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Original Article

Comparative evaluation of the color stability of universal composites

Merve Gürses[1], **Nevin Çobanoğlu**[1], **Omar Faez Abdulateef**[1]

[1] Selçuk University, Faculty of Dentistry, Department of Restorative Dentistry, Konya Turkey

Correspondence:

Dr. Merve GÜRSES
Selçuk University, Faculty of Dentistry, Department of Restorative Dentistry, Konya, Turkey.
E-mail:
merve.gurses@selcuk.edu.tr

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Abstract

Aim: The aim of this study is to compare the color stability of different universal composites and to evaluate the effects of keeping them in water for 1 week before coloring.
Methodology: Filtek Ultimate (FU), Estelite Σ Quick (EQ), and Ceram X One (CX) composites were used. The specimens were kept in the dark, dry environment for 24 hours, then polished, and each composite group was divided into 3 groups: the control, the group that was kept in water for 1 week before coloring and coloring (n=7). The samples in the control group were kept in distilled water for 3 weeks. Samples in the coloring group were colored with coffee for 2 weeks (C), and the samples in the last group were kept in water for 1 week and then stained with coffee for 2 weeks (W+C) (n=7). Color measurements for all samples were taken twice, once before and once after the coloring period. The color changes of the samples were measured using the ΔE* parameter, which was calculated with before and after measurements.
Results: For all composite resins, the ΔE values of the samples in the W+C and C groups were significantly higher than those in the control group. When the composites were compared with each other, the differences between the ΔE values of the composites in the control, W+C, and C groups were not statistically significant. For FU and ESQ, at the end of the coloration period, there were no statistically significant differences between the W+C and C groups. However, for CX, the color change of the samples in the W+C group was significantly higher than that in the C group.
Conclusion: Storage in distilled water for 1 week before staining did not reduce the color change values of the samples. Thus, after composite restorations are performed, there is no need to advise patients to avoid staining foods, especially in the first week after restoration.

Keywords: color stability, composite resin, spectrophotometry, ΔE value, ΔL value

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Introduction

For the clinical success of aesthetic restorations, it is crucial to ensure they accurately mimic the optical properties of natural teeth, such as color and transparency. However, color stability is also important for these restorations (1). Color stability of resin-based composites is affected by intrinsic and extrinsic factors. Intrinsic discoloration is caused by chemical changes within the material, such as the oxidation of unreacted monomers and photo-initiator components that are not consumed during exposure to light as well as hydrolysis of the interface between the filler particles and the polymer matrix (2, 3). Extrinsic discoloration is caused by diffusions of ions and pigments that can accumulate on the composite resin, together with water (4).

Many studies have been conducted on the behavior of composite materials in the oral environment and their interactions with colorants (5–9). Because color stability is related to polymerization of the monomers in the resin matrix, in studies evaluating color change in composite resins, samples are usually exposed to coloring liquids after soaking in distilled water for 24 hours to complete polymerization (10, 11). However, it has been reported that post light cure polymerization can be longer than a week (12). This additional polymerization, called dark polymerization, is mainly controlled by the diffusion of trapped free radicals through a vitrified polymer matrix (13). Therefore, the purpose of this study is to evaluate how keeping composites in distilled water for 1 week before exposure to coloring liquid affects the color stability of composite resins. A timeframe of 1 week was selected in order to provide enough time to reach dark polymerization and achieve the release of non-polymerized monomers. To the best of the researchers' knowledge, no previously published study has been conducted for this purpose. The results of this study will provide information about the effects of delaying exposure to staining liquids on the color stability of composite resin restorations.

The null hypotheses of the study are as follows: (1) There will be no difference between the color stability of composites, and (2) storage in distilled water for 1 week before exposure to the coloring solution will not positively affect the color stability of composite resins.

Materials and Methods

A total of 63 disc-shaped samples, with a diameter of 8 mm and a thickness of 2 mm, were prepared. Filtek Ultimate (3M, Germany) (FU), Estelite Σ Quick (Tokuyama, Japan) (EQ), and Ceram X One (Dentsply, Germany) (CX) composite resins were used in the study. The samples were polymerized for 30 seconds with (1200 mW/cm^2, 385-515 nm) an LED light device (Blue lex LD-105, Taiwan), then stored in dry, dark conditions for 24 hours. All samples were then polished with OneGloss (Shofu, Ratingen, Germany) polishing rubbers, and each composite group was divided into 3 groups (n=7):

1. Distilled water (W): The samples were stored in distilled water for 3 weeks.
2. Coffee (C): The samples were stored in coffee (Nescafe Gold Nestle, Switzerland) for 45 minutes a day and kept in distilled water the rest of the time for 2 weeks. In this way, 14 days of staining were simulated.
3. Water+Coffee (W+C): The samples were stored in distilled water for 1 week before exposure to staining as in the coffee group.

