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Color stability and surface roughness of polished anterior restorative materials

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The purpose of this study was to investigate the effects of different finishing-polishing techniques on the color stability and surface roughness of various anterior restorative materials after staining. A composite, a compomer, and a resin-modified glass ionomer were used to prepare 120 specimens. Specimens were divided into subgroups: polishing discs, liquid polishing material, aluminium oxide-bonded discs, and control. The specimens were stained in a coffee solution. Color parameters ($L^*a^*b^*$) and surface roughness before and after staining were measured. The color was affected by the material type ($p<0.05$) and finishing-polishing systems ($p<0.05$). The composite showed the highest color stability; however, the color differences of all groups were visible even to the nonskilled operator. The R_a values did not significantly change after staining for any of the restorative groups ($p>0.05$). The finishing-polishing systems had an effect on color after storing in staining solution.

Keywords: Color, Resin-modified glassionomer, Compomer, Composite, Finishing-polishing techniques

INTRODUCTION

Compliance of the color of a restoration and preservation of this harmony for a long time is the most important criteria for judging the success of a resin-based restoration, even in pediatric dentistry. Nowadays, many children are referred to clinics with esthetic concerns as they start to make friends in preschool. Therefore, dental restorations must have an appropriate color in order to be esthetically pleasing and a smooth surface for low plaque retention. However, color failure is one of the most common problems in anterior restorations. The existing teeth and restorations in the mouth may exhibit color changes because of various internal and external factors[1]. Extrinsic discoloration occurs outside the tooth substance, and it arises when either external pigment is deposited within the plaque or when there are reactions within the porous surfaces. Pigments may become internalized by enamel defects, the porous surface of exposed dentine, acquired defects such as tooth wear and gingival recession, dental caries, and restorative materials[2,3]. This situation is not desirable by either dentists or patients.

A variety of polishing methods have been developed to improve the life and quality of restorations. However, after coming into contact with the oral environment, changes to both the surface roughness and color of the restorations are observed. Many studies have shown that certain beverages and foods affect the esthetics and physical properties of restorations (microhardness, surface roughness)[4,5].

In pediatric dentistry, polyacid-modified composite resin (compomer) and resin-modified glassionomer cement (RMGIC) are widely used restorative materials owing to their flouride-releasing properties. Flouride-releasing materials are especially recommended in both adults and children who are at high risk for dental caries; compomers and RMGIC are also indicated for use in anterior regions for esthetic concerns.

Accordingly, this study investigated the effects of different finishing and polishing techniques on the surface roughness and color stability of various anterior restorative materials after staning: compomers, RMGIC, and composites.

The null hypotheses to be investigated in this study were:

1. There are no differences among the polishing systems on the color stability of anterior restorative materials after staining.
2. There are no differences among the polishing systems on the surface roughness of anterior restorative materials after staining.
3. There is no relationship between color stability and surface roughness.

MATERIALS AND METHODS

Samples preparation

A composite resin (Admira, VOCO, Cuxhaven, Germany), a RMGIC (Fuji II® LC, GC, Alsip, IL, USA), and a compomer (Dyract®, Dentsply/De Trey, Konstanz, Germany) currently indicated for esthetic anterior restorations were used in the present study. Information regarding material type, composition, and manufacturer is given in Table 1.

Forty samples were prepared for each group (n=120). The samples were prepared in a cylindrical brass mold that had a diameter of 10 mm and a depth

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Table 1 Materials used in this study

Material	Product	Batch No	Manufacturer
Resin-modified glass ionomer (RMGIC) Liquid: Polyacrylic acid, 2-Hydroxyethyl methacrylate (HEMA), Proprietary Ingredient, 2,2,4, Trimethyl hexamethylene dicarbonate, Triethylene glycol dimethacrylate (TEGDMA) Powder: Alumino-fluoro-silicate glass (amorphous)	Fuji II LC	1106011	Shade A3 GC Corporation (Tokyo, Japan)
Compomer Urethane dimethacrylate (UDMA), Carboxylic acid modified dimethacrylate (TCB resin), TEGDMA, Trimethacrylate resin, Camphorquinone, Ethyl-4-dimethylaminobenzoate, Butylated hydroxy toluene (BHT), UV stabiliser, Strontium-alumino-sodium-fluoro-phosphor-silicate glass, Highly dispersed silicon dioxide, Strontium fluoride (2.5–10%), Iron oxide and titanium dioxide pigments	Dyract Extra	0909001006	Shade A3 Dentsply/De Trey (Konstanz, Germany)
Composite Bis-phenol A diglycidylmethacrylate (Bis-GMA), di-UDMA, TEGDMA, three-dimensionally curing anorganic-organic copolymers, additive aliphatic and aromatic dimethacrylates, fillers; glass-ceramic, SiO_2 microparticle 0.7 μm, range of filler size, 0.04–1.2, fillers 78wt%	Admira	1103163	Shade A3 Voco (Cuxhaven, Germany)
Aluminum oxide bonded discs (AOBD) Polymerized urethane dimethacrylate resin Aluminum oxide Silicone dioxide	Enhance	100113	Dentsply Caulk (Milford, DE, USA)
Polishing discs (PD) Aluminum oxide abrasive discs	Sof-Lex	P090508	3M ESPE (St. Paul, MN, USA)
Liquid polishing material (LPM) Dipentaerythriol diacrylate esters, ethanol	BisCover LV	1000010770	Bisco (Schaumburg, IL, USA)

