Effect of Bleaching on Staining Susceptibility of Resin Composite Restorative Materials

ÇIĞDEM ÇELIK, DDS, PHD*
BULEM YÜZÜGÜLLÜ, DDS, PHD†
SELIM ERKUT, DDS, PHD‡
A. RÜYA YAZICI, DDS, PHD§

ABSTRACT

Statement of the Problem: Effect of bleaching procedures on staining susceptibility of resin restorative materials is still questionable.

Purpose: The aim of this study was to evaluate the staining susceptibility of restorative materials bleached with 20% carbamide peroxide home bleaching agent and subsequently immersed in coffee and tea.

Materials and Methods: Forty-two disk-shaped specimens were fabricated for each of the resin composites (Filtek Supreme XT [3M ESPE, St. Paul, MN, USA], Ceram-X Mono [Dentsply, Konstanz, Germany], and Aelite All Purpose Body [BISCO, Inc., Shaumburg, IL, USA]). The baseline color values were measured with a spectrophotometer. The specimens of each restorative material were randomly divided into two groups ($N = 21$). While the first group specimens were stored in distilled water (nonbleaching group-control), bleaching agent (Opalescence PF 20% [Ultradent Poducts, South Jordan, UT, USA]) was applied on the top surface of each specimen of the second group (bleaching group). After color change values were measured, the specimens were randomly divided into three subgroups ($N = 7$) according to the staining solutions. The color change values (ΔE^*ab) were calculated and the data were subjected to analysis of variance. Statistical significance was declared if the p value was 0.05 or less.

Results: There was no statistically significant difference within each restorative material's ΔE^*ab values after bleaching ($p = 0.714$). Also, the staining solutions did not cause a statistically significant difference between ΔE^*ab values of bleaching compared with nonbleaching groups ($p = 0.146$). Significant interaction was found only between restorative materials and staining solutions ($p = 0.000$).

Conclusion: Bleaching of the tested resin composites did not increase their susceptibility to extrinsic staining in vitro.

CLINICAL SIGNIFICANCE

Bleaching did not affect staining susceptibility of the tested resin composite restorative materials.

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*Instructor, Baskent University, Faculty of Dentistry, Department of Conservative Dentistry, Ankara, Turkey
†Assistant professor, Baskent University, Faculty of Dentistry, Department of Prosthodontics, Ankara, Turkey
‡Associate professor, Baskent University, Faculty of Dentistry, Department of Prosthodontics, Ankara, Turkey
§Associate professor, Hacettepe University, Faculty of Dentistry, Department of Conservative Dentistry, Ankara, Turkey

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INTRODUCTION

Tooth-colored restoratives have become the most frequently used materials because of their esthetic properties. Although great improvements have been achieved during recent years, one of the major disadvantages of resin-based restorative materials is the tendency to discoloration after prolonged exposure to the oral cavity.[1,2] Color stability of resin composites is affected by several intrinsic and extrinsic factors. The intrinsic factors are generally related to the material itself, such as the alterations of the resin matrix and fillers and also incomplete polymerization.[3] Extrinsic factors for discoloration of resin composites include staining by adsorption or absorption of colorants as a result of contamination from exogenous sources, such as coffee and tea, other beverages, and nicotine.[4,5] It has also been reported that color stability of resin composites may be influenced by surface properties because of a greater tendency toward discoloration of rougher surfaces.[6,7] Surface properties of a restorative material are affected by many factors, such as the filler type and composition of the resin composite,[8] finishing and polishing techniques,[6] and bleaching treatments.[9–11]

