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Color Stability Evaluation of Different Posterior Composites

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Abstract

Objective: The aesthetic success of composite resins is directly related to surface roughness and color stability. External discolorations on the composite restoration surface due to plaque accumulation or coloring agents can be easily removed from the restoration surface with polishing.

Methods: Three different posterior composite materials were used to evaluate the color changes of composites in this study (Gradia Direct, Dentsply Spectrum, 3M ESPE Filtek Ultimate). Seven cylindrical samples of 5 mm diameter and 2 mm thickness were prepared from each material. Color measurements were made from the samples at 4 different intervals: after placing the samples in distilled water for 24 hours, after placing them in sour cherry juice for 24 hours, after storing them in the distilled water again for 24 hours, and after repolishing. Composite colors were measured using a clinical spectrophotometer (VITA Easyshade V).

Results: Mean and SD values of CIELAB color coordinates and WID from resin-based composites (Dentsply Spectrum, Gradia Direct, and Filtek Ultimate) are recorded. There were significant differences in color differences (ΔE^*ab) among composites evaluated for different periods (T1–T0 and T2–T1; $P < .05$). The mean values of Filtek Ultimate were significantly different from other composites in the T1–T0 groups ($P < .05$). Mean values of Dentsply Spectrum were significantly different from Gradia Direct and Filtek Ultimate in the T2–T1 groups ($P < .05$).

Conclusion: All the different composites showed a ΔE value above the perceptibility threshold of 1.2. Filtek Ultimate showed a significant color change after exposure to the sour cherry juice. It can be concluded that sour cherry juice has an influence on the color stability of different posterior composites.

Keywords: Coloring agents, composite resins, color stability

INTRODUCTION

As an alternative to amalgam alloys, the application of aesthetic filling materials to posterior teeth led to the development of posterior composites in the 1980s.[1] The aesthetic success of composite resins is directly related to surface roughness and color stability.[2]

In addition to internal factors such as oxidation of amine accelerators, oxidation in a polymer matrix structure, presence of unreacted methacrylate groups, and water absorption in a resin matrix, external factors such as absorption and adsorption of coloring agents are effective in the discoloring of composite resins.[3,4] While external discolorations on the composite restoration surface due to plaque accumulation or smoking habits can be easily removed from the restoration surface, internal discolorations that may affect the entire structure usually require restoration.[5]

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Color selection in dentistry can be done with the help of a color scale or with digital measuring devices. While numerous factors, including the physician's experience, the light source, and the color of the walls and floors in the workplace, can influence the color choice in measures performed with the assistance of the scale, measurements made with digital measurement devices, such as the spectrophotometer, produce repeatable and more accurate findings.[6] The Commission Internationale de l'Eclairage Color System (CIELAB) is often used to evaluate the color change in composite materials. The CIELAB color system has 3 coordinates, L^*, a^*, and b^*. L^* refers to the lightness (lightness–darkness) of the color. a^* and b^* denote the hue of the color. These 3 coordinates give the numerical value of the color and allow a single value ΔE to be used to determine color variations.[7]

Although the coloring effects of beverages such as tea, coffee, cola, and wine on composite fillings were investigated in the literature, no study was found on the coloring effect of sour cherry juice.[5,8] The aim of this study was to determine the color change of 3 different posterior composite materials after coloring with sour cherry juice by a spectrophotometer and to evaluate the effect of polishing on the color change. The null hypotheses were that (i) sour cherry juice staining would not make any difference to the color of different brand resin composites and (ii) polishing after staining would not make any difference to the color of resin composites.

MATERIAL AND METHODS

Preparation of Samples

Three different posterior composite materials in A1 color were used to evaluate the color changes of posterior composites in this study. The composition of the composites used is given in Table 1. In the study, 7 cylindrical samples of 5 mm diameter and 2 mm thickness were prepared from each material. After the composites were placed in the Teflon mold, in order to obtain a smooth surface, celluloid tape and microscope glass were placed on the composite surface and polymerized for 20 seconds with a light device (VALO Grand, Ultradent, South Jordan, Utah, USA) in accordance with the manufacturer's recommendations. After polymerization, the surfaces of the samples were polished using polishing discs (3M ESPE™, Minneapolis, St. Paul, Minn, USA). The discs were applied dry at medium speed for 60 seconds, respectively, according to their thickness, using a clinical contra angle handpiece and a micromotor.

This study was exempted from obtaining ethical approval and informed consent due to its nature.