of 2 mm. After the materials were placed into the mold, a transparent polyester strip (Mylar, DuPont, Wilmington, DE, USA) was placed on the materials. Slight pressure was applied to obtain a smooth surface and to remove excess material. The materials were manipulated and polymerized according to the manufacturers' instructions. All specimens were polymerized by an LED light-curing unit (T-LED, Elca Technology, Imola, Italy) with a light intensity of 1,100 mW/cm^2, using 20 s of exposure to the top and bottom surfaces.

Specimens were wet-ground with 1,000-grit silicon carbide abrasive paper for 10 s for the purpose of surface standardization.

Upon completion of the sample preparation, the samples were randomly divided into four subgroups according to different finishing and polishing systems (n=10).

Finishing and polishing processes

Except for the control group, three different finishing and polishing systems were used.

- No polishing procedure was applied to the control group.
- In the second group, aluminium oxide-bonded discs (AOBD) (Enhance®, Dentsply/DeTrey) and pastes were used for polishing.
- In the third group, the specimens were polished with a series of polishing discs (PD) (Sof-Lex™, 3M/ESPE, St. Paul, MN, USA) with a slow-speed handpiece (K10, Kavo, Leutkirch, Germany), applying each disk (coarse, medium, fine, and superfine) for 15 s.
- In the fourth group, a liquid polishing material (LPM) (BisCover™, Bisco, Schaumburg, IL, USA) was used according to the manufacturer's recommendations.

All prepared specimens were stored in distilled

water at 37°C for 24 h for rehydration and completion of the polymerization.

Color stability

The colors of all specimen groups were measured before exposure to the immersion solution using a spectrophotometer (Easyshade®, Vita Zähnfabrik, Bad Säckingen, Germany) using CIE (Commission International de l'Éclairage) $L^*a^*b^*$ relative to standard illuminant A against a white background. Standard illuminants provide a basis for comparing images or colors recorded under different lighting[6]. Natural daylight was used when the measurements were performed. Measurements were repeated three times for each specimen and the mean values of the L^*, a^*, and b^* data were calculated.

Surface roughness

Surface roughness was measured with a profilometer (Perthometer M2, Mahr, Germany). During the measurements, the samples were fixed. Measurements were repeated three times at different locations on the sample surface. The profilometer was calibrated before each measurement and the mean roughness of the test specimens was obtained.

All specimens were stored in 100 mL of coffee (Nescafe Classic, Nestlé Suisse SA, Vevey, Switzerland) at 37°C for 48 h. After 48 h in the coffee solution, the specimens were rinsed with distilled water for 5 min and blotted dry with tissue paper.

The color and surface roughness measurements were repeated as previously described. The color variation E^* between the color at baseline and after 48 h storage (ΔE^*) for each disk sample was calculated using the following equation[7] :

$\Delta E^*=[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$. Values of $\Delta E^*\geq 3.3$ were considered clinically unacceptable[7].

Surface roughness changes were calculated by the differences between the mean values obtained before and after immersion.

Scanning electron microscope (SEM) analysis

The aim of SEM (JEOL JSM- 6390 LV, JEOL, Tokyo, Japan) analysis was to observe the micromorphology of the polished restorative materials after staining procedure. Sample preparation procedures were carried out same as experimental groups and then the surfaces of specimens were gold sputter-coated and were observed by SEM. The entire surface was scanned and the most representative areas were photographed at a magnification of 1,000 and 5,000× and an accelerating voltage of 20 kV.

Statistical analysis

The results of testing were entered into an Excel (Microsoft, Seattle, WA, USA) spread sheet for calculation of descriptive statistics. The data were analyzed with statistical software (SPSS PC, Vers.12.0, SPSS, Chicago, IL, USA). The average roughness profile (R_a) of the specimens and differences between two color measurements (ΔE^*) were evaluated with two-way analysis of variance for significant differences. Tukey HSD test and paired-t tests were used to perform multiple comparisons (α=0.05). To determine the effects of polishing techniques on the color variation, the relationships were evaluated with the Pearson correlation test for each restorative material ($p<0.05$).

RESULTS

Effects of polishing method and restorative material type on color stability

The two-way ANOVA results showing the differences in ΔE^* values among the restorative materials and polishing methods are shown in Table 2. Table 3 shows the mean and standard deviation values of ΔE^* according to restorative materials and polishing methods. The polishing method and restorative material type independently significantly affected the ΔE^* of the restorative materials ($p<0.05$). When the polishing methods were evaluated, the control group showed the highest ΔE^* and there were significant differences between the control and LPM groups ($p<0.05$). When the restorative materials were evaluated, the composite resin showed the lowest ΔE^*, and there were no differences between the compomer and RMGIC ($p>0.05$).

