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Original Article

Evaluation of color stability after the application of a bleaching agent to different composite resins

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Abstract

Aim: In dentistry, it is desirable to preserve the properties of composites for a long time. With the development of technologies, the number of different composites used in dental treatment has increased. With contemporary patients' aesthetic expectations, bleaching treatmens are often sought, and the literature contains many studies on the effects of bleaching on composites. Our study aimed to examine the color stability of different types of composites immersed in different solutions after bleaching treatment.

Methodology: A total of 72 samples (n = 8) of three composite materials were examined: Omnichroma (Tokuyama Dental Co., Tokyo, Japan), Estelite Posterior (Tokuyama Dental Co., Tokyo, Japan), and Quadrant (Cavex, Holland BV, Netherlands). All specimens were subjected to Total Blanc (Nova DFL, Rio de Janeiro, Brazil), which is an office-type bleaching agent. After bleaching treatments, the specimens were immersed in distilled water. The baseline measurements were then recorded. After being immersed in distilled water, tea, or coffee for seven days, the final color measurements were recorded. A VITA Easy Shade device (Vita Zahnarzt, Bad Säckingen, Germany) was used to take color measurements. The CIEDE2000 formula was used to calcuate ΔE_{00} values. The Kruskal-Wallis test was used to compare the ΔE_{00} values obtained from the composite samples to assess color stability. The results were rated at a significance level of $p < 0.05$.

Results: After bleaching treatments, the interaction between the different composites and the solutions in which they were immersed had a statistically significant effect on ΔE_{00} values ($p < 0.05$). The highest mean value was obtained with the quadrant composite material that was immersed in the coffee solution.

Conclusion: It is clear that tea and coffee cause discoloration in dental composites after bleaching treatments. Due to the sorption of these solutions into the composite structure, dentists should warn patients to be cautious about consuming beverages after bleaching.

Keywords: Tooth bleaching, color stability, composite resin, CIEDE2000

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Introduction

Color stability is one of the most important factors in the success of an aesthetic restoration. In the literature, color stability is defined as the ability of a material to maintain its color under certain environmental conditions and over a period of time (1). Although the physical properties are improved by reducing the particle size and increasing the filler amount, the inability of composite resins to maintain

their color stability for a long time is one of the most important reasons for the renewal of restorations (2–4). These tooth-colored materials can undergo color change under the influence of many internal and external factors. The content of the resin matrix, the polymerization of the composite, and the filler content play important roles in intrinsic coloration. The water absorption of the resin matrix causes the absorption of pigments, which accelerates the discoloration of the composite (5). A composite resin with high water absorption causes discoloration by absorbing water-soluble coloring pigments (6, 7). Different methods are applied to make colored composites aesthetically acceptable. In addition to mechanical methods, such as tooth brushing, different chemical bleaching agents can be applied to remove discoloration (8, 9).

Bleaching treatments can be performed by dentists in the office environment using agents containing a high concentration (25–40%) of hydrogen peroxide (HP) or carbamide peroxide (CP). A lower concentration of HP (3–7%) or CP agents (6–20%) can also be applied at home by the patient under the supervision of a physician (10). Dental bleaching techniques are reliable, economical and effective methods to treat the discoloration of teeth (11). Despite the positive effect of bleaching on people's quality of life, bleaching gels can act as solvents on composites (12, 13).

Bleaching agents can affect the color of existing restorations in the oral cavity. The presence of an organic matrix in the structure of composite resins causes it to be more affected by bleaching agents than other restorative materials (9, 14). Bleaching agents can break the bonds in the structure of resin-based composites, causing the structure to break down. As a result of this deterioration in the structure, a decrease in the aesthetic properties expected from composites can be observed. It is known that rough surfaces cause external staining, bacterial involvement, and periodontal disease (10). Previous studies have shown that the color change in composites is directly related to the type, concentration, and exposure time of the bleaching agent. The relationship between bleaching and different composites is still being discussed in the literature (14), and the effect of bleaching on composites has been the subject of many studies. Therefore, our study aimed to evaluate the color stability of three different types of composites treated with office bleaching after immersion in different solutions.

Materials and Methods

Three composite resins were selected for the present study:

- Omnichroma (Tokuyama Dental Co., Tokyo, Japan),
- Estelite Posterior (Tokuyama Dental Co., Tokyo, Japan)
- Quadrant LC (Cavex, Holland BV, Netherlands).