The color of the specimens was measured with a VITA Easyshade V (VITA Zahnfabrik, Germany) spectrophotometer on a flat white surface. Color measurements of all samples were taken twice at baseline (after 24 hours of specimen curing) and after staining. The color changes of the samples were evaluated with the ΔE* parameter, calculated using L, a, and b values as follows:

$$\Delta E^*=[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$$
$$\Delta L^*=L2-L1$$
$$\Delta a^*=a2-a1$$
$$\Delta b^*=b2-b1$$

Statistical analysis

All statistical analyses were performed using Sigmaplot software version 14 (Systat Software Inc, CA, USA). The data were first analyzed for normality with the Shapiro-Wilk test. One-way ANOVA was used in the statistical analysis of the color change (ΔE) data of the samples. Student's t test was used for pairwise comparisons. The level of significance was set at $p<0.05$.

Results

The averages and standard deviations of the color changes of the composite resin groups and the differences between the groups are shown in Table 1. For all composite resins, the ΔE values of the samples in the W+C and C groups were significantly higher than those in the W group ($p<0.001$). When the composites were compared with each other, difference between the ΔE values of the composites in the W, W+C and C groups was not statistically significant ($p>0.05$). For FU and ESQ, at the end of the staining period, there was no statistically significant difference between W+C and C ($p>0.05$), but; for CX, the color change of the samples in the W+C was significantly higher than the C ($p=0.026$).

Table 1. Mean (standard deviation) of color change value ΔE. Grouped values with the same superscript are not statistically different ($p<0.05$).

	Filtek Ultimate	Estelite Σ Quick	Ceram X One
Control	0.99±(0.42)^{a}	1.05±(0.68)^{a}	1.70±(0.33)^{a}
C	8.76±(2.09)^{b}	7.39±(1.48)^{b}	7.63±(1.5)^{bc}
W+C	8.13±(3.39)^{b}	8.73±(3.66)^{b}	11.13±(3.32)^{b}

Discussion

Color changes can be observed in composite materials due to recurrent contact with coloring foods taken with the diet. According to studies (14–17), numerous factors can affect the color stability of composites as incomplete polymerization, water absorption, coloring properties of food and beverages, oral hygiene, and surface roughness. This study, it was aimed to compare the color stability of three different composite resins and evaluate the effect of kept in water for one week before staining on color stability.

Coffee, a dark solution, accumulates in the structure of the restorative material, reducing the light transmittance of the material thanks to the large amount of pigments it contains (18). Um and Ruyter (16) reported that the colorants in coffee are fixed to the surface after adhesion, so the coloring effect of coffee is high. In other studies, it has been shown that coffee causes a significant color change in composites (19–21). Similarly, in this study, the color change values of all samples kept in coffee were significantly higher compared to the water group. However, no statistical difference was found between ΔE values in any group when composite resins were compared. The filler particle amount and size can affect the color stability of the composite resins by affecting the surface roughness and polishing ability. The fact that the composite resins used in the study contain a similar amount of filler may be the reason why there is no difference in color change values.

It was previously reported that color change of composites might occur as a result of oxidation of unreacted monomers held in the polymer network and photoinitiators not consumed during exposure to light (2). These ingredients are released when placed in an aqueous environment (2,22). Therefore, in this study, the hypothesis is that soaking the samples in water for one week may cause less coloration to allow dark polymerization of the monomer in the resin matrix and the release of non-polymerized monomers before exposure to coffee coloration was evaluated. It was stored in distilled water for one week before staining and did not affect the color stability of FU and EQ. In the CX group, samples that were colored after being kept in water for one week showed significantly higher color change values than samples that were colored without being kept in water. The cause of high color change values at W+C group can be originated from keeping in water for an extra one week of W+C group than C.

On the other hand, changes occur in the chemical structure of the composite material after being kept in water. Due to these changes, the tendency to staining may increase (23). Excessive water absorption causes the resin structure to expand and plasticize and leads to the formation of micro-cracks by the hydrolysis of the silane. Thus, staining agents can leak into the micro-cracks between the filler-resin matrix and the spaces at the interface and cause discoloration (24). It has been demonstrated that materials with hydrophilic structure have higher water absorption values and show more coloration than hydrophobic materials (25). The hydrophilicity ranking of the resin matrix has been reported as TEGDMA>BIS-GMA>UDMA and Bis-EMA (26). In fact, both FU and ESQ contain TEGDMA, which CX does not contain. Probably, the 1-week period is not sufficient for the above-mentioned changes in the material that will occur with excessive water absorption. Other reasons, such as the polymerization degree of the composite resins and the difference in their chemical composition, may have been the cause of the difference between CX and the other two composite resins.

The hypotheses established in the study that there is no difference between the color stability of the composites and that stored in distilled water for one week before staining will not affect the color stability of the composites positively were accepted.

Conclusions

Within the limitations of this study, it was observed that coffee caused the color change in all composite resins. Stored in distilled water for one week before staining did not reduce the color change values of the samples and even increased the color change values in the CX group. After composite restorations are performed in the clinic, there is no need to advise patients to avoid coloring foods for the first week.

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