There were significant interaction between restorative material types and polishing methods for ΔE^* ($p<0.05$). For the compomer group, the results for the three polishing methods were similar to those for the control group ($p>0.05$), but the ΔE^* of the PD groups was statistically higher than that of the LPM groups ($p<0.05$). There were no significant differences among groups for the composite resin ($p>0.05$). As far as RMGIC is concerned, the highest ΔE^* values were observed in the control group, which was significantly different from the LPM and PD groups ($p<0.05$) and there were no differences among polishing techniques ($p>0.05$).

Among the AOBD groups, ΔE^* of the composite was significantly less than that of the other restorative materials. When the PD groups were evaluated, the ΔE^* values of the composite and RMGIC were similar to each other ($p>0.05$) and better than that of the compomer ($p<0.05$). When the LPM groups were evaluated, all the color changes of the restorative materials were found to be similar ($p>0.05$).

Two-way ANOVA results for ΔL^*, Δa^*, and Δb^* of the restorative materials and polishing methods are shown in Table 2. For ΔL^*, which represents an object's brightness, there were significant differences among both the restorative materials and polishing methods ($p<0.05$). L^* values decreased after staining in all groups ($\Delta L^*<0$), meaning that the specimens became darker. When the effects of restorative material type were compared, the lowest ΔL^* value was observed in the composite and the highest in RMGIC. In a comparison of the effect of polishing method, the highest ΔL^* value was observed for the control and the lowest for the LPM group ($p<0.05$) (Tables 4 and 5).

The a^* values increased after staining for all groups

Table 2 Two-way ANOVA results for comparison of ΔE^*, ΔL^*, Δa^* and Δb^* values

	Source	Type III sum of squares	Df	Mean square	F	Sig.
ΔE^* values	Restorative materials	309.12	2	154.56	26.99	0.000
	Polishing technique	81.57	3	27.19	4.74	0.004
	Restorative materials×Polishing technique	97.24	6	16.20	2.83	0.013
ΔL^* values	Restorative materials	442.99	2	221.49	49.30	0.000
	Polishing technique	114.51	3	38.17	8.49	0.000
	Restorative materials×Polishing technique	128.11	6	21.35	4.75	0.000
Δa^* values	Restorative materials	156.54	2	78.27	12.12	0.000
	Polishing technique	81.10	3	27.03	4.18	0.008
	Restorative materials×Polishing technique	224.14	6	37.35	5.78	0.000
Δb^* values	Restorative materials	600.33	2	300.16	41.83	0.000
	Polishing technique	11.49	3	3.83	0.53	0.660
	Restorative materials×Polishing technique	110.12	6	18.35	2.55	0.023

Table 3 Mean color changes (ΔE^*) (SD) of tested materials after staining

	RMGIC	Compomer	Composite	Total
Control	[b] 9.65 (1.50) A	[a,b] 7.99 (1.90) A	[a] 4.62 (1.12) B	7.42 [b]
AOBD	[a,b] 8.26 (1.30) B	[a,b] 6.93 (2.24) C	[a] 3.92 (1.54) A	6.37 [ab]
PD	[a] 6.96 (1.36) A	[b] 10.29 (4.13) B	[a] 4.91 (2.34) F	7.38 [b]
LPM	[a] 6.35 (3.38) G	[a] 5.85 (3.15) G	[a] 4.07 (2.61) A	5.42 [a]
Total	7.80B	7.76B	4.38A	—

Same lowercase letters indicate an insignificant difference within the same column ($p<0.05$). Same uppercase letters indicate an insignificant difference within the same row ($p<0.05$).

Table 4 ΔL^*, Δa^*, Δb^* (SD) values among restorative materials

	RMGIC	Compomer	Composite
ΔL^*	−6.30 (1.01) A	−4.63 (3.37) B	−1.65 (3.67) C
Δa^*	1.65 (2.38) B	−0.47 (1.36) A	2.15 (1.29) B
Δb^*	−0.20 (0.68) A	4.79 (5.18) B	0.35 (1.10) A

Same uppercase letters indicate an insignificant difference within the same row ($p<0.05$).

Table 5 ΔL^*, Δa^*, Δb^* (SD) values among polishing systems

	Control	AOBD	PD	LPM
ΔL^*	−5.37 (3.13) A	−4.63 (2.85) A	−4.08 (0.65) AB	−2.70 (3.62) B
Δa^*	2.51 (0.42) B	0.84 (3.13) AB	0.44 (3.39) A	0.64 (5.32) A
Δb^*	1.26 (5.82) A	2.08 (1.43) A	1.47 (4.43) A	1.77 (1.46) A

Same uppercase letters indicate an insignificant difference within the same row ($p<0.05$).

($\Delta a^*>0$) except for the compomer. An increased a^* value means the specimen shifted toward red. There were significant differences among the restorative materials and polishing methods ($p<0.05$). When the effects of restorative material type were compared, the lowest Δa^* value was observed in the compomer, which was statistically lower than that of the others ($p<0.05$). As far as the effects of polishing method are concerned, the PD and control groups showed the lowest and highest Δa^*, respectively, and these were statistically different ($p<0.05$) (Tables 4 and 5).