Tooth bleaching agents used in improving the esthetics of the natural dentition have become increasingly popular. Bleaching has been suggested as an efficient and conservative approach for removing intrinsic and extrinsic stains from teeth.[12–14] Vital tooth bleaching can be done in the office by the clinician using high concentrations of hydrogen peroxide (HP) or at home by the patient with lower concentrations of carbamide peroxide (CP). During the bleaching treatment, not only do these materials contact teeth but also restorative materials for extended periods of time. That is the reason why many studies have focused on the effect of bleaching agents on surface microhardness, roughness, and color stability of tooth-colored restorative materials.[9–11,15–23] Cooley and Burger[15] have reported that surface roughness, hardness, and lightness of resin composites are increased after bleaching treatment. In a recent study, evaluating the effects of bleaching on the surface roughness and hardness of an ormocer, a packable composite and a flowable composite, it was found that the roughness of the tested materials was increased.[23] Concurring with these results, Turker and Biskin[9] also revealed that bleaching could have an effect in increasing surface roughness of resin composites, which may cause easier staining. Bleached resin restorative composite materials' staining susceptibility can partly be related to surface roughness. Home bleaching is very popular because it utilizes mostly over-the-counter products and is less expensive compared with office bleaching procedures. However, home bleaching with high concentrations of CP may have adverse effects because of increased surface roughness and staining of the existing resin restorations, especially when not controlled by a clinician subsequently. According to the authors' knowledge, there is limited research about the effect of high-concentration bleaching procedures on the staining susceptibility of resin restorative materials.

The aim of the present study was to evaluate the staining susceptibility and color stability of restorative materials bleached with 20% CP home bleaching agent and subsequently immersed in two different staining solutions. The null hypothesis tested was that the bleaching agent application would not affect the staining susceptibility of resin composites.

MATERIALS AND METHODS

The restorative materials used in the present study were a nanofill resin composite, Filtek Supreme XT (3M ESPE, St.Paul, MN, USA); a nanoceramic resin composite, Ceram-X Mono (Dentsply, Konstanz, Germany); and a microhybrid resin composite, Aelite All Purpose Body (BISCO, Inc.,

TABLE 1. COMPOSITION OF THE RESTORATIVE MATERIALS USED.

Restorative materials	Manufacturer	Lot number	Filler weight (%)	Filler volume (%)	Filler composition
Aelite All Purpose Body	BISCO, Inc., Dental Products, Shaumburg, IL, USA	0600005269	73	53	Ethoxylated bisphenol A dimethacrylate Triethyleneglycol dimethacrylate Glass filler Amorphous silica
Filtek Supreme XT	3M ESPE, St. Paul, MN, USA	20070410	78.5	59.5	Non-agglomerated nanosilica filler(20 nm), Agglomerated zirconia/silica nanocluster (0.6–1.4 µm)
Ceram-X Mono	Dentsply, Konstanz, Germany	0605001581	76	57	Ba-Al-Borosilicate glassfiller (1–1.5 µm), Silicone dioxide nanofiller (10 nm)

Shaumburg, IL, USA), which were all in A2 shade (Table 1).

Specimen Preparation

Forty-two disk-shaped specimens from each restorative material (10 mm in diameter and 2 mm in thickness) were prepared in a polytetrafluoroethylene ring covered with a transparent polyester strip (Mylar, Henry Schein, Melville, NY, USA) and glass slides. Resin composites were polymerized with a light emitting diodes unit (Elipar Freelight 2, 3M ESPE) in standard mode for 20 seconds with a light intensity of 400 mW/cm^2 from both upper and lower surfaces of the specimens. The output of the curing units was checked with a radiometer (Kerr, Demetron, Orange, CA, USA). The distance between the light tip and the specimen was standardized by the use of a 1-mm glass slide. All specimens were stored in distilled water for 24 hours at 37°C to ensure maximum polymerization.

The upper surfaces of the specimens were then ground with 1,200-grit silicone carbide paper under running water to achieve a smooth standard surface without any oxygen inhibition layer.

Color Measurements

The baseline color values (L^*, a^*, b^*) of each specimen were measured with a spectrophotometer (Minolta CM-3600d, Minolta Co., Osaka, Japan). Quality of color is examined by the Commission Internationale de l'Eclairage System as tristimulus values and reported as color differences (ΔL^*, Δa^* and Δb^*) in comparison with standard conditions.[24] The spectrophotometer was calibrated with a standard white card before each group of specimens was measured, and measurements were repeated three times for each specimen before the mean values were calculated.

