Selcuk Dental Journal 11/1 (Nisan 2024): 5-9

Research Article / Araştırma Makalesi

The Effect of Home Bleaching on Color Match with Anterior Monochromatic Resin Composite Restoration

Ev Tipi Beyazlatma Tedavisinin Anterior Tek Renk Kompozit Restorasyon ile Renk Uyumuna Etkisi

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ABSTRACT

Background: The aim of this study is to assess the color matching in class III restorations made with monochromatic resin composites after bleaching with different carbamide peroxide concentrations.

Methods: Twenty human incisors that were free of caries or enamel abnormalities and freshly extracted were cleaned of blood, debris, and calculus. The mesial and distal surfaces were restored with monochromatic resin composites (Omnichroma, Tokuyama, Japan). Polishing discs (Zenit Flex, President Dental, Germany) were used for the composite restoration. All samples were randomly divided into two groups; all of the mesial surfaces were isolated, and distal surfaces were coated with %10 and %16 carbamide peroxide (Opalescence PF; Ultradent Products, Inc., USA). Color matching was evaluated on photographs with a digital colorimeter. The SPSS software program was used to perform statistical analysis (IBM Corp., Armonk, NY, USA).

Results: A statistically significant difference was found between the color matching of the restorations after the 5th treatment with 16% carbamide peroxide ($p = 0.004$) and at the end of the 10th treatment with 10% carbamide peroxide ($p = 0.028$). Depending on the carbamide peroxide concentration, after the 5th treatment, a statistically significant difference was found between 16% and 10% carbamide peroxide ($p = 0.000$), but no statistically significant difference was found after the 10th treatment ($p > 0.05$).

Conclusions: After carbamide peroxide bleaching, the hard tissue color became lighter. Since there is no color pigment in the monochromatic resin composite, the color might be lighter after bleaching. Therefore, these composites may be considered safer for bleaching.

Keywords: Bleaching, Color Match, Composite

ÖZ

Amaç: Bu çalışmanın amacı, monokromatik rezin kompozit ile yapılan sınıf III restorasyonlarda farklı karbamid peroksit konsantrasyonları ile beyazlatma tedavisi sonrası renk değişiminin değerlendirilmesidir.

Gereç ve Yöntemler: Bu çalışmada, çürük veya mine anormallikleri olmayan ve periodontal veya ortodontik nedenlerle yeni çekilmiş 20 anterior kesici dişi üzerinedeki kan, debris ve diştaşı temizlenip, mezyal ve distal yüzeyleri monokromatik kompozit ile restore edildi. Tüm örnekler rastgele iki gruba ayrıldı, tüm mezyal yüzeyler izole edildi ve distal yüzeylere %10 ve %16 karbamid peroksit uygulandı. Renk uyumu, dijital kolorimetre ile fotoğraflar üzerinde değerlendirildi. İstatistiksel analiz için SPSS yazılım programı kullanıldı.

Bulgular: %16 karbamid peroksit ile 5. tedavi ($p = 0.004$) ve %10 karbamid peroksit ile 10. tedavi sonunda ($p = 0.028$) restorasyonların renk uyumu arasında istatistiksel olarak anlamlı fark bulundu. Karbamid peroksit konsantrasyonuna bağlı olarak 5. uygulamadan sonra %15 ile %10 karbamid peroksit arasında istatistiksel olarak anlamlı bir fark bulundu ($p = 0.000$), ancak 10. uygulamadan sonra istatistiksel olarak anlamlı bir fark bulunamadı ($p > 0.05$).

Sonuçlar: Karbamid peroksit ile beyazlatma sonrası sert doku rengi daha açık hale geldiği görüldü. Monokromatik rezin kompozitlerde renk pigmenti bulunmadığından beyazlatma sonrası renk daha açık olabilmektedir. Bu nedenle bu kompozitlerin beyazlatmada daha güvenli olduğu düşünülebilir.

Anahtar Kelimeler: Beyazlatma, Kompozit, Renk Uyumu

1. Introduction

Restoring proper tooth function, form, and esthetics is the main goal when replacing a missing tooth structure. The color characteristics of dental materials are correlated with their esthetic success, and obtaining an excellent color match between the restorative material and dental hard tissue is of great significance in esthetic restorations.[1] For this purpose, recently developed materials that mimic the natural tooth structure will meet the expectations of clinicians and patients.[2]

Resin composite materials are often preferred in dental treatment because of their mechanical properties, low cost, good esthetics, conservative properties, and suitability for a variety of clinical situations.[3] Various factors affect the appearance of dental resin composites, including color characteristics like lightness, chroma, hue, and translucency.[4]

