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Original Article

The effect of optical brightening toothpaste on the color stability of esthetic restorative materials

Firdevs Kahvecioğlu[1], Elçim Çoban[2], Hayriye Esra Ülker[2]

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

Abstract

Aim: The aim of this study is to evaluate the effects of whitening toothpaste applications on the color stability of different tooth-colored restorative materials (Fuji IX, GC Fuji II LC, Equia Forte, and Kerr Point 4).
Methodology: Standardized fourty disc-shaped specimens were prepared from esthetic restorative materials and polished. The baseline color values of each specimen were then measured using a spectrophotometer, according to the Commission Internationale de l'Eclairage L*, a*, and b* (CIELAB) color scale. Ten specimens from each group were then immersed in two different beverages (cherry juice and coke) for seven days. After immersion, the color value of each specimen was re-measured. Each sample was brushed with whitening toothpaste for 30 seconds using an electric toothbrush. The samples were kept in distilled water at room temperature and brushing continued twice a day for seven days. The color change value, Delta E (ΔE), was calculated. Data were analyzed by two-way ANOVA and post hoc Tukey's test.
Results: When the results were evaluated, after the colored samples had been brushed with whitening toothpaste, a difference was found between the Delta E values according to the materials used ($p < 0.001$), but no difference was found in relation to the beverages ($p > 0.001$). When the values of the color changes were evaluated after the first brushing with whitening toothpaste and before the specimens were colored with drinks, a difference was observed in the Fuji II cola, Fuji II cherry, and Equia Forte cola groups ($p < 0.05$). When the values of the color changes were evaluated for specimens in which brushing had been done twice a day for seven days with whitening toothpaste and before they were colored with drinks, a significant difference was observed in the Fuji II cherry and Equia Forte cola groups ($p < 0.05$).
Conclusion: Using Signal White Now whitening toothpaste for 2 min 2 times a day for seven days caused significant changes in the color of the restorative materials. Color change is dependent upon the type of restorative material that is used.

Keywords: color stability, toothpaste, beverages, glass ionomer cement

Correspondence:

Dr. Firdevs KAHVECİOĞLU
Selcuk University, Faculty of Dentistry, Department of Pediatric Dentistry, Konya, Turkey.
E-mail:
drfirdevskahveci@hotmail.com

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Introduction

The esthetic properties of the materials are also important in the restorative treatment of acquired diseases (tooth decay and erosion), for developmental defects, and for discoloration in the teeth. As a result of the restorative processes, the esthetics of the tooth are as important as the functions of biting, chewing, and phonation. Indeed, in some cases, the main problem is the esthetics, and this is all that needs rehabilitation. For this reason, materials that have similar physical and esthetic properties as dental tissue are preferred in restorative treatment planning (1).

Teeth are exposed daily to a variety of conditions that have the potential for staining, and this exposure changes the surfaces of restorative materials, causing esthetic deterioration. Therefore, it is important to understand how prolonged exposure to daily drinks can change the colors of restorative materials, and whether such changes can be perceived by the human eye (2-4).

Whitening toothpastes are designed to clean tooth structures, both physically and chemically, by removing stains or preventing their build-up (5, 6). Toothpastes contain abrasives (7), surfactants, calcium chelators, enzymes, and polymers to remove stains or prevent them from building up. Recent research has shown that abrasives are the primary cleaning agent in the compositions of toothpastes (7, 8).

There are a limited number of studies in the literature that examine the effects that the pastes used for whitening teeth have on the color of the restorations (9-11). The aim of this study is to evaluate the effects that applying whitening toothpaste has on the color stability of different tooth-colored restorative materials.

Materials and Methods

Sample preparation

Ten samples (10 mm diameter; 2 mm thickness) were prepared from each of the four restorative materials, using cylindrical molds according to the manufacturer's instructions. Each sample disc was polished using a low-speed nozzle. The samples were kept in distilled water at room temperature (36°C) during the day before staining, and then the 40 samples prepared from the materials were randomly divided into four groups, with 10 samples per group.