Bleaching Procedure

The bleaching agent used in the study was a home bleaching agent, Opalescence PF 20% (Ultradent Poducts, South Jordan, UT, USA). Chemical composition of this bleaching agent includes 20% CP, 3% potassium nitrate, 0.11% fluoride ion, carbopol, glycerin, and flavoring. The specimens of each restorative material group were randomly divided into two groups ($N = 21$). The first group specimens of each resin composite were stored in distilled water (nonbleaching group-control) and the second group specimens were subjected to the bleaching procedure (bleaching group). The bleaching agent was applied to the top surface of the specimens 6 hours per day for 8 days to simulate the bleaching procedure

TABLE 2. SIGNIFICANCE OF COLOR CHANGE (ΔE^*ab) VALUES AMONG COMPARISON OF RESTORATIVE MATERIALS, BLEACHING PROCEDURES, AND STAINING SOLUTIONS.

Comparison groups	*p* Value
Restorative materials	0.000*
Bleaching procedure	0.784
Staining Solutions	0.000*
Restorative materials—Bleaching procedure	0.714
Restorative materials—Staining solutions	0.005*
Bleaching procedure—Staining solutions	0.304
Restorative materials—Bleaching procedure—Staining solutions	0.146

*Statistically significant, $p < 0.05$.

according to the manufacturers' instructions. After the daily bleaching procedure, the specimens were gently rinsed with tap water for 1 minute to remove the bleaching agent and then dried and stored in distilled water at 37°C. At the end of 8 days, the color values were remeasured for the bleaching and nonbleaching groups.

Staining Procedure

Twenty-one specimens of control and bleaching groups were randomly divided into three subgroups. The specimens in each group ($N = 7$) were immersed in one of the two staining solutions (tea or coffee) or distilled water (control) for 3 hours a day at room temperature over a 30-day immersion period. In a pilot evaluation performed to establish the immersion time, the optimal contact time in mouth for a hot beverage was found to be 60 seconds for each cup. Therefore, this study simulates a total of 5 years with an average of three cups of hot beverage consumption per day. The tea (Yellow Label, Lipton, Rize, Turkey) was prepared by immersing two prefabricated tea bags (2 × 2 g) into 200 mL of boiling water for 3 minutes. To prepare the coffee, 5 g of instant coffee (Nescafe Classic, Nestle, Istanbul, Turkey) was poured into 200 mL of boiling water. After stirring for 1 minute, the solution was filtered through filter paper. The test group specimens were immersed in vials containing 20 mL of freshly prepared tea or coffee solution and the control group specimens were immersed in vials containing 20 mL of distilled water. The vials were sealed with parafilm to prevent evaporation of the staining solution. After each staining period, the specimens were gently rinsed with distilled water, air dried, and kept in distilled water at 37°C.

After 30 days of immersion, the color values were remeasured and the mean color change value (ΔE^*ab) was calculated as follows:[25]

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

where L^* is lightness, a^* is green-red ($-a$ = green; $+a$ = red) and b^* is blue-yellow ($-b$ = blue; $+b$ = yellow). The discoloration that is $\Delta E^*ab > 3.3$ was considered visually perceptible and clinically unacceptable.[3,26,27]

Statistical Analysis

Differences in color change values (ΔE^*ab) were analyzed by analysis of variance (ANOVA) ($p < 0.05$). Three-way ANOVA was used to determine the effect of bleaching agent on color changes among the resin composites in three different solutions. Multiple comparisons of data were analyzed using Tukey HSD post hoc test.

RESULTS

Three-way ANOVA revealed that the bleaching agent application did not affect the color stability in any resin composite group ($p = 0.714$) (Table 2). No statistically significant difference was observed between nonbleaching and bleaching groups ($p = 0.784$).