The b^* values increased after staining for all groups ($\Delta b^*>0$) except for RMGIC. An increased b^* value means the specimen shifted toward yellow. There were no differences among the polishing methods ($p>0.05$). When the restorative materials were compared, the highest Δb^* value was observed in the compomer group and the value was significantly different from that of the others ($p<0.05$) (Tables 4 and 5).

Surface roughness changes

The mean values of the surface roughness before and after staining are presented in Table 6. The R_a values of the polishing system groups did not significantly change after staining in any of the restorative groups ($p>0.05$).

According to the results of Pearson correlation test, there was a positive correlation between the surface roughness change and the color change in RMGIC group ($p<0.05$), however there were no correlation in other restorative materials (composite resin and compomer) (Fig. 1).

SEM images of surface topography

The SEM images of RMGIC (Fig. 2) showed a smoother surface for the LPM and control groups, whereas there were no differences in surface roughness between the PD, AOBD, and LPM subgroups.

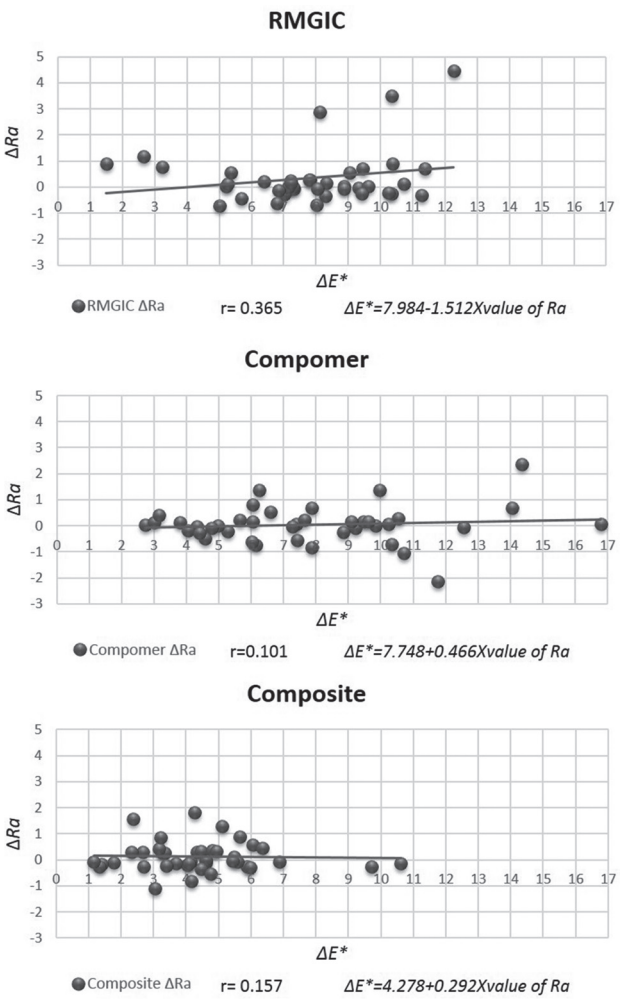

Fig. 1 Correlation between surface roughness and color changes.

Table 6 Mean (SD) of Ra values (μm) before and after staining for each tested material and polishing system

		Before staining	After staining	
RMGIC	Control	2.24 (0.35)	2.13 (0.28)	(p=0.33)
	AOBD	1.60 (0.71)	1.52 (0.43)	(p=0.60)
	PD	0.75 (0.24)	1.05 (0.86)	(p=0.24)
	LPM	0.71 (0.23)	1.07 (0.46)	(p=0.06)
Compomer	Control	1.94 (0.74)	1.69 (0.17)	(p=0.37)
	AOBD	0.58 (0.26)	0.86 (0.64)	(p=0.21)
	PD	0.49 (0.35)	0.74 (0.70)	(p=0.38)
	LPM	0.84 (0.40)	0.73 (0.18)	(p=0.45)
Composite	Control	1.66 (0.61)	2.84 (2.11)	(p=0.06)
	AOBD	0.68 (0.22)	0.66 (0.19)	(p=0.74)
	PD	0.41 (0.36)	0.35 (0.24)	(p=0.67)
	LPM	0.49 (0.18)	0.79 (0.49)	(p=0.08)

