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Original Article

Effect of repolishing on the surface roughness and color stability of air-abraded resin composites

Nurcan Altaş[1], Aysu Aydınoğlu[2], Burcu Gözetici Çil[3], Ergün Keleşoğlu[4], Kadir Sağır[4], Afife Binnaz Hazar Yoruç[2]

[1] İstanbul Medipol University, School of Dentistry, Department of Periodontology, Istanbul, Turkey
[2] Yıldız Technical University, Faculty of Chemistry and Metallurgy, Department of Metallurgy and Materials Engineering, Istanbul, Turkey
[3] İstanbul Medipol University, School of Dentistry, Department of Restorative Dentistry, Istanbul, Turkey
[4] Turkish-German University, Faculty of Science, Department of Materials Science and Technology, Istanbul, Turkey

Abstract

Aim: Air powder polishing (APP) can cause roughness on composite surfaces, and consequently the color change that occurs over time affects the aesthetic negatively. Here, we aim to investigate the effect of repolishing on the roughness and discoloration of resin composites after APP to avoid its negative effects for the first time.
Methodology: A total of 39 composite discs were randomly allocated into three groups: Group I: Control (n = 13), Group II: Air Powder Polished (n = 13), and Group III: Air Powder Polished + Re-polished (n = 13). Color and surface roughness of the discs were measured before and after immersion in coffee for 1 week. Color was measured using a colorimeter (CR-400, Konica Minolta, Osaka, Japan), and roughness was measured using a surface roughness analyzer (SJ-400, Mitutoyo, Japan).
Results: All specimens in the groups, except those in Group III, showed significant changes in roughness, and all materials showed significant color changes after immersion in the coffee relative to the baseline. There was no statistically significant difference between the groups in terms of roughness and color.
Conclusion: In this study, we showed that repolishing after APP does not significantly improve the color stability and roughness of the composite restorations.

Keywords: Dental air abrasion, surface roughness, repolishing, composite resin, colorimeter, coloring agent

Correspondence:

Dr. Nurcan ALTAŞ
Istanbul Medipol University, School of Dentistry, Department of Periodontology, Istanbul, Turkey.
E-mail:nurcanaksaka@gmail.com

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Introduction

The esthetic success of restorations depends on their similarity with natural teeth. Numerous studies have shown that some beverages, such as coffee, can cause discoloration in restorations (1, 2). Clinically visible color change is one of the main reasons for the replacement of a composite restoration (3, 4).

Finishing and polishing procedures are very important for both the clinician and the patient, since the surface texture of composite restorations highly affects their color, wear, esthetic, and long-term clinical success (1). Rough surfaces that occur when these procedures are not performed properly can result in deterioration of esthetics, increased plaque accumulation, and increased risk of periodontal inflammation and recurrent carries (5).

Air powder polishing (APP) has been used in clinical practice for a long time. In this procedure, various particles such as sodium bicarbonate, aluminum trioxide, calcium carbonate, or glycine are directed to the tooth surface by an air jet along with water (6, 7). APP is an effective, fast, and facile way to eliminate plaque and extrinsic discoloration. However, some studies have shown that APP increases roughness and creates depressions on the surface of resin composite restorations and can eventually cause discoloration. (6, 8). Therefore, clinicians can assume that repolishing after APP will be useful to regain resistance against staining that may occur in the patient’s daily routine.

In this study, we aimed for the first time to demonstrate the effect of repolishing on the surface roughness and color stability of air-powder-polished resin composites.

Materials and Methods

Preparation of specimens

All samples were produced by a single, experienced, and blinded operator according to the manufacturer’s directions. An A2 shade composite resin (Gradia Direct GC Europe, Belgium) was placed into a silicone disc mold (10×2 mm), and a Mylar strip was laid on it. The excess of the composite was removed by applying pressure over the strip. The specimens were cured for 40 s with an LED light source (LED.B, Guilin Woodpecker Medical Instrument, Guilin, Guangxi, China) and polished with aluminum oxide discs (Sof-Lex, 3M ESPE, St. Paul, MN, USA). The polymerized and polished 39 specimens were kept in glass tubes containing distilled water at 37 °C for 24 h prior to additional treatments.

Surface treatment

A total of 45 samples were prepared in our study. After the production phase was completed, 6 samples were excluded from the study due to irregularities that occurred on the composite surface.

Samples were randomly (using the lottery method) divided into three groups according to surface treatment protocols: Group I: Control (n = 13); Group II: specimens were air-polished with sodium bicarbonate powder (n = 13); and Group III: specimens were re-polished after APP (n = 13).