Coloring Procedure

Initial color measurements of the samples were made after keeping them in distilled water (pH: 7.00) for 24 hours. After the measurements, the samples were placed in sour cherry juice (Cappy cherry drink, Coca-Cola Company, İstanbul, Turkey). Distilled water (pH: 7.00) was used as the control group. Composite resins were kept in juice for 24 hours, and color measurements were made again. Afterward, the samples were again kept in distilled water for 24 hours, and the measurement was repeated. In order to see the effect of the polishing discs on the color change, the samples were polished with polishing discs, and color measurement was made for the last time.

Color Evaluation

Composite colors were measured using a clinical spectrophotometer (VITA Easyshade V, Vita Zahnfabrik, Bad Säckingen, Germany) by placing the device tip centrally to the composite surface. Each measurement was recorded as CIE $L^*a^*b^*$ value. Prior to the measurements, the device was calibrated following manufacturer's instructions against the provided calibration block for white balance. Color measurements were performed against the white reference background tile relative to the standard illuminant D65. Device was calibrated before each measurement, and the average CIE $L^*a^*b^*$ value was obtained by measuring 3 times from each sample. ΔE values between composite samples were calculated using the following formula:

$\Delta E = [(\Delta L)2 + (\Delta a)2 + (\Delta b)2]^{½}$,

($\Delta L = L2^* - L1^*$, $\Delta a = a2^* - a1^*$ and $\Delta b = b2^* - b1^*$)

The $L2$, $a2$, and $b2$ values represent the CIE $L^*a^*b^*$ values measured in each coloring period of the composite samples, while the $L1$, $a1$, and $b1$ values represent the CIE $L^*a^*b^*$ values measured at the beginning.

Based on the previous literature, the following criteria were used to determine whether the obtained ΔE^*ab value affects clinical use and the color difference:[9,10]

$\Delta E > 3.3$, clinically all observers can visually distinguish the color difference.

$\Delta E = 1$, 50% of the observers can visually notice the color difference.

$\Delta E < 1$, color difference is not clinically detectable.

Main Points

- The composition of the composite and the type of beverage used can affect how strongly the resins in the composite can be discolored.
- The nanofilled composite in this study discolored more than the microhybrids.
- The color of the composite is unaffected by polishing after discoloration.
- When deciding the composite to be used for the restoration, dentists should take the material's composition and degree of discoloration into account.

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Table 1. Composition of Composite Materials Used in the Study

Material	Composition	Type of the Composite	LOT Number	Manufacturer
Gradia Direct Posterior	Matrix: UDMA co-monomer matrix Filler type: Silica, prepolymerized fillers, fluoroaluminosilicate glass with a particle size of 0.85 μm Filler content: 80 wt%	Microhybrid universal composite	1909261	GD Corporation, Tokyo, Japan
Dentsply Spectrum	Matrix: Bis-GMA-adduct, Bis-EMA, TEGDMA, photoinitiators, and stabilizers Filler type: 57 vol% (77 wt%) bariumaluminumborosilicate glass, bariumfluoroaluminioborosilicate, and highly dispersed silicon dioxide Filler content: 57 vol% (77 wt%)	Microhybrid universal composite	2008000582	Dentsply DeTrey, Konstanz, Germany
3M ESPE Filtek Ultimate	Matrix: bis-GMA, UDMA, TEGDMA, bis-EMA, PEGDMA Filler type: Non-agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4–11 nm zirconia filler, and aggregated zirconia/silica cluster filler Filler content: 66.6 vol% (72.5 wt%)	Nanofilled universal composite	N926938	3M ESPE, St. Paul, Minn, USA

UDMA, Urethane dimethacrylate; Bis-GMA, bisphenol A-glycidyl methacrylate; EMA, bisphenol A diglycidyl methacrylate ethoxylated; TEGDMA, triethylene glycol dimethacrylate; PEGDMA, Polyethylene glycol dimethacrylate.

Values with ΔEab^* value greater than 3.3 were considered clinically unacceptable color change.[11] But also, according to Paravina et al.[12] $\Delta E=2.7$ is the acceptability threshold and $\Delta E=1.2$ is the perceptibility threshold. An unsatisfactory color change of $\Delta E=2.7$ is accepted for this investigation with all of this information.