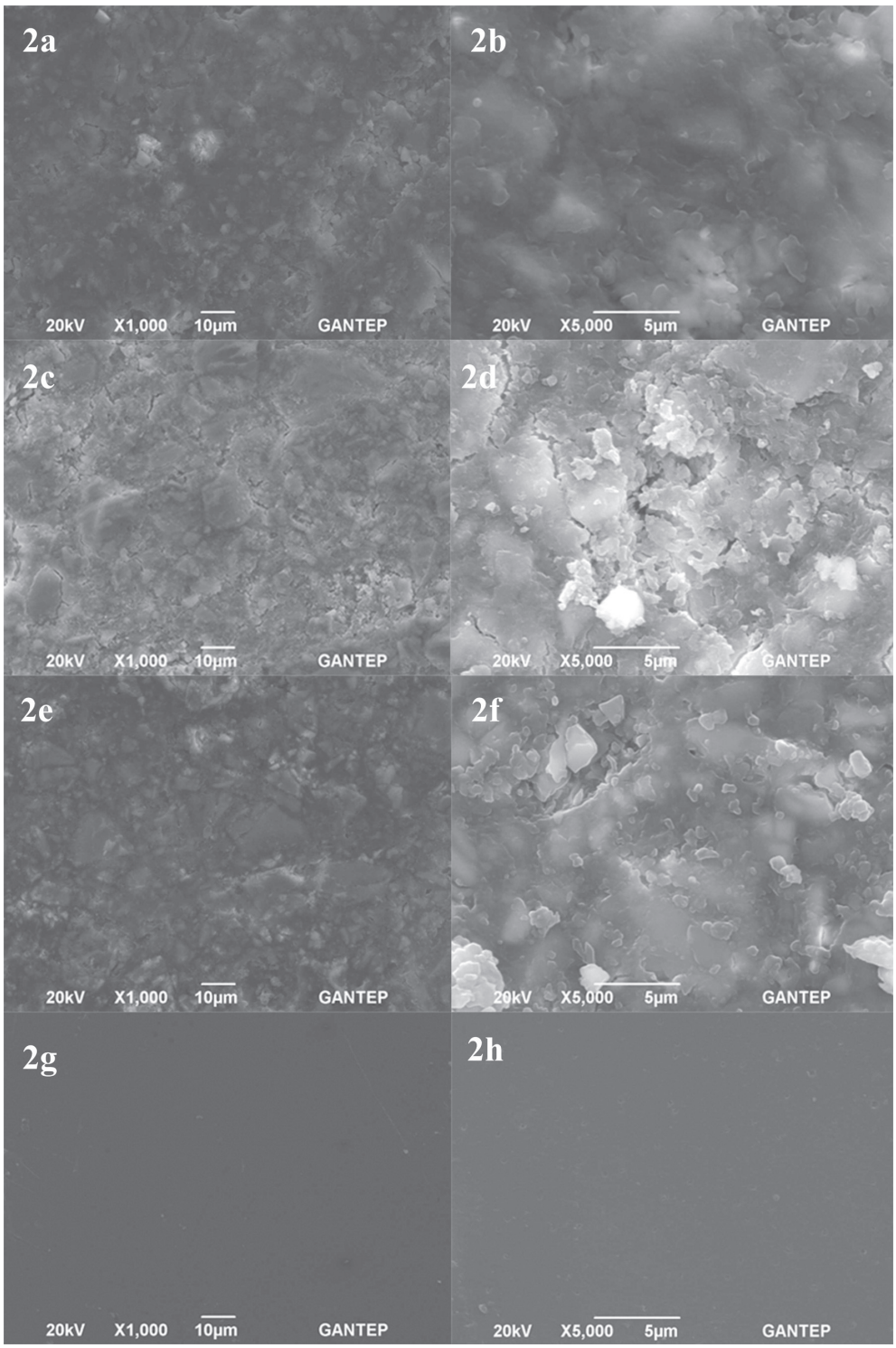

Fig. 2 SEM images of RMGIC polished by (a, b) control, (c, d) AOBD, (e, f) PD, and (g, h) LPM after staining.

The SEM images of the compomer after staining according to polishing system are shown in Fig. 3. SEM analysis shows similar surface images for the control, AOBD, and PD groups. However, the LPM group seems smoother and muddier. The difference in the mean color changes between the PD and LPM groups was

