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Effect of different tea brands on color change of flowable resin composite

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ABSTRACT

Aims: This study aimed to evaluate the color change of a low-viscosity fluid resin composite (FRC) aged in 2 different brands of black tea and a Ceylon tea for three different periods (24 hours, 7 days, and 28 days).

Methods: Twenty-eight Filtek Ultimate FRC samples with a diameter of 10 mm and a thickness of 2 mm were prepared and polymerized using polytetrafluoroethylene molds. All samples were numbered and polished, and initial color measurements were made. Samples were divided into three experimental groups and a control group (Distilled water) (n=7). All samples were kept in solutions for 24 hours, 7 days, and 28 days, and at the end of these periods, color measurements were made with a spectrophotometer. Data were recorded according to the CIE Lab system. ΔE was calculated by dividing the sum of squares of the difference of the last and first color measurement values by two. One-way ANOVA and Tukey test were used in the analysis of the data.

Results: The Yellow Label black tea group caused significantly more color change in 24 hours than the Ceylon tea ($p<0.05$). Significantly more color changes were observed in the Altınbaş black tea group at 28 days compared to 24 hours ($p<0.05$). More color changes were observed in the experimental groups at 7 and 28 days compared to the control group ($p<0.05$).

Conclusion: All the tea solutions made coloration on the FRC. The color change increased as the exposure time to the solution.

Keywords: Flowable resin composite, color stability, spectrophotometer, tea

INTRODUCTION

Resin-based dental composites (RBDC) are widely used in the anterior and posterior regions to design restorations that mimic dental tissue.[1] Various modifications have been made to RBDCs since their introduction in the early 1960s. Composites with different physical properties and clinical performance are available in the dental market, depending on the resin matrix,[1] viscosity,[2,3] filler size, and distribution.[3]

By reducing the amount of filler, the viscosity of RBDCs was reduced, and flowable resin composites (FRC) were obtained.[4] FRCs, initially developed for class 5 cavities, are also used in clinical use in different indications (minimally invasive class 1,2 and 3).[5] The discoloration of RBDC and FRCs due to internal and external factors is one of the main problems of restorations.[6] In addition, with the decrease of the filler content in FRCs, the translucency and polishability increased while the color stability decreased.[7] At the resin matrix and filler interface, the discoloration that occurs over time with the aging of the restoration is intrinsic. External discoloration occurs when substances such as tea, coffee, coloring foods, or cigarette smoke are attached to the restoration surface.[8]

The International Commission on Illumination [Commission Internationale de Liéclairaqe (CIE)] Lab system is a measurement tool that maintains its reliability and validity in dentistry and makes subjective color perception objectively measurable. L* expresses the lightness-darkness or brightness degree, while a*(red-green) and b*(yellow-blue) express the saturation properties of the color. The amount of color difference is expressed as ΔE and calculated by the formula $\Delta E = [(L1^*-L0^*)2 + (a1^*-a0^*)2 + (b1^*-b0^*)2\ ]1/2$. While "0"s in the formula represent the first measurement values, "1"s represent the last measurement values.[9]

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Tea has critical cultural values in the world and Turkey with its features, preparation, presentation, and how it feels when drunk.[10] Regarding tea consumption, Turkey ranks third in the world after China and India. Turkey's annual per capita tea consumption is around three kilograms.[11] While there are many studies on the coloration caused by tea in RBDCs,[6,8,12-15] there are limited studies on this subject in FRCs.[3,16] Therefore, this study aimed to use two different black teas [Yellow Label black tea (Yellow Label, Lipton, Rize, Turkey), and Altınbaş black tea (Altınbaş, Çaykur, Rize, Turkey)] and one Ceylon tea (Istikan, Finlays Colombo FLC, Sri Lanka) to evaluate the color stability of a low-viscosity FRC (Filtek Ultimate Flowable, 3M, USA) aged. The hypotheses of this study can be listed as follows:

H0: There will be no significant difference between the experimental groups regarding coloration at different measurement times.

H1: Experimental groups will cause significantly more coloration than the control group.

METHODS

The study was carried out with the permission of Dicle University Faculty of Dentistry Local Ethics Committee (Date: 29.03.2023, Desicion No: 2013-11). All procedures were carried out in accordance with the ethical rules and the principles.