A total of 72 samples (n = 8) of the three different composites were prepared. The composite materials and solutions used in this study are presented in Table 1. Using polyethylene molds with cylindrical specimens (7 × 2 mm), the composite specimens were polymerizated using a polywave LED light curing unit (Valo Cordless, Ultradent Inc., UT, USA) in the regular mode (1000 mW/cm^2). The composite groups were finished and polished with Sof-Lex polishing discs (3M ESPE, USA). After the one-day polymerization process, all specimens were subjected to Total Blanc (Nova DFL, Rio de Janeiro, Brazil) office-type bleaching agent. After bleaching treatments, the specimens were immersed in distilled water for one day. Color measurements were obtained at three different points using a VITA Easyshade® Advance 4.0 device (VITA Zahnfabrik, Bad Säckingen, Germany). As a result of the measurement, L*, a*, b*, c*, and h* values were obtained and recorded.

Table 1. Summary of the products used in the study

Product	Composition	Manufacturer
Omnichroma (-)	UDMA, TEGDMA, 79 wt% uniform sized supra-nano spherical filler (SiO_2-ZrO_2 260 nm), round-shaped composite filler (containing 260 nm spherical SiO_2-ZrO_2), w/w 79%, v/v 68%	Tokuyama Dental Co., Tokyo Japan
Estelite Posterior (A3)	Bis-GMA, TEGDMA, Bis-MPEPP, silica-zirconia fillers, w/w 84%, v/v 70%	Tokuyama Dental Co., Tokyo Japan
Quadrant LC (A3)	Bis-GMA, Ba-Al-F-silica glass fillers (0.02-2 µm), SiO fillers (0.02-0.07 µm), w/w 72%, v/v 60%	Cavex, Holland BV, Netherlands
Distiled Water	200 ml	MOS LAB, Ankara, Türkiye
Yellow Label Tea	Tea	Lipton, Rize, Türkiye
Nescafe Classic	5 g coffee 200 ml distilled water	Nestle Türkiye, Bursa, Türkiye

For the final measurements and analysis, the composite samples were randomly divided into three groups according to whether they had been exposed to distilled water, tea (Yellow Label Tea, Lipton, Rize, Turkey), or coffee (Nescafe Classic, Nestle Türkiye, Bursa, Turkey) (Table 1). Following seven days of incubation (15) at 37°C, the samples were rinsed with distilled water. The samples were then dried with blotter paper, the final color measurements were taken, and the L*, a*, b*, c*, and h* values were obtained and recorded. The differences (ΔE_{00}*) between the measured colors of the different samples were calculated using the CIEDE2000 formula (16).

CIEDE2000 formula;

$$\Delta E_{00} = [(\Delta L/K_L S_L)^2+(\Delta C/K_C S_C)^2+(\Delta H/K_H S_H)^2+RT(\Delta C/K_C S_C)(\Delta H/K_H S_H)]^{½}$$

Statistical analysis

Statistical analyses in this study were performed in the package program SPSS Statistics version 21.0 (IBM SPSS Inc., Armonk, NY, USA). The data were presented with arithmetic mean ± standard deviation. The assumption of normality in the data was assessed using the Kolmogorov-Smirnov test. It was determined that the obtained parameters were not suitable for normal distribution. ΔE_{00} values obtained from the composite samples were compared using the Kruskal-Wallis test to appraise color stability. The results were rated at a significance level of $p < 0.05$.

Results

The ΔE_{00} values of three different composite materials stored in solutions were examined in the present study. Among the composites, when the color changes observed in the composite samples were examined, the lowest ΔE_{00} value was found in relation to the Omnichroma samples, whereas the highest ΔE_{00} value was found with regard to the Quadrant samples. Descriptive statistics concerning the ΔE_{00} values of the composites are presented in Table 2. The main effect of the material on the ΔE_{00} values was determined to be statistically significant ($p = 0.006$). Pairwise comparisons were performed to identify the groups that caused this difference, which revealed that the ΔE_{00} values among all the composite groups were associated with statistically significant differences (Fig. 1, Table 3).