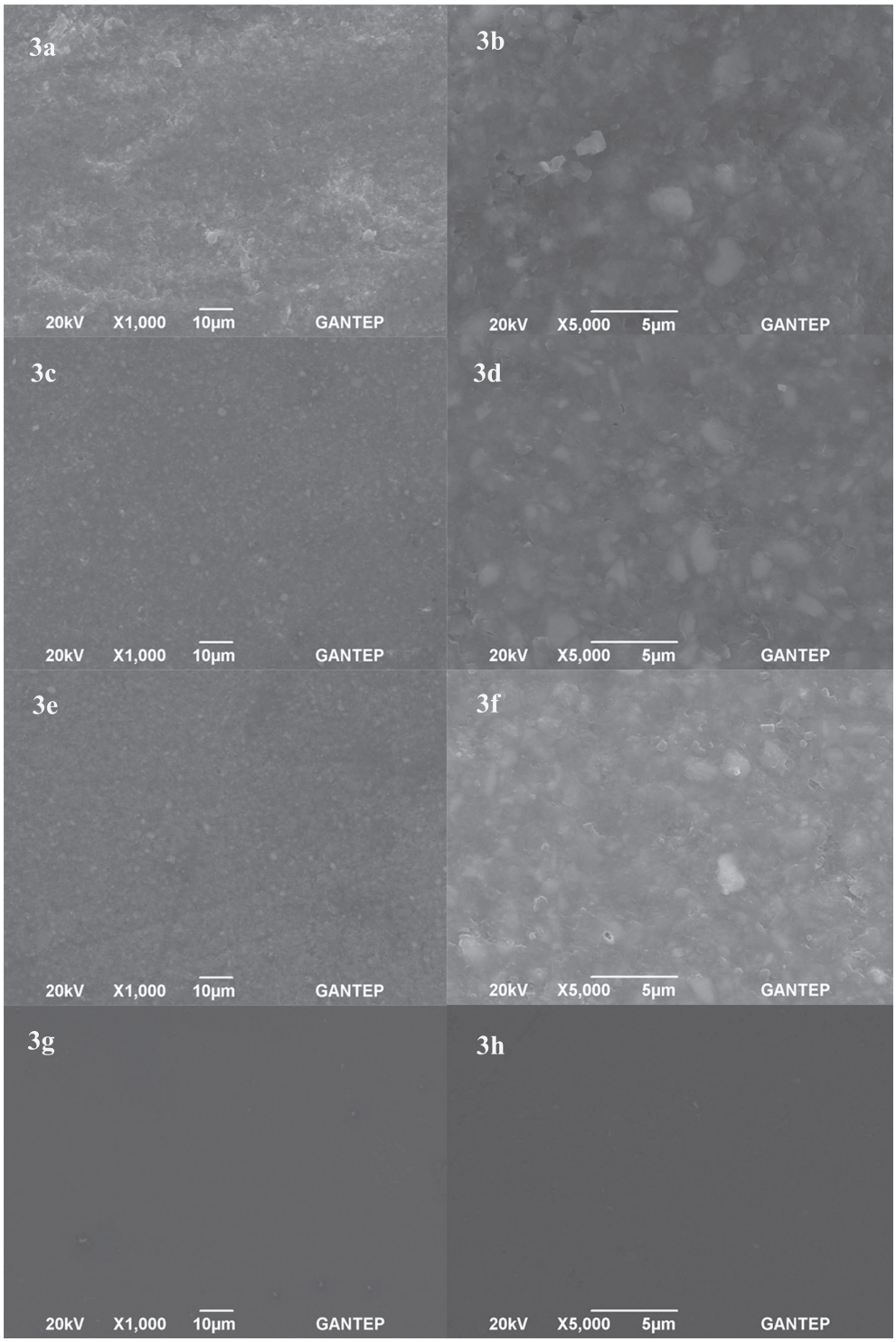

Fig. 3 SEM images of compomer polished by (a, b) control, (c, d) AOBD, (e, f) PD, and (g, h) LPM after staining.

significant, consistent with the SEM images.

For the composite groups (Fig. 4), changes of R_a and ΔE^* values before and after staining were similar for all subgroups, which appear as slight differences in the SEM images except for the LPM group.