There was also no statistically significant difference between nonbleaching and bleaching groups,

TABLE 3. MEAN ΔE^*ab VALUES AFTER STAINING PROCEDURES.

Restorative materials	Water	Tea	Coffee
Filtek Supreme XT			
Control	0.69 ± 0.54	4.91 ± 2.61*	4.44 ± 2.28*
Bleaching	0.53 ± 0.19	5.61 ± 1.13*	4.24 ± 1.41*
Aelite All Purpose Body			
Control	0.48 ± 0.24	4.56 ± 1.12*	2.76 ± 0.55
Bleaching	0.76 ± 0.31	3.97 ± 1.08*	3.12 ± 0.43
Ceram-X Mono			
Control	1.95 ± 1.14	8.88 ± 2.07*	5.59 ± 0.94*
Bleaching	1.94 ± 0.86	7.20 ± 0.83*	6.34 ± 1.09*

*Indicates clinically unacceptable value ($\Delta E^*ab > 3.3$).

which were subjected to staining procedures ($p = 0.146$). A significant difference was found only between staining solutions ($p = 0.000$), where tea showed the highest ΔE^*ab values compared with coffee for all resin composite groups (Table 2).

In the present study, ΔE^*ab values higher than 3.3 were interpreted as visually perceptible and clinically unacceptable ($\Delta E^*ab > 3.3$).[3,26,27] Whereas coffee and tea had a visually perceptible staining effect on Filtek Supreme XT and Ceram-X Mono specimens, only tea demonstrated perceptible color change in the Aelite All Purpose Body group (Table 3).

The difference between resin composites was statistically significant regardless of the bleaching or staining procedure ($p = 0.000$). Ceram-X Mono specimens showed the highest ΔE^*ab values among restorative materials tested and there was a significant difference between Ceram-X Mono/Filtek Supreme XT ($p = 0.000$) and Ceram-X Mono/Aelite All Purpose Body ($p = 0.000$).

DISCUSSION

Bleaching has become a routine treatment for improving esthetics. However, it is unavoidable to prevent restorations from bleaching agent exposure especially during home bleaching treatment. Therefore, it was decided to investigate the effects of bleaching agents on the staining susceptibility of resin composites. As it had been mostly reported that bleaching increases the surface roughness of resin composites,[9,23,28,29] it might be expected that composite restorations would stain more easily after bleaching because rough surfaces mechanically tend to retain surface stains more than smoother surfaces.[30,31] However, in the present study, bleaching was found to have no effect on the staining susceptibility of the resins when immersed in two different staining solutions. Therefore, the null hypothesis tested was accepted.

There are controversial results about the staining susceptibility of bleached enamel in the literature. In a recent study,[32] the influence of 35% HP bleaching agents on enamel surface susceptibility to wine staining was investigated. It was reported that unbleached surfaces were more stain-resistant to wine than those bleached with HP. Another study[33] evaluated the effect of a 16% CP bleaching gel, on enamel staining susceptibility and concluded that the enamel staining susceptibility significantly increased after vital bleaching. Contrary to these results, Adeyemi et al.[34] evaluated if there was a tendency for bleached enamel to take up extrinsic stains more than unbleached enamel. They found that bleaching of enamel did not increase the susceptibility of enamel to extrinsic staining. Attin et al.[35] evaluated the influence of tea applied at various time intervals after bleaching of enamel on intrinsic tooth color. They concluded that application of tea directly after bleaching with 10% CP does not significantly affect the outcome of a bleaching treatment irrespective of the time interval elapsed between the bleaching procedure and the contact of the tooth surface with tea. Although they investigated the enamel surface, their findings were similar to the present study. This is very important in clinical situations because best esthetics are obtained if restorative materials and enamel are both unaffected by staining after bleaching.