Statistical Analysis

The means and SD values of L^*, a^*, b^* were statistically analyzed using a 2-way analysis of variance (2-way ANOVA). The 2 factors were the period of coloring application and the type of resin-based composite. Color differences (ΔE^*ab) were evaluated by 1-way ANOVA. The difference between groups was evaluated by Tukey's multiple comparison test ($\alpha=0.05$). A global significance level of 95% was applied. All statistical analyses were performed using a standard statistical software package (Statistical Package for Social Sciences 20.0, Chicago, Ill, USA). $P < .05$ was considered statistically significant.

RESULTS

The mean and SD values of CIELAB color coordinates from resin-based composites [Dentsply Spectrum (DS), Gradia Direct (GD), and Filtek Ultimate (FU)] before staining application (T0), after staining application (T1), after water storage (T2), and after repolishing of composites (T3) are shown in Table 2. The period of staining application ($P \leq .05$) and the type of composite ($P \leq .05$) significantly influenced L^*, a^*, b^*. For all resin based composites (RBC), the values of L^* did not change ($P > .05$), but values of a^* and b^* did change ($P \leq .05$), after various applications (T1, T2, and T3). Table 3 shows the mean and SD values of color differences (ΔE^*ab) between different periods of staining application (T1–T0, T2–T1, or T3–T2) for each RBC. There were significant differences in color differences (ΔE^*ab) among composites evaluated for different periods (T1–T0 and T2–T1; $P < .05$; Table 3). The mean values of FU were significantly different from other composites in the T1–T0 groups ($P < .05$). The mean values of DS were significantly different from GD and FU in the T2–T1 groups ($P < .05$).

DISCUSSION

The findings demonstrate that, as predicted, there were substantial variations in color differences (ΔE^*ab) between composites studied during various time periods. As a result of the pigments found in popular foods and beverages, resin composite restorations are constantly subjected to staining agents. Our findings concerning the impact of staining different resin-based composites elaborate the previous work that looked at the impacts of orange juice, tea, red wine, cola, and

Table 2. Mean and SD Values of CIELAB Coordinates (L^*, a^*, and b^*) for All Resin-Based Composites at Different Periods (T0: After 24 Hours of Specimen Preparation and Immersing in Distilled Water at 37°C; T1: After Immersing in Staining Solution for 24 Hours; T2: After Immersing in Water for 24 Hours; T3: After Repolishing Resin Composites)

		L^*	a^*	b^*
		Mean ± SD	Mean ± SD	Mean ± SD
Spectrum	T0	81.51 ± 0.77a	–0.34 ± 0.34a	14.81 ± 1.82a
Gradia	T0	80.94 ± 1.17a	–1.97 ± 0.13a	14.47 ± 0.79a
Filtek Ultimate	T0	81.86 ± 1.91a	–0.34 ± 0.18a	19.09 ± 0.74a
Spectrum	T1	82.63 ± 0.81a	0.21 ± 0.35b	16.44 ± 1.93b
Gradia	T1	80.83 ± 0.87a	–0.24 ± 0.12b	18.56 ± 0.60b
Filtek Ultimate	T1	80.99 ± 1.93a	1.13 ± 0.18b	24.93 ± 0.77b
Spectrum	T2	81.74 ± 0.35a	–0.27 ± 0.06a	17.80 ± 0.35c
Gradia	T2	82.50 ± 0.87a	–1.19 ± 0.12a	24.03 ± 0.61c
Filtek Ultimate	T2	80.96 ± 1.94a	–0.54 ± 0.17a	28.74 ± 0.76c
Spectrum	T3	80.19 ± 0.39a	–1.04 ± 0.07c	13.96 ± 0.39a
Gradia	T3	81.99 ± 0.94a	–1.89 ± 0.10c	17.99 ± 0.65a
Filtek Ultimate	T3	79.90 ± 2.12a	–1.16 ± 0.18c	21.41 ± 0.82a

Two-way analysis of variance was performed for comparing composite and time of application ($P \leq .05$). Different lowercase letters show statistical differences for mean values at the same period (T0, T1, and T2) and for different composites in the column.