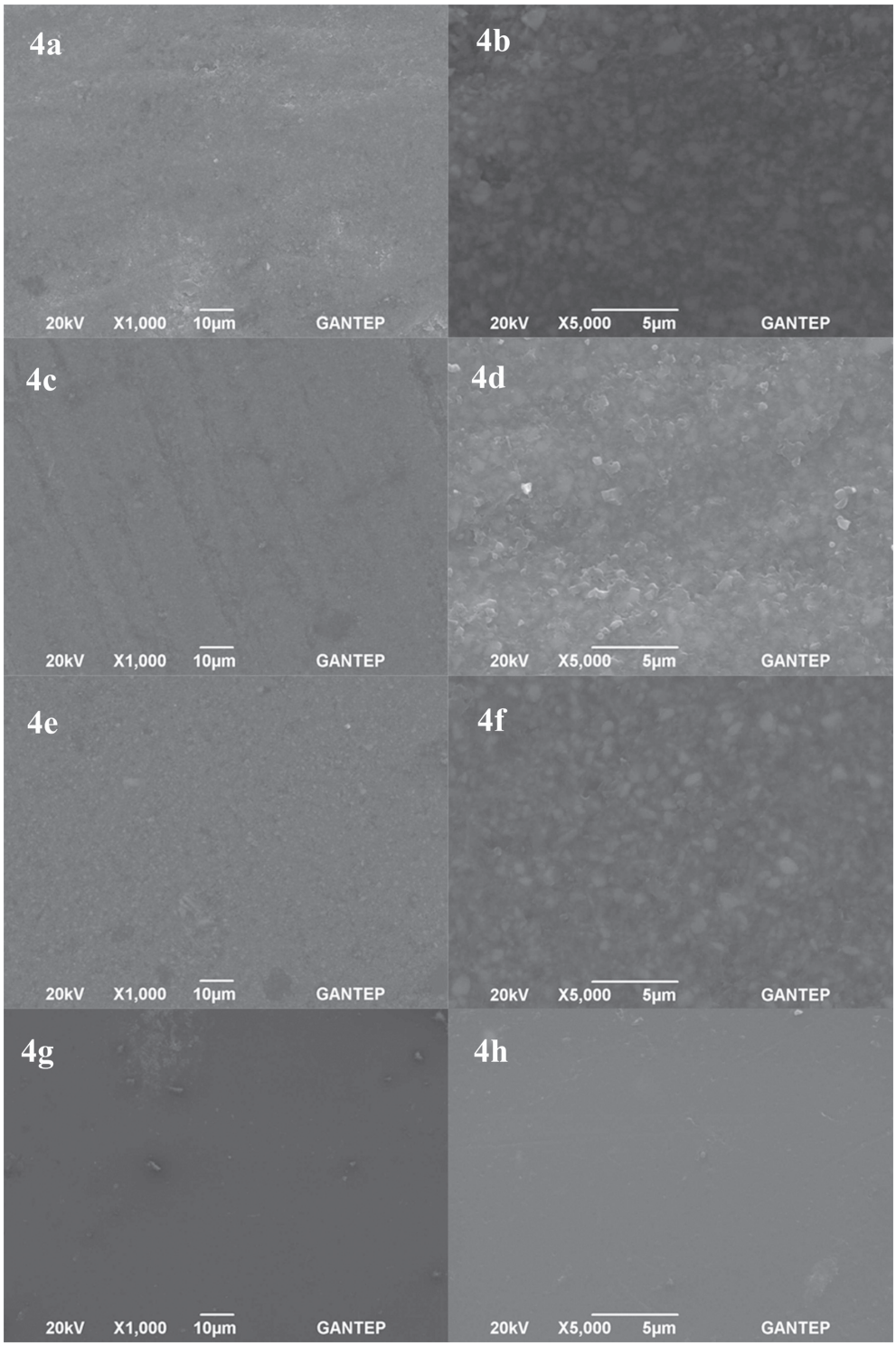

Fig. 4 SEM images of composite polished by (a, b) control, (c, d) AOBD, (e, f) PD, and (g, h) LPM after staining.

DISCUSSION

The present study evaluated the changes of color and surface roughness of polymeric materials that were polished with different finishing and polishing systems after staining by a staining solution, coffee. In the present

study, the composite groups showed the lowest ΔE^*, whereas there was no difference between the compomer and RMGIC groups. Although ΔE^* values between 1.0 and 3.7 are visually detectable, values of 2.72 to 6.8 are reported to be acceptable for dental restorations[8-10]. In the present study the value of ΔE^* more than 3.3 was considered clinically unacceptable.

RMGIC is indicated for class III cavities, and it can be immediately polished after restoration. In the present study, color changes were perceptible in all tested groups. All polishing techniques were similar in terms of color stability. However, the PD and LPM groups of RMGIC showed the least color changes. The AOBD group was similar with control group which had significantly lower performance than the PD and LPM groups. It has been previously reported that glass ionomer cements lack color stability, which can be explained by the degradation of metal polyacrylate salts[11,12]. Hotwani *et al.*[12] believed that the amount of resin and filler particles may affect the color stability. In the present study, although RMGIC showed the least color stability, it was observed that the polishing systems affected the color change. Hotwani *et al.*[12] reported the color stability of an RMGIC material after staining in three different beverages and upon pH cycling for a period of 4 weeks without using any polishing system. In the RMGIC group, they reported a significant increase in mean color change (7.41) after 4 weeks of immersion in orange juice[12]. In the RMGIC control group of the present study, the ΔE^* value was 9.65 and there was positive correlation between surface roughness and color changes in RMGIC group. The reason for the higher value of ΔE^* in the present study may be because coffee has more of a coloring effect than other beverages. In addition, in the SEM image of the RMGIC control group (Fig. 2a), some cracks were observed. These cracks may affect the staining process. By polishing the restoration, surface cracks may be removed.

When comparing the compomer subgroups, LPM, which showed the least color change, was found to be similar to the control and AOBD groups. However, when the compomer and composite were compared, only the LPM groups were similar. Furthermore, the SEM images of LPM were similar in all groups. These results are consistent with the color change values. Yu *et al.*[13] used PD to polish a compomer that was shade 3. They measured the sample's color after 7 days of immersion in deionized water, conditions that were different from those of the present study. When the color after immersion in coffee solution was measured on the first day and the 7th day, values of 1.38 and 2.68 values were calculated[13]. In the present study, the compomer group polished with PD was the most stained group. The difference may be due to brushing the samples after immersion in the study of Yu *et al.* Bagis *et al.*[14] reported that the ΔE^* values of a composite group were significantly lower than those of a compomer group with or without resin coating and that in all of the tested restorative materials, the ΔE^* values were significantly higher in the coated group than in the control group. In the present study, although the compomer group showed lower color stability than the composite group, which is consistent with Bagis *et al.*'s study, the ΔE^* values of the coated samples of all resin groups were lower than those of the control groups.

