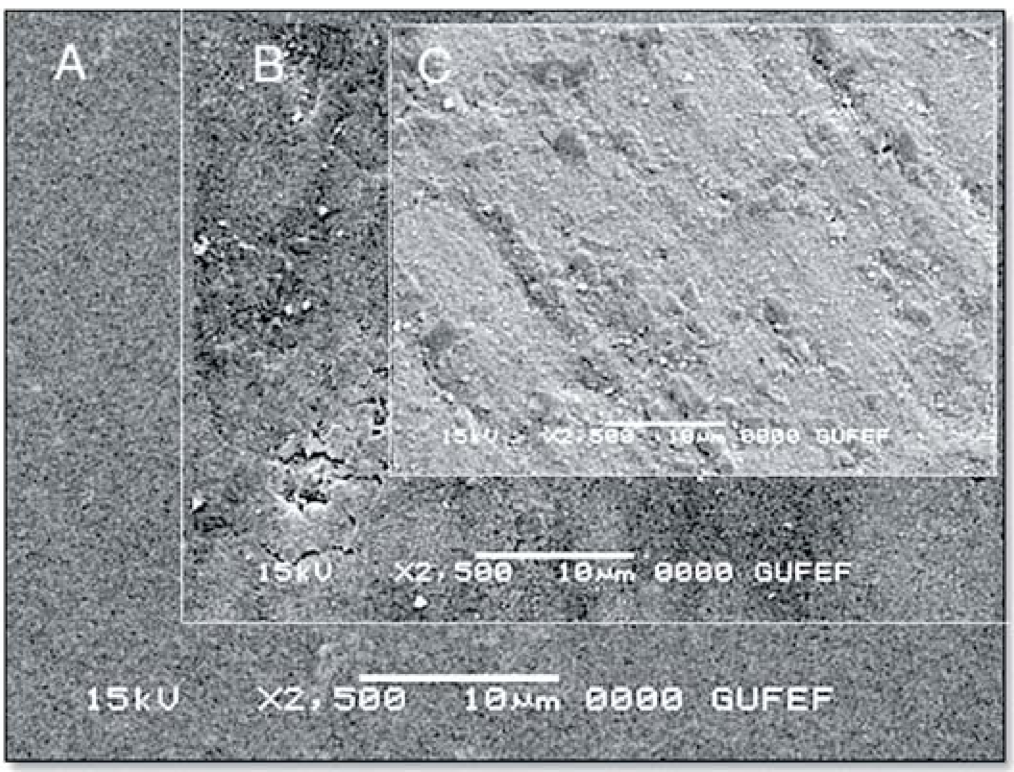

Figure 3. SEM photographs of Clearfil ST at 2500X magnification finished with: **A.** Mylar matrix, **B.** Sof-Lex discs, and **C.** Po-Go discs.

both other finishing systems. This result is in agreement with other studies[12,25-27] reporting the Mylar strip produced the smoothest surface. However, after placing composite restorations, removal of excess material or re-contouring of restorations is often necessary. Furthermore, the Mylar exposed surface is a resin rich surface layer that is easily abraded in the oral environment. If it is not polished, rough, inorganic filler material will be exposed.[9] Once the restorative material is touched with a contouring instrument, it is difficult to return to matrix like smoothness or gloss.

Mechanical profilometers have been used to measure surface roughness for *in vitro* investigations. Although the profilometers provides somewhat limited two-dimensional information, an arithmetic average roughness is calculated and used to represent various material/polishing surface combinations in treatment decisions.

The effect of finishing and polishing systems on surface roughness of composites has been reported in the literature.[1,3,15,26] In most of these studies multi-step systems were evaluated, and it was concluded these systems provided the smoothest surface.[28,29] To reduce the cost and clinical time, the one-step Po-Go finishing polishing diamond micro-polisher system was introduced to the dental profession.

Jung et al.[30] evaluated four finishing and polishing systems on the surface roughness of three packable and one hybrid resin composite and found aluminum oxide embedded Sof-Lex discs caused a significant reduction in roughness. The limitations of aluminum oxide discs are due to their shape. It is often difficult to use the discs efficiently for creating, finishing, and polishing anatomically contoured surfaces especially in the posterior regions of the mouth.

Other studies have also shown the ability of aluminum oxide discs to produce smooth composite surfaces, and they concluded the capability of aluminum oxide discs to produce smooth surfaces was related to their ability to cut the filler particle and matrix equally.[31-34] In this study Sof-Lex discs produced a smoother surface than Po-Go discs for all tested materials ($p<0.05$).

Resin composites are available with a variety of filler types that affect both their handling characteristics and physical properties. Resin composite fillers appear to play an intrinsic role in how well a composite finishes. In composites where the filler particles are significantly harder than the matrix, the resin phase may suffer a preferential loss during finishing and polishing. This will result in the positive relief of filler particles on the surface.[35,36] In this study no significant difference was observed between hybrid and posterior composites finished with Sof-Lex discs ($p>0.05$); however, when the hybrid composite was finished with Po-Go discs, smoother surfaces were produced than those for the posterior resin ($p<0.05$). Similarly, no significant difference was observed between microfill and packable composite surfaces finished with Sof-Lex discs ($p>0.05$). However, the difference was significant when finished with Po-Go discs ($p<0.05$). This could be due to the superior abrasive effect of aluminum oxide discs or the effect of differences in the clinical application.

Ryba and others[37] investigated two finishing methods on several packable composites and found significant differences in surface roughness among the different materials that differ mainly in their inorganic filler, the size of the filler, size distribution, and the extent of filler loading. Based on the results of this study, the effects of the polishing system on surface roughness was dependent on both the system and materials employed.

Chung[13] reported significantly less roughened surfaces for microfilled composites than hybrid composites. Berastequi and others[1] concluded microfilled resin composites provided a better finish when treated with aluminum oxide discs. In this study the average surface roughness of hybrid composites revealed no significant difference with microfill composites for both finishing systems ($p>0.05$).

Weitmann and Eames[21] and Shintani et al.[5] have reported no perceptible difference in plaque accumulation between polished surfaces that resulted in Ra values within a 0.7-1.4 µm range. In this study the Ra values produced with the two finishing and polishing systems for all tested materials are within this range. In this context, a smoother composite surface was obtained with Sof-Lex discs, but Po-Go discs produced a clinically acceptable surface roughness.

Conclusion

The Mylar matrix strip provided a smoother surface than Sof-Lex and Po-Go discs. Furthermore, Sof-Lex discs produced smoother surfaces than Po-Go discs. Sof-Lex and Po-Go systems produced clinically acceptable surface roughness for microfill, hybrid, and packable composite resin materials. The effect of a finishing and polishing system on surface roughness was dependent on both the system and the composite resin restorative material.

Clinical Relevance

Surface roughness is a critical factor that influences the clinical behavior of dental restorations. Inadequate surface texture of composite resin can lead to gingival irritation, surface staining, plaque accumulation, and secondary caries.

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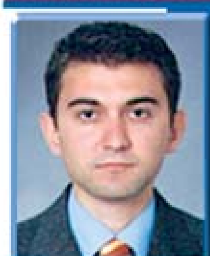

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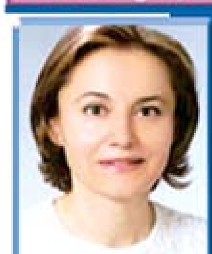

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