As mentioned previously, all samples were polished according to the manufacturer’s instructions using aluminum oxide discs. For Group II, a standard air-polishing unit (ProSmile Handly, Sirona Dental Systems GmbH, Bensheim, Germany) was positioned perpendicular to the specimen surface at a distance of 10 mm, and the samples were abraded for 10 s. Group III was re-polished with Ultradent Diamond Polish Mint (Ultradent Products, South Jordan UT, USA) for 30 s after the APP procedure. APP and repolishing were performed by a second operator.

Immersion protocol

All specimens were rinsed with distilled water for 10 s and then immersed in filtered coffee (Kenya, Starbucks Company, USA) for 1 week at 37 °C. The 20 g of coffee was added to 100 ml of boiling water. After 10 min of blending, the coffee was filtered through filter paper. The staining solution was replaced every 48 h to prevent any contamination, and the solution container was sealed with parafilm to reduce evaporation (8). After 1 week, all composite discs were washed with distilled water for 10 s and dried with an adsorbent paper.

Measurement of color change and surface roughness

Color and surface roughness measurements were performed before and after 1 week of immersion by a third examiner who was blinded to the polishing stage in order to avoid bias. The surface roughness of all specimens was measured using a portable stylus-type surface tester (SJ-400, Mitutoyo, Tokyo, Japan). Three measurements at different locations were recorded, and the average value of the roughness profile (Ra) was calculated.

Color measurements of all samples were recorded with a colorimeter (CR-400, Konica Minolta, Osaka, Japan) using CIE (Commission Internationale de l'Eclairage).

After calibration was carried out according to the manufacturer's recommendations, three different measurements were performed on each sample surface. The average L*, a*, and b* values which reflects white/black, red/green, and yellow/blue axes, respectively were recorded, and the color difference between the baseline and after 1 week of storage was calculated according to the following formula:

$$\Delta E^{*} = [(\Delta L^{*})^2+(\Delta a^{*})^2+(\Delta b^{*})^2]^{1/2}. \quad (1)$$

Statistical analysis

The analyses were performed using SPSS 23.0 (IBM SPSS Inc., Armonk, NY, USA), and $p < 0.05$ was considered statistically significant.

The distribution of variables was measured using the Kolmogorov-Smirnov test. Quantitative independent data were analyzed using the Kruskal-Wallis test.

Two-way analysis of variance (ANOVA) was used to evaluate the effect of APP and repolishing on the color stability and surface roughness.

Results

The mean surface roughness and distribution graphs between the groups are shown in Table 1 and Figure 1, respectively. Figure 1 shows the distribution of Ra before and after immersion in the coffee. The highest difference in surface roughness before and after immersion (ΔRa) was observed in Group I (0.1877 ± 0.0529) and the lowest ΔRa was observed in Group III (0.1176 ± 0.0648) (Table 1).

The statistical differences of the intra and intergroups for roughness are shown in Table 2. All materials in the groups, except for Group III (p = 0.054), resulted in a significantly higher surface roughness when compared to their baseline ($p < 0.05$), but there was no statistically significant difference between the groups in terms of Ra ($p > 0.05$).

Regarding intra-group comparisons, all groups showed significant color changes in terms of their L*, a*, and b* values after 1 week of immersion in coffee (Table 2, $p < 0.05$). However, there was no statistically significant difference between the groups ($p > 0.05$).

The mean L, a, b, ΔL, Δa, Δb, and ΔE values, and standard deviations (SD) of each group are listed in Table 3. The highest ΔE* values were observed in Group I, and the lowest ΔE* values were observed in Group II. The total color shift of the ΔE* values did not differ significantly between the groups after 1 week (p = 0.651).

Table 1. Median and mean surface roughness (Ra) observed with the different polishing procedures. ΔRa denotes the change in Ra after immersion to the coffee solution for 1 week.