In the present study, we observed less color change in the composite groups than in the compomer and RMGIC groups, although all the materials showed clinically perceptible discoloration after storage in the coffee solution. This result is in agreement with previous studies[13,14]. Hydrophobic materials such as resins are believed to exhibit greater stain resistance and color stability than hydrophilic materials[13,15,16]. The results of the present study confirm this conclusion. Güler *et al.*[5] reported that composite materials that were polished with PD demonstrated higher color change values than the control group. The composite groups of the present study demonstrated similar color changes among the polishing systems and control group. Zimmerli *et al.*[8] evaluated a nanofilled composite coated with LPM after staining and aging in a coffee solution, thermocycling, and toothbrushing procedures and reported color changes that could be detected by the human eye. They also reported that simulated toothbrushing had a partly reversible influence on the color change[8].

L^* values represent an object's brightness. The present study showed decreased L^* values in all groups after staining, which means that the samples became darker. Other studies have also reported a large decrease in L^* values and a moderate increase in a^* and b^* values of composites and compomers stained by coffee[8,13]. In a study in which artificial accelerated aging was used, L values were reported to have increased in the control groups, whereas the L values of groups sealed with LPM were observed to have decreased[17].

Increases in a^* and b^* values indicate shifts toward red and yellow, respectively. In the present study, the a^* values increased after staining for the RMGIC and composite groups but not for the compomer group. When polishing systems were analyzed, PD had the lowest a^* value. The b^* values increased after staining except for RMGIC. Increased a^* and b^* values were reported in LPM-sealed composite specimens in Aguilar *et al.*'s study[17].

As far as the polishing systems were concerned, the control group showed the highest ΔE^*, which was significantly higher than that of the LPM group, so the first null hypothesis of the study was rejected. Higher ΔE^* values were reported to have been found when LPM was used as a surface sealant as compared with a control group[5,17] in contrast to the results of the present study. The previously reported SEM images were more regular in the LPM group than in the control group[17]. In the present study, there were no differences between the control and LPM subgroups of the composite and compomer groups. However, in the RMGIC group, the control group had significantly higher ΔE^* values than the LPM group. LPM is a resin-based material that contains fewer filler particles. LPM may provide color stability for RMGIC by filling the cracks of the material

by virtue of its viscosity. However, LPM is susceptible to thermocycling; visible crack patterns and partial debonding were detectable on the surface. Application of a surface sealant has been suggested for polishing of a provisional restoration[8].

Previous studies have reported that an increase in surface roughness allows stain penetration[7,18]; however, the present study showed no relationship between color stability and surface roughness in composite resin and compomer groups, which is consistent with the results reported by Smales and Gerke[19]. R_a values of less than 10 μm are clinically undetectable, and hence any system that delivered a surface roughness of less than 10 μm would be acceptable[20]. In the present study, all R_a values were clinically undetectable according Kaplan's criteria.

It is important to note that surface roughness is not the only reason for color changes. Dietschi *et al.* reported that staining may be related to water sorption[21]. The water acts as a carrier for staining agents in the water sorption process[22], and therefore stain adsorption tends to follow the evolution of water sorption, occurring primarily during the first week[23]. Some factors such as resin matrix, dimensions of filler particles, depth of polymerization, staining agents, and the pH values of the staining solution have also been reported to affect the discoloration of restorative materials[12,13]. The lower pH value of staining solutions has been reported to increase staining[13,24], but the present study did not show an association between pH and color change. Coffee, which had the greatest pH value in the solutions used in Yu *et al.*'s study, induced the least color changes[13]. The color change of the compomer group polished with PD and immersed in coffee solution was higher than the values reported by Yu *et al.*

Sen *et al.*[25] reported that the difference between the mean R_a values of Bis-acryl resin groups and methacrylate-based resin groups was significant when the samples were polished with aluminum oxide paste or diamond paste. In contrast, the present study showed similar R_a values between Bis-acryl resins groups and methacrylate-based resin groups. The similarity may be due to the aromatic dimethacrylate content of the composite.

Bagis *et al.*[14] used a resin coating on the surface of a compomer and a microhybrid composite and aged the samples with UV. They reported that the R_a values of the samples after aging were significantly higher than those before aging in both the compomer and composite groups, independent of the resin coat, and higher R_a values for the composite than for the compomer after UV aging. It was also reported that the resin-coated samples had significantly higher R_a values than the control group after UV aging for both the compomer and the composite. Bagis *et al.*[14] believed that higher and clinically unacceptable R_a values after UV aging might be related to the aging method that was used in their study. In the current study, there were no differences among the polishing systems and restorative material groups on the surface roughness after staining and thus second null hypothesis of the study was accepted.

The present study has several limitations. Various staining solutions with different staining capacities have been used in previous studies. The staining solution used in this study could not reflect all the substances to which teeth may be exposed. Many aging factors mentioned above may influence the staining degree. In addition, the relationship between surface roughness and color stability should be clarified by further studies.

CONCLUSION

Finishing and polishing procedures may influence color stability. There was interaction between the polishing systems and type of restorative material. When RMGIC was used, PD and LPM showed better results. In the compomer group, fewer color changes were observed in the AOBD and LPM groups. All polishing materials showed similar color changes in the composite group. There were no correlation between the surface roughness change and the color change in composite resin and compomer groups, however there was a positive correlation in RMGIC group.

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