In the study, twenty-eight A2-colored Filtek Ultimate FRC samples were prepared using polytetrafluoroethylene molds with 12 mm outer diameter, 10 mm inner diameter, and 2 mm thickness. While preparing the samples, transparent tape and a glass coverslip were applied to allow excess material to overflow. The overflowing material was removed from the molds. Then, each sample was polymerized from both surfaces for a total of 20 s with the Elipar S10 (3M Espe, St. Paul, MN, USA) light device with a light intensity of 1200 mW/cm² following the manufacturer's instructions. The samples were kept in an oven at 37°C for 24 hours to absorb water. To ensure surface standardization, Sof-Lex (3M ESPE, St.Paul, MN, USA) polishing discs were applied to all samples for 15 seconds by a single operator at 20.000 rpm, in the order of coarse, medium, fine and superfine discs. The samples were numbered, and the initial color measurements were measured with a spectrophotometer (Vita Easyshade V, Vita Zahnfabrik, Germany). Measurements were repeated three times and averaged. The samples were randomly divided into four groups (n=7). All solutions were divided into 3 ml Eppendorf tubes and when the solutions reached 37°C, the samples were immersed in the solutions. The tubes were kept in an oven at 37°C for the measurement period. Solutions were refreshed once a week.

- **Group 1 (Ceylon tea):** 200 ml of 100°C boiling water was used for each sachet to prepare the tea solution. While the tea solution was being prepared, the tea bag was shaken slightly at 0, 2, and 5 minutes, and was removed from the water at 5 minutes.
- **Group 2 (Yellow Label black tea):** It was prepared following the same procedure as Group 1.
- **Group 3 (Altınbaş black tea):** It was prepared following the same procedure as Group 1.
- **Group 4 (Control):** Samples were kept in distilled water at 37°C.

At the end of 24 hours, 7 days, and 28 days, the samples were removed from the incubated solutions and washed in distilled water for 5 minutes each and then dried. Measurements were made in the darkroom only under a fluorescent daylight lamp (Master TL-D 90 Graphica 18W965SLV/10, Philips, Netherland) and on a gray background. Measurements were repeated three times and averaged. The CIE Lab formula calculated the color difference (ΔE) between the initial and final measurements obtained.

Statistical Analysis

The data obtained in the research were analyzed using the SPSS (version 25.0, IBM Corp, Armonk, New York, US) package program. Descriptive statistics (mean, standard deviation) are presented in **Table 1**. The Shapiro-Wilk test showed that the data were normally distributed. One-way ANOVA and Tukey test were used to compare the groups. The significance level was accepted as 0.05.

Table 1. Comparison of color changes according to solution and application times (ΔE)

Exposure time	Control	Ceylon tea	Yellow Label black tea	Altınbaş black tea
24 hours	1.67 ± 1.10^{a}	$3.81\pm1.77^{A,b}$	7.41 ± 2.43^{c}	$4.65\pm2.36^{A,b,c}$
7 days	2.38 ± 0.96^{a}	$8.17\pm3.08^{B,b}$	8.88 ± 2.93^{b}	$7.99\pm2.49^{A,B,b}$
28 days	3.24 ± 1.26^{a}	$10.99\pm2.79^{B,b}$	10.56 ± 2.82^{b}	$8.89\pm3.22^{B,b}$

a-c: Indicates the differences within the same row. A-B: Indicates the differences within the same column. *One way ANOVA

RESULTS

In 24 hours, three groups showed more coloration than the control group ($p<0.05$). In addition, the Yellow Label black tea group caused significantly more coloration than the Ceylon tea group ($p<0.05$). There was no significant difference between Yellow Label black tea and Altınbaş black tea groups and between Altınbaş black tea and Ceylon tea groups ($p>0.05$). At 7 and 28 days, three groups showed more coloration than the control group ($p<0.05$). There was no significant difference between the three experimental groups ($p>0.05$). There was no statistically significant difference in the color measurements made according to the measurement times in the Yellow Label black tea group ($p>0.05$). Significantly

more coloration was observed in the Ceylon tea group at 7 and 28 days compared to 24 hours ($p<0.05$), but no significant difference was found between 7 and 28 days ($p>0.05$). Significantly more coloration was observed in the Altınbaş black tea group in 28 days compared to 24 hours ($p<0.05$), but no significant difference was found between 24 hours and 7 days ($p>0.05$). In addition, no significant difference was found between 7 and 28 days ($p>0.05$).

DISCUSSION

This study investigated the color change caused by three different tea solutions (Ceylon tea, Yellow Label black tea, and Altınbaş black tea) on an FRC (Filtek Ultimate) material. Color change on the 7th and 28th days increased compared to 24 hours in the Ceylon tea and Altınbaş black tea groups at different measurement times. Although the color change increased over time in the Yellow Label black tea group, this change was not significant. Thus, while the H0 hypothesis was rejected for Ceylon tea and Altınbaş black tea groups, it was accepted for Yellow Label black tea. All three tea solutions caused significantly more color change than the control group at all times. Thus, the H1 hypothesis was accepted.