Table 1. Restorative materials, whitening toothpaste and contents of the materials

Materials *used* in the *st*udy	Content of *m*aterials
Fuji II LC GC EUROPE N.V., Leuven, Belgium	Alumino-fluorosilicate glass, polyacrylic acid, 2-hydroxyethylmethacrylate, 2,2,4-trimethyl hexamethylene dicarbonate, triethylene glycol dimethacrylate
Fuji IX GC EUROPE N.V., Leuven, Belgium	Polyacrylic acid, Aluminosilicate glass, Proprietary ingredient
Equia Forte GC EUROPE N.V., Leuven, Belgium	Powder: 95% strontium, Fluoro-aluminosilicate glass, 5% poly acrylic acid Liquid: 40% Aqueous poly acrylic acid Equia Forte coat: 40%-50% methyl methacrylate, 10%-15% colloidal silika, 0.09% camphorquinone, 30%-40% urethane methacrylate, 15% phosphoric ester monomer
Point 4 (P4) Kerr Corp., Orange, USA	Kerr Corp., Orange, USA Bis-GMA, TEGDMA, Bis-EMA, barium, and silica glass (76 wt % filler) SonicFill (SF) Lot no. 5478244 Kerr Corp., Orange, USA Bis-GMA, TEGDMA, Bis-EMA, silicon dioxide, barium glass (83.5 wt % filler)
Signal White Now Unilever, France	Hydrogenated Starch Hydrolysate, Aqua, Hydrated Silica, Sodium Lauryl Sulfate, PEG-32, Aroma, Cellulose Gum, Sodium Fluoride, Sodium Saccharin, PVM / MA Copolymer, Mica, Trisodium Phosphate, Glycerin, Sodium Lauryl Sulfate, Lecithin, Caprylyl Glycol, Limonene, CI 74160, CI 77891

Color measurement

The initial color values of the polished discs of the restorative materials were measured using a spectrophotometer, according to the Commission Internationale de l'Eclairege L* a* b* color scale (CIELAB, VITA Easyshade® V, Germany). Colorimetric measurements of the samples were made by recording

the L*, a*, and b* values that enable the colors to be determined in three-dimensional space.
Before the measurements were taken, each sample was rinsed with distilled water for five seconds and then dried with a paper towel. The spectrophotometer was calibrated before each measurement was done. Three measurements were obtained from each disc, and the average L*, a* and b* values were used for final analysis. All measurements were made at the same location and on a white background.

Painting procedure

The dietary colorants used in this study were beverages with colors that can cause staining of the surfaces of dental materials. Two different beverages were used in this experiment: cola (Coca Cola, The Coca-Cola Company, İstanbul, Turkey) and cherry juice (Tropicana, Fruko Meşrubat San. Ltd. Şti., İstanbul, Turkey). Ten samples for each group were immersed in two drinks for seven days. The samples were kept in the incubator at 37 °C, and the drinks were refreshed every day. Distilled water was used as a control group for seven days at 37°C. After the samples had been dipped, the color values of each were measured again, and the color change value (ΔE) was calculated as follows:

$\Delta E = \surd ((\Delta L^*) 2+ (\Delta a^*) 2+ (\Delta b^*) 2)$

Whitening

Each sample was brushed for 30 seconds using an electric toothbrush with 1.7 W power and a frequency of 60 Hz (Oral B, Braun GmbH, Kronberg, Germany). To standardize the brushing force, the electric toothbrush was placed in a mold and whitening toothpaste (Signal White Now, Unilever, UK, 250 mg) was added each time. Each sample was then cleaned in an ultrasound bath (Sonicare, Yoshida Dental Mfg. Co. Ltd., Osaka, Japan) and soaked in distilled water for 24 hours at room temperature, and scrubbing continued in this manner twice a day for seven days. The samples were subjected to color evaluations to obtain L* a* b* values at the end of 24 hours and seven days.

ΔE_{R-B} = Color change between L *, a *, and b * values obtained after staining the samples and after initial measurement

ΔE_{M-R} = Color change between L *, a *, and b * values obtained after the first brushing of samples with whitening paste and after coloring

ΔE_{M-B} = Color change between L *, a *, and b * values obtained after the first brushing of samples with whitening paste and after the initial measurement

ΔEM_{7-B} = Color change between L *, a *, and b * values obtained after seven days brushing of samples with whitening paste and after initial measurement.

Statistical analysis

Analysis of the data was carried out with SPSS software version 22 (IBM SPSS Inc., Armonk, NY, USA). Data were analyzed by two-way ANOVA analysis of variance and post hoc Tukey's test.

Results

The mean and standard deviations of the ΔE values of the restorative materials at the end of the first and seventh days are shown in Table 2.

After the colored samples were brushed with whitening paste, a difference was found between ΔE values depending on the material ($p < 0.001$), but no difference was found depending on the beverage ($p > 0.001$). When the color change was evaluated before the whitening toothpaste, first brushing and coloring with drinks, a difference was observed in the Fuji II cola, Fuji II cherry, and Equia Forte cola groups ($p < 0.05$). When the color change was evaluated before the whitening toothpaste, brushing twice a day for seven days and coloring with drinks, a difference was observed in the Fuji II cherry and Equia Forte cola groups ($p < 0.05$).

Table 2. Mean and standard deviations of ΔE values of restorative materials at the end of the one day and seven days.

	Day 1		Day 7	
	Cola	Cherry Juice	Cola	Cherry Juice
Fuji II	5,97±2,76	14,35±1,76	2,11±0,85	7,49±4,04
Fuji IX	2,1±1,25	2,95±0,87	3,31±2,06	2,6±0,88
Equia Forte	5,55±3,76	2,64±1,21	5,56±1,79	3,22±1,14
Kerr Point 4	1,72±0,79	2,25±0,99	2,29±0,83	2,97±0,64

Discussion

It is not always easy to interpret the results of in vitro studies and clinical studies in the field of teeth whitening. They are not always randomized, and often more than one parameter is changed. Changing multiple parameters at the same time makes it difficult to understand the work. In general, a great challenge for planning and conducting clinical studies in the field of teeth whitening is the selection of population-representative inclusion criteria as teeth staining is strongly correlated to dietary and other factors (12). For these reasons, we have found it particularly appropriate to study with a single whitening toothpaste.

Dental restorative materials that is exposed to food ingredients and beverages in the oral environment (2, 3). To achieve excellent esthetics, tooth-colored materials must maintain inherent color stability and resistance to surface staining. This is often attributed to the nature of the material. External stains are caused by the action of colorants found in various foodstuffs such as beverages and food. Techniques available to improve the appearance of stained teeth include polishing, whitening toothpastes, teeth whitening, replacing fillings, and applying crown veneers. Among these methods, the simplest and cheapest method that can be obtained without a prescription and can be applied by the patient is the use of whitening toothpastes. The interaction between the bleaching agent and the restorative material is therefore of clinical significance and needs to be evaluated.

Spectrophotometers and colorimeters have been used because they eliminate the subjective interpretation of visual color comparison (13). The CIELAB system was chosen for the determination of color differences (14). The ability to perceive color differences varies between people, and the smallest color difference that the human eye can perceive has been the subject of debate. Different studies have reported unacceptable color change values at $\Delta E^* \geq 2$ (15), $\Delta E^* \geq 3.3$ (16-19), and $\Delta E^* \geq 3$ (20-22). Most studies state $E^* \geq 3.3$ as the threshold for clinical acceptability of the color change.

Internal and/or external factors can cause discoloration of composite resins. Intrinsic discoloration is determined by the quality of the resin matrix, photoinitiator, and inorganic filler (23). The external color change is mainly caused by colorants absorbed from beverages and foods. Many studies have shown that the most important factor affecting the color stability and long-term success of composite resin restorations is external color change (3,4). According to the results of this study, when the composite filling material Kerr Point 4 was brushed with whitening paste, it showed similar results with the values before coloring. The resulting color difference is too small to be perceived by the eye ($\Delta E^* <3.3$).

Glass ionomer-based restorative materials are frequently used in dentistry due to their positive properties, such as fluoride release and chemical bonding to teeth. However, glass ionomer-based restorative materials are very sensitive to the technique applied, degradation by organic acids originating from dental plaque, and food intake (24). In our study, the most important color change after brushing was observed in the Fuji IX group, a conventional glass ionomer cement. After brushing with whitening paste, it has reached similar colors to its original form.

Equia is a unique restorative system for esthetic and economic posterior restorations and is impressive at all levels. The Equia system, a new generation of glass ionomer, Equia forte and Equia coat, combines highly refined resin coating material that brings glass ionomer technology to the next level. In the Equia forte cherry juice group, similar results were observed with the initial from the first brushing, while different results were observed in the cola group. This situation may have occurred due to the acidity of the cola. While the Equia forte coat applied to the surface protects the surface of the restorative material from acids, it can be colored because it is resin-based.

The color stability is also related to the resin matrix, dimensions of filler particles, depth of polymerization, staining agents. Among the materials tested, a more noticeable color change was observed in RMGIC (25, 26).

Resin modified glass ionomer cements are materials produced to reduce the moisture sensitivity of conventional glass ionomer cements and to improve their mechanical properties. However, there is 2-hydroxyethyl methacrylate (HEMA) in the structure of these materials. As HEMA has a hydrophilic property, there are studies reporting that the water absorption of resin-modified glass ionomer cements is greater than that of conventional glass ionomer cements (27, 28).

Resin-modified glass ionomer cement is not recommended in esthetically critical areas due to its tendency to discolor due to cola exposure (29).

Conclusions

The results of this study can give an insight into how different restorative materials may behave when exposed to different beverages, thus affecting the clinician's choice of material and the patient's control of dietary habits. The color change is dependent upon the type of restorative material. Using Signal White Now whitening toothpaste for 2 min 2 times a day for seven days caused significant changes in the color of the restorative materials. The color change depends on the type of restorative material.

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