Manufacturers have suggested CP in various concentrations, ranging from 10% to 20% or higher. Previous studies[36,37] revealed that the higher CP concentration was more effective than the lower concentration, as it took longer to whiten teeth with low CP concentrations.[38] Therefore, Opalescence PF 20% was preferred in the present study. Increase in surface roughness is related to the bleaching agent and also the restorative material. Opalescence PF 20% has the pH of 6.70, which means that it did not exhibit acidic property and might have not roughened the surfaces of resin composites tested. Moreover, the duration of bleaching exposure might be another factor. In the present study, manufacturers' recommendations were strictly followed in application of bleaching procedures. If exposure time was extended, these agents might have caused rougher surfaces. Moraes et al.[29] examined the effect of 10% and 35% CP bleaching agents on the surface roughness of enamel, feldspathic porcelain, and microfilled and microhybrid resin composites. Whereas 10% CP bleaching agent caused a rougher surface on porcelain alone, 35% CP bleaching agent caused significant surface roughness on enamel, porcelain, and microhybrid composite. Microfilled resin composite samples showed no significant alteration throughout, regardless of the surface treatment. In a study evaluating the effects of home bleaching agents (10% and 15% CP) on the surface roughness of resin composite restoratives, it was revealed that only hybrid resin composites were not significantly roughened.[39] On the other hand, in other studies, the influence of bleaching agents on surface roughness of resin composites was found to be negligible.[20,40] Hence, the results of the current study might be related to the restorative resin composite materials used.

In the present study, there was no visually perceptible color change in any of the resin composite groups after bleaching application. Canay and Cehreli[11] demonstrated that the color change of resin composites after 10% CP application was not visually detectable; however, compomer and macrofill composites showed perceptible color change after the 10% HP application. Therefore, it is generally recommended to bleach teeth prior to restoration. Rosentritt et al.[28] stated that no differences in color behavior could be found between bleached fine microhybrid composites and the organically modified ceramics (ormocer). Furthermore, Kim et al.[20] determined that CP home-bleaching systems caused no perceptible color change in either nanofilled or microhybrid resin composites. The results of different studies may be related to surface roughness, substrate composition, and water absorption rate; all of which may result in permeability alterations and irregularities left on bleached surfaces, which could favor changes in esthetic characteristics and accumulation of pigments.[11,28]

Rosentritt et al.[28] indicated that restorative materials with different monomer systems, such as composites, compomers, or ormocers, might show different resistance to bleaching agents. They stated the amount of color change of materials after bleaching may be related to the matrix content, the filler type, and volume of the resin material. According to the results of the current study, Ceram-X Mono specimens showed the highest ΔE^*ab values among restorative materials tested. Ceram-X Mono, a nanoceramic resin composite, is comprised of ormocer nanoparticles and contains glass fillers (1.1–1.5 μm). Unlike conventional polymers, ormocers have an inorganic backbone based on silicon dioxide and are functionalized with polymerizable organic units to produce three-dimensional compound polymers.[41] The present study revealed that Ceram-X Mono showed the greatest color change, and it may be related to these structural differences.

The results of this study demonstrated that the tested resin composites reacted differently in the two staining solutions. It has been reported that coffee causes more discoloration than tea.[42] However, in the present study, both coffee and tea had a visually perceptible staining effect on Filtek Supreme XT and Ceram-X Mono specimens. Yazici et al.[43] found that the effect of coffee on color change was similar to tea. On the other hand, according to the results of the present study, only tea demonstrated perceptible color change on Aelite All Purpose Body specimens after the staining procedure. Therefore, the effect of staining solutions on color changes of resin composites might be material dependent.

CONCLUSION

Although home bleaching with high concentrations of CP may have differing effects on roughness and hardness of resin restorations, within the limitations of the present study, it can be concluded that the bleaching procedure did not affect staining susceptibility of the tested restorative materials.

DISCLOSURE

The authors do not have any financial interest in the companies whose materials are included in this article.

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Reprint requests: Çiğdem Çelik, DDS, PhD, Baskent University, School of Dentistry, Department of Conservative Dentistry, 06490, Bahcelievler, Ankara, Turkey; Tel: +90 312 2151336/105; Fax: +90 312 2152962; email: ccivelek@hotmail.com