Composite restorations often require renewal primarily due to discoloration observed in the restorations over time.[17] These discolorations can be attributed to internal factors related to the resin's structure and external factors resulting from exposure to various elements, including contamination from blood or saliva. Moreover, external factors include inadequate polymerization, improper finishing and polishing techniques, suboptimal oral hygiene practices, smoking, and dietary habits.[17,18]

The clinical performance of the restoration is directly affected by the surface roughness of the material. Increased surface roughness can cause wear, plaque accumulation, and discoloration.[12] In one study, Sof-Lex discs provided the lowest surface roughness, and samples polished with these discs were relatively less colored.[13] In our study, we used Sof-Lex polishing discs to eliminate the effect of roughness on coloration.

In our study, a spectrophotometer was used to evaluate color measurement objectively. According to the CIE Lab color system, when ΔE is greater than 1, there is a visually perceptible color change in the materials, and 3.3 is an acceptable threshold value. All tea solutions tested in this study and distilled water used as a control solution showed clinically detectable color changes on Filtek Ultimate FRC. The color change caused by the tea solutions was 3.3 above the critical threshold in the literature.

Tea is a beverage consumed a lot in daily life in Turkey.[19] There are many studies in the literature to evaluate the external coloring of composite resin. In these studies, filler particle size, polymerization time, and immersion media were evaluated and found to be effective in color stability.[14,15,20-22] In addition to the immersion environment, another factor to be considered in the color stability of the composite resin is the immersion time.[23] In our study, immersion times are 24 hours, 7 days, and 28 days. Güler et al.[21] examined the effect of polymerization, filler particle type, and dyeing solution on the coloring of the composite resin. They stated that an average cup of beverage was drunk in 15 minutes, and 3.2 cups of coffee per person were drunk and reported that the 24-hour immersion time corresponded to 1 month. In 2016, Turkey consumed an average of 3160 grams of tea per person yearly.[24] Considering that a cup of tea is brewed with 2.5 grams, this corresponds to 1.264 cups per year, 105.33 cups per month, and 3.5 cups per day. Although this rate may seem higher than coffee consumption, the volume of the exposed solution will be lower in a tea glass. Therefore, our study calculated that the 24-hour immersion period corresponds to approximately one month. Therefore, the 7-day immersion period corresponds to 7 months, and the 28-day immersion period corresponds to 2 years and four months.

It has been reported that secondary metabolites such as caffeine, tartaric acid, and phenols are highly effective in the coloration of composites.[25] In the production of tea, the number of secondary metabolites obtained per unit of tea mass as a result of the extraction process increases.[26] In our study, the ΔE value was higher in the Ceylon tea group. However, there was no significant difference between the Yellow Label black tea, Altınbaş black tea, and Ceylon tea groups due to the 7 and 28 days of application. This may be due to the increased amount of secondary metabolites in its content.

Reducing the filler particle size results in a more homogeneous filler distribution in the resin matrix and, thus, smoother surfaces. However, it has been observed that decreasing particle size in nano-filled composite resins increases the coloration potential.[27] One study observed that the micro-filled Durafill composite had significantly more color stability than the nano-filled Filtek Z-350 composite.[28] In a similar study, micro-filled, micro-hybrid, and nano-hybrid composites were compared, and they found that the nano-composite changed color the most in tea on the 7th and 30th days.[27] Similarly, we saw more color changes in the material on our study's 7th and 28th days. In another study, nanohybrid, and nanofilled composites were compared and it was observed that Filtek Ultimate FRC was significantly more colored

than other flowable composites (G-aenial Injectable Flow, Filtek Bulk-Fill Flowable, Estelite Universal Super Low Flow). In addition, when the authors used tea as a coloring solution, they saw that the color change in Filtek Ultimate FRC was above the threshold value and significantly more than other composite resins at the end of 6 days.[29] Our study shows that the coloration potential of a nano-filled FRC is high for all coloring media.

For this reason, if this material is to be preferred, especially in the aesthetic region, patients should be warned about drinking coloring drinks. A study conducted by Türkün et al.[30] determined that the tea and coffee discolorations in composite materials could be removed by bleaching and re-polishing methods. Therefore, regular polishing of restorations in which this material is preferred can restore the discoloration and ensure the sustainability of aesthetics.

Although oral cavity temperature simulation was performed in an oven in this study, the absence of salivary and brushing cycles may have limited the variation of ΔE. Given the ease of application of FRCs, further studies on the color change of these materials are needed.

CONCLUSION

In this study, in which we discussed the problem of color stability of FRCs against stains caused by widely consumed tea brands, clinically unacceptable color change was observed on the material surface for 24 hours or more, regardless of brand.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Dicle University Faculty of Dentistry Local Ethics Committee (Date: 29.03.2023, Desicion No: 2013-11).

Informed Consent: Because the study was designed laboratory study, no written informed consent from was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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