Monochromatic resin composites are resin-based materials created to visually mimic all shades using just one nominal shade.[5, 6] As a result, it is claimed that monochromatic resin composite materials can cover the traditional VITA colors only with one shade.[6] According to the manufacturer, Omnichroma (OM) by Tokuyama Dental Corporation, Japan, is monochromatic resin composite and a new product with no added pigment that offers chromatic matching capability within a wide range.[2] OM was created through a different chromatic technology that uses textural color, in which the material attenuates or magnifies certain light wavelengths to blend in, rather than using red and yellow pigment supplements for color.[1] It comprises zirconium dioxide (ZrO_2) and silicon dioxide (SiO_2) in the form of a supra-nano spherical filler with a particle size of 260 nm.[1,7]

Bleaching is a common esthetic procedure for whitening of teeth.[8] Bleaching materials contain reactive oxygen species (ROS), which oxidize the chromophores that infiltrate the tooth structure. As a result of the formation of smaller molecules that reflect more light, tooth structure seems lighter.[9] The traditional "teeth whitening" treatment dramatically brightens natural teeth but may have little whitening

Gönderilme Tarihi/Received: 15 Mart, 2023
Kabul Tarihi/Accepted: 14 Kasım, 2023
Yayınlanma Tarihi/Published: 26 Nisan, 2024
Atıf Bilgisi/Cite this article as: Ünal M, Paken G, Güvenç P, Yağcı Ö, Kesgin B. The Effect of Home Bleaching on Color Match with Anterior Monochromatic Resin Composite Restoration. Selcuk Dent J 2024;11(1): 5-9 Doi: 10.15311/ selcukdentj.1253003

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effect on dental restorations.[2, 10] It is thought that the minimal color changes that occur in composite resin restorations after bleaching are due to the superficial cleaning of the samples; these changes are not intrinsic.[10]

However, composite resins might react with ROS. Hence, it is essential to investigate their relationship.[9] Although the effects of bleaching on the color change of composites are debatable, various types of resin-based composites may react differently to these procedures. Consequently, when a bleaching material is applied, the color of the composite resin may not necessarily match the color of the bleached tooth structure.[11]

Because of the limited data in the literature on the clinical significance of color matching and the effect of bleaching on teeth with resin composite restoration, the aim of this study was to evaluate the color matching of monochromatic resin composites after bleaching with different carbamide peroxide (CP) concentrations. The null hypothesis investigated in this study is that there is no color difference between monochromatic resin restorations with and without bleaching.

2. Material and Methods

This study was approved by the Uşak University Faculty of Medicine Clinical Research Ethical Review Board (document number: 80-80-10). **Table 1** shows the materials used for this research. **Figure 1** illustrates a summary of the study methodology.

Table 1. Materials used in this study

Material	Type of Material	Compounds	Manufacturer
Omnichroma	Monochromatic Resin Composite	Filler type: Spherical Silica- Zirconia and Composite fillers, Filler size: 79.0 wt (%/68.0vol%), Monomer: UDMA, TEGDMA, Universal Shade	Tokuyama Dental, Tokyo, Japan
Opalescence PF 16% Regular	Tooth Whitening Systems	16% Carbamide Peroxide = 5.8% Hydrogen Peroxide Ingredients: Glycerin, Water (Aqua), Urea (Carbamide) Peroxide, Xylitol, Carbomer, PEG-6, Sodium Hydroxide, EDTA, Potassium Nitrate, Sodium Fluoride,	Ultradent, South Jordan, UT, USA
Opalescence PF 10% Mint	Tooth Whitening Systems	10% Carbamide Peroxide = 3.6% Hydrogen Peroxide Ingredients: Glycerin, Water (Aqua), Xylitol, Urea (Carbamide) Peroxide, Carbomer, PEG-6, Sodium Hydroxide, EDTA, Peppermint Oil (Aroma), Potassium Nitrate, Sodium Fluoride,	Ultradent, South Jordan, UT, USA

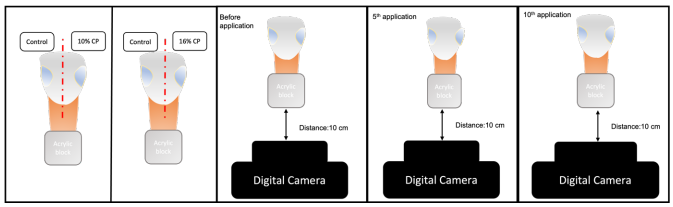

Figure 1. A summary of the study's materials and methods

CP: Carbamide Peroxide

Using power analysis (G-power software, Germany), it was determined that each group of specimens should consist of at least five samples to achieve a confidence level of 95% (1-α) and a test power of 95% (1-β). Consequently, 40 cavities (20 human incisors) that were free of caries or enamel abnormalities and freshly extracted for periodontal or orthodontic reasons were included in this study and cleaned of blood, debris, and calculus. All the tooth specimens were examined visually with a dental probe under dental operatory light by two different dentists. Class III cavity preparations on both mesial and distal sides of 20 extracted teeth (2 mm depth[1,2,12] and 3 mm diameter[3], total of 40 cavities) were performed using a diamond bur #1014 (Kg Sorensen, Brazil). The depth and diameter measurements were made with a digital caliper by a single operator. Class III cavities are located