Table 3. Mean and SD Values of CIELAB (ΔE) Color Differences Between Different Periods (T0 After 24 Hours of Specimen Preparation and Immersing in Distilled Water at 37°C; T1: After Immersing in Staining Solution for 24 Hours; T2 After Immersing in Water for 24 Hours; T3: After Repolishing Resin Composites)

		T1–T0	T2–T1	T3–T2
		Mean ± (SD)	Mean ± (SD)	Mean ± (SD)
Dentsply Spectrum	ΔE_{ab}	2.46 ± (1.54)[a]	2.04 ± (1.10)[a]	4.67 ± (2.26)[a]
Gradia Direct	ΔE_{ab}	4.51 ± (0.67)[a]	5.84 ± (0.83)[b]	6.21 ± (1.25)[a]
3M Filtek Ultimate	ΔE_{ab}	6.41 ± (2.35)[b]	4.59 ± (3.19)[b]	7.87 ± (3.21)[a]
P		**.001**	**.008**	.067

One-way analysis of variance was performed to compare color differences in columns ($P \leq .05$). The same lowercase letter shows no statistical differences ($P > .05$) for mean values of ΔE^*ab between 2 periods (T0, T1, or T2) and for different composites (column).

coffee and their effects on the color stability of the composite materials.[13] In difference, we focused primarily on the effects of exogenous staining components of sour cherry juice in this study due to the population's widespread consumption.

We adopted the decision to conduct an in vitro study under standardized staining circumstances to subject all samples to the same staining process without any potential bias due to dental cleaning, eating, or drinking habits. With this method, all variables could be completely controlled, and the staining solution/composite interval could be the same for all the tested materials. Furthermore, because it does not harm humans, this strategy has a clear ethical advantage.

In the current study, nanofilled universal composite (3M FU) showed evident color change [ΔE_{ab} T0–T1 = 6.41 ± (2.35), ΔE_{ab} T1–T2 = 4.59 ± (3.19), and ΔE_{ab} T2–T3 = 7.87 ± (3.21)] compared with microhybrid universal composites (DS and GD when immersed in sour cherry juice. This result is similar to a study that reported that the hybrid composite resin demonstrated a color match that was superior to the tested microfilled and nanofilled composites both immediately and after a year.[14] Contrary to this information, a research reported that when compared to microhybrid composites, nanofilled composites photoactivated with greater irradiance had superior color stability.[15] The choice of restorative material between nanofilled/nanohybrid and microhybrid composite still rests with the physician doing the restoration, according to a 2018 review.[16]

3M Filtek Ultimate showed a significant color change after exposure to the sour cherry juice (T1) compared to the distilled water (T0). Gradia Direct and 3M FU showed a significant color change after they were stored in the distilled water (T2) after staining (T1). The initial hypothesis, according to which sour cherry juice staining would not affect the color of different brands of resin composites, was rejected.

The choice to employ multiple-step process polishing systems for assessing polishing performance was influenced by research showing that multiple-step processes increased the staining resistance for both nanofilled and microhybrid composite resins,[17] although no significant difference was found between the resin composites after polishing (T3) compared to the staining (T2). Accordingly, the second null hypothesis that "polishing after staining would not make any difference to the color of resin composites" was accepted.

In accordance with prior studies, a spectrophotometer was employed to eliminate any bias resulting from human eye assessment.[13,18] The CIELAB system is the most preferred technique for assessing the colorimetric properties of tooth-colored restoratives in terms of standardization and study repeatability.[19] The process utilizes human perception to determine the color and assigns 3 coordinates to it. The aforementioned equation can be used to compute general shade alterations (ΔE) in the composite resin using absolute measurements made in $L^*a^*b^*$ color parameters.[20] According to a study by Paravina et al.[12] the perceptibility threshold is $\Delta E = 1.2$ and the acceptability threshold is $\Delta E = 2.7$. It is interesting to note that all samples stained with sour cherry juice showed a color change over the acceptability threshold, according to the results of the spectrophotometric study. This outcome is comparable to a research that found that all samples of microhybrid and nanofilled composites submerged in colored drinks exhibited ΔE values over the threshold for acceptability.[15] The color stability of composites is negatively impacted by beverages; thus, this discovery has therapeutic significance.

One of the study's most significant limitations is the fact that the depth of the coloring agents into the material was not examined. To link surface damage to color change and better understand how these attributes interact during composite staining, surface roughness measurement and three-dimensional profile or scanning electron microscopy images of material surfaces, taken both before and after staining, may be helpful.

Given the restrictions placed on this in vitro investigation, it can be assumed that sour cherry juice has an influence on the color stability of different posterior composites. All the different composites showed a ΔE value above the perceptibility threshold of 1.2. 3M Filtek Ultimate showed a significant color change after exposure to the sour cherry juice. After being preserved in distilled water after staining, GD and 3M FU displayed a noticeable color change. No significant difference was found between the resin composites after polishing.

Ethics Committee Approval: This study was exempted from ethical approval due to its nature.

Informed Consent: This study was exempted from obtaining informed consent due to its nature.

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