Treatment Groups	Median	Mean (Ra)	ΔRa
Group IA (Control) Aluminum oxide disc polishing before immersion coffee solution	0.17	0.18 ±0.07	0.19 ±0.05*
Group IB (Control) Aluminum oxide disc polishing after immersion coffee solution	0.39	0.37 ±0.18	
Group IIA Air powder polishing before immersion coffee solution	0.17	0.23 ±0.16	0.16 ±0.07*
Group IIB Air powder polishing after immersion coffee solution	0.32	0.39 ±0.19	
Group IIIA Repolishing with mint before immersion coffee solution	0.17	0.23 ±0.14	0.12 ±0.06*
Group IIIB Repolishing with mint after immersion coffee solution	0.24	0.34 ±0.19	

*Std. Error Difference

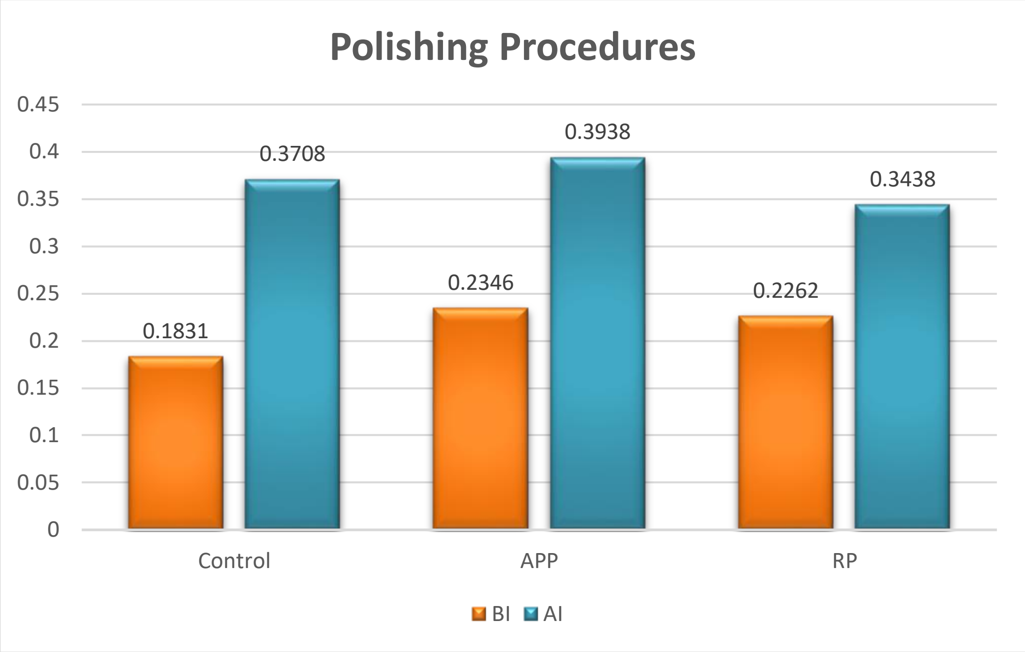

Figure 1. Distribution of surface roughness (Ra) between groups before and after immersion in the coffee

Table 2. Statistical difference of roughness (Ra), values that reflect white/black (L^*), red/green (a^*), and yellow/blue (b^*) axes for the different groups.

	p (Ra)^M	p (L^*)^M	p (a^*)^M	p (b^*)^M
Group IA-Group IB	<0.050 (=0.007)	<0.050 (=0.009)	<0.050 (=0.009)	<0.050 (=0.016)
Group IIA-Group IIB	<0.050 (=0.009)	<0.050 (=0.009)	<0.050 (=0.009)	<0.050 (=0.009)
Group IIIA-Group IIIB	>0.050 (=0.054)	<0.050 (=0.009)	<0.050 (=0.009)	<0.05 (=0.009)
Group IA-Group IIA	>0.050 (=0.700)	>0.050 (=0.463)	>0.050 (=0.251)	>0.050 (=0.251)
Group IA-Group IIIA	>0.050 (=0.662)	<0.050 (=0.009)	>0.050 (=0.753)	>0.050 (=0.251)
Group IIA-Group IIIA	>0.050 (=0.837)	<0.050 (=0.047)	>0.050 (=0.249)	>0.050 (=0.917)
Group IB-Group IIB	>0.050 (=0.959)	>0.050 (=0.117)	>0.050 (=0.295)	>0.050 (=0.465)
Group IB-Group IIIB	>0.050 (=0.778)	>0.050 (=0.917)	>0.050 (=0.076)	>0.050 (=0.347)
Group IIB-Group IIIB	>0.050 (=0.281)	>0.050 (=0.175)	>0.050 (=0.530)	>0.050 (=0.754)

Kruskal-wallis /Wilcoxon test

Table 3. Median and mean values that reflect white/black (L^*), red/green (a^*), yellow/black (b^*) axes. The change in the mean values of L^*, a^*, and b^* after 1 week of immersion to the coffee solution is given by ΔL^*, Δa^*, Δb^*, respectively. The change in color after 1 week of immersion to the coffee solution, denoted by ΔE^* is calculated using $\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$. The numbers after the ± symbol are the standard deviations.

	L^*		a^* (-)		b^*		ΔL^*	Δa^* (-)	Δb^*	ΔE^*
	Median	Mean	Median	Mean	Median	Mean				
Group IA (Control)	74.77	75.02 ±0.91	2.08	2.09 ±0.10	17.04	16.14 ±2.37	10.55 ±0.75	0.93 ±0.11	3.75 ±1.09	11.23
Group IB (Control)	64.71	64.47 ±1.42	1.15	1.17 ±0.23	12.22	12.39 ±0.62				
Group IIA	74.24	74.44 ±0.64	1.94	2.02 ±0.23	18.03	17.55 ±1.27	8.712 ±0.64	1.04 ±0.14	4.724 ±1.05	9.96
Group IIB	65.79	65.72 ±1.29	0.89	0.98 ±0.23	13.4	12.83 ±1.98				
Group IIIA	73.74	73.73 ±0.19	2.16	2.11 ±0.10	17.49	18.00 ±1.50	8.98 ±0.28	1.21 ±0.09	5.29 ±0.88	10.49
Group IIIB	64.59	64.75 ±0.61	0.87	0.90 ±0.16	13.14	12.71 ±1.27				

Discussion

The surface roughness (Ra), measured in micrometers (μm), refers to surface irregularities of the material resulting from the production stage or properties of the product (9). An increase in Ra of more than 0.2 μm, which is the estimated value determined for bacterial adhesion, results in increased plaque deposition, discoloration, and increased risk of caries and periodontal inflammation (10). Therefore, finishing and polishing procedures are typically applied to obtain a smooth surface on restorations.

Johnson et al. suggested that the application of sodium bicarbonate or aluminum trihydroxide particles should be avoided in dental restorative materials (11). In some studies that evaluate the effect of sodium bicarbonate powder on the surface texture of various restorative materials, it has been demonstrated that the highest roughness occurs in composite restorations (12,13).

In this study, the tested resin materials were immersed in coffee for 1 week. All materials except for Group III showed significant ($p < 0.05$) changes in roughness after coffee exposure, including the control group. The increased surface roughness in the control group might be explained by chemical erosion from coffee arising from its acidic nature (8). In contrast, Group III was found to be more resistant to roughness changes compared with the other two groups. However, there was no statistically significant difference in the surface roughness between the groups.

The highest and lowest differences in Ra between the initial measurement and 1 week after immersion were found in Group I and Group III, respectively. Considering this result, repolishing after APP may decrease the roughness. However, more studies designed to reflect this particular situation are required.

It has been previously reported that resin-based composite restorations are stained by coffee, tea, cola, and red wine (14, 15). Since coffee is widely used in daily life and has a high staining capacity, it was used as a colorant in this study.

The objective CIE L*a*b* system, which can detect the lowest color differences, was chosen to measure color changes (16). The authors reported that ΔE* values ranging from 1 to 3 could be detected by the naked eye, which is clinically acceptable. ΔE* values equal to or greater than 3.3 were considered visible and clinically unacceptable color changes (17,18). In this study, all composite resin specimens immersed in coffee showed clinically unacceptable ΔE* values, which ranged from 9.96 to 11.40. According to the data obtained from our study, significant discoloration of resin composite materials in all groups after 1 week of immersion in coffee was not surprising. The highest color change was observed in Group I, whereas the lowest color change was observed in Group II, which was air powder polished. In contrast, Group III, which was re-polished with mint, was the most stable with regard to the surface roughness.

It was also found that Group II produced the roughest surfaces but exhibited the lowest discoloration. On the contrary, Group I produced a smoother surface. However, it exhibited the highest color change. These results indicated that discoloration is not significantly dependent on surface roughness.

This study has various limitations, such as a short immersion period in coffee and flat composite specimen surfaces prepared differently from clinically irregular composite surfaces. Therefore, further studies should be carried out to evaluate the effectiveness of repolishing after APP on surface roughness and discoloration using different repolishing methods or composite materials.

Conclusions

Consequently, APP did not significantly increase the surface roughness of the composite resin; therefore, repolishing did not improve the surface quality. The results clearly showed that the repolishing process applied after APP did not have any significant effect on the discoloring performance of the composite resin restoration. Future studies should address the limitations of this study by investigating the effect of repolishing after APP using different polishing techniques and composite materials with clinically irregular surfaces.

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