Table 2. ΔE_{00} and standard deviation values of the composite samples

Composite	Mean	Std. Deviation	Median	Minimum	Maximum
Omnichroma	3.74	1.97	3.9	0.92	6.8
Estelite Posterior	6.43	3.4	6.6	0.91	13.47
Quadrant	9.6	3.59	10.39	1.99	14.37

Table 3. Comparison of the color changes in the composites according to the brands and *p*-values

Composite	ΔE_{00}	*p*	Composite	*p*
Omnichroma	3.74±1.97		Omnichroma-Estelite Posterior	0.03
Estelite Posterior	6.43±3.4	0.006	Omnichroma-Quadrant	0.00
Quadrant	9.6±3.6		Estelite Posterior-Quadrant	0.04

Among the solutions, when the color changes of the composite samples were examined, the lowest ΔE_{00} value was observed in the samples kept in distilled water, and the highest ΔE_{00} value was observed in the samples kept in coffee. The descriptive statistics for the ΔE_{00} values of the solutions are given in Table 4. The main effect of the solution was found to be statistically significant on ΔE_{00} values ($p = 0.00$).

Pairwise comparisons were made to determine which groups caused this difference. When the solutions were evaluated among themselves, there was a statistical difference between the main solution groups of distilled water-tea, distilled water-coffee, but no statistically significant difference was found between tea and coffee. (Fig. 2, Table 5).

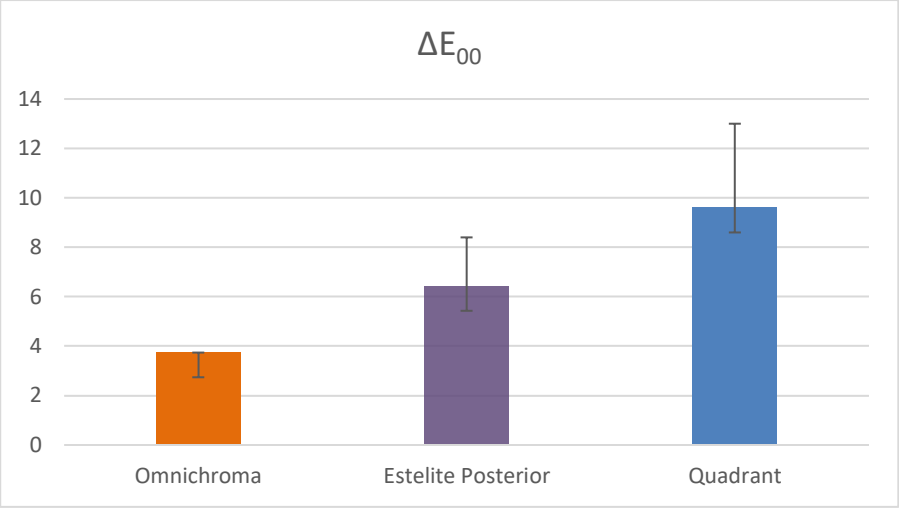

Figure 1. Comparison of color changes of composites according to brands

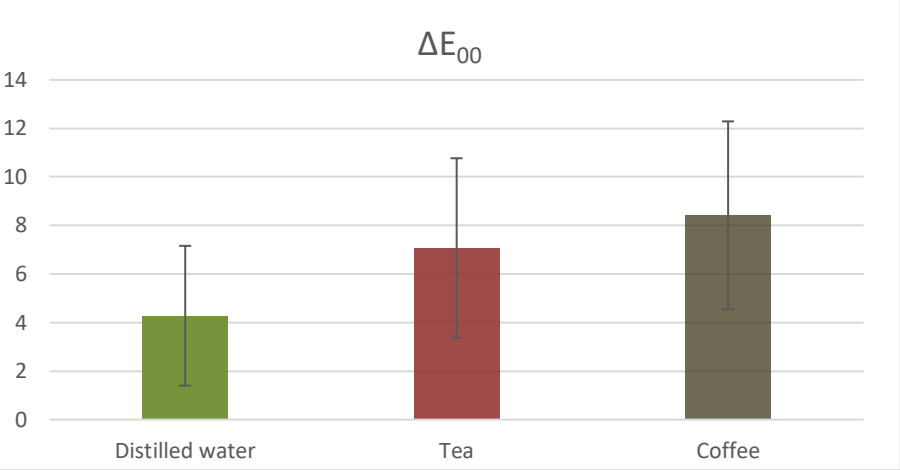

Figure 2. Comparison of color changes of composites according to solutions

Table 4. ΔE_{00} and standard deviation values of the composite samples stored in solutions

Solution	Mean	Std. Deviation	Median	Minimum	Maximum
Distelled water	4.28	2.88	3.9	0.92	11.61
Tea	7.07	3.7	7.14	0.91	13.32
Coffee	8.42	3.87	8.16	1.39	14.37

Table 5. Comparison of the color changes in the composites according to the solutions and p values

Solution	ΔE_{00}	*p*	Solution	*p*
Distilled water	4.28±2.88		Distilled water-Tea	0.032
Tea	7.07±3.7	0	Distilled water-Coffee	0.001
Coffee	8.42±3.87		Tea-Coffee	0.707

Discussion

Color stability is very important in relation to the success of resin composite aesthetic restorations (15). Indeed, composite materials should preserve the initial aesthetic appearance of the restored tooth for many years (17). Therefore, numerous prior studies have investigated the color stability of dental composites (7, 15, 18), although they have tended to observe the properties of the composites either after they have been stored in solutions (7, 18) or after bleaching treatment (19, 20). In light of this, we chose to examine the effects of common drinks on the color stability of dental composites following bleaching treatment. On the basis of the gathered data, the results of this study revealed significant differences in the color stability of the composites due to the main effect of the material and the main effect of the solution. Thus, the color stability of resin composite materials is related to both the material type and the utilized solution.

Protocols have previously been established to determine the color match between restorations and healthy tooth structures. For instance, the Munsell and International Commission on Illumination (Commission Internationale de Liéclairaqe [CIE]) L*a*b* color systems are commonly used for the color measurement of restorative materials in the field of dentistry. More specifically, the CIE L*a*b* color difference formula is designed to provide numerical data (ΔE) concerning the magnitude of the perceived color difference between two objects (21). Yet, while the CIE L*a*b color system is generally used for digital color measurements, the currently preferred system is the CIEDE 2000. In fact, a recent study concluded that the CIEDE 2000 formula better reflects the color differences perceived by the human eye than the CIE L*a*b color system (22). According to the CIEDE 2000 system, the threshold value for detecting a color difference is ΔE_{00} = 0.8, whereas the clinically acceptable threshold value is ΔE_{00} = 3.1. The color change can be measured using various instruments (23).

Hydrogen peroxide, which is the active agent used in bleaching procedures, interacts with chromophore molecules and oxidizes both macromolecules and pigments. It does so by converting into free radicals and breaking the large pigmented molecules responsible for coloration down into smaller ones by means of oxidation and reduction reactions (5). In addition, composite resins can also undergo hydrolytic degradation when stored in aqueous environments (15). In the literature, such composites have been immersed in different liquids for different periods (7, 15, 18). In this regard, Nasim et al. (15) reported that storage in solutions for seven days gives sufficient results in terms of the color change. In this study, the composite samples were stored in distilled water, tea, and coffee for seven days incubation at 37°C.

In previous studies concerning color changes in restorative materials, different composites have been utilized (7, 15, 18–20). Nevertheless, it is clear that additional studies involving these composites would contribute to the literature. As a consequence, in the present study, after bleaching, the color stability of three different dental composites was assessed under the actions of drinks commonly consumed by the general population. Moreover, Omnichroma, Estelite Posterior, and Quadrant LC composites were chosen for use in this study because they are frequently used by practitioners.

Resin composite restorations are exposed to different beverages in the oral flora. The surface of resin composites becomes discolored when exposed to colored beverages (26). In the present study, the coffee solutions caused a greater color change than the tea solutions, although the difference was not statistically significant. Although the findings of this study support those of previous studies, it must be recognized that different brands and color evaluation techniques were used (3, 8).

The present in vitro study demonstrated that the color changes seen in composite resins are related to the structure of the material and the type of the solution. This finding is of great importance in terms of partially addressing the lack of data concerning the color changes experienced by composites. Further studies should be performed to evaluate these composites when immersed in beverages for longer periods of time or using samples that have not been bleached. In addition, clinical studies are required to implement the results of this in vitro analysis.

Conclusions

The findings of this study demonstrated that tea and coffee cause color changes in dental composites on the seventh day following bleaching treatment, with the degree of the change depending on the utilized composite materials and solutions.

The lowest degree of color change was recorded for the Omnichroma samples stored in distilled water. Moreover, tea and coffee caused greater color changes than distilled water, meaning that these beverages may affect the clinical properties of restorations. Due to the sorption of these solutions into the composite structure, dentists should warn patients to be careful in terms of consuming beverages after bleaching.

In addition, it is clear that more in vitro and in vivo studies concerning the color changes and stabilities of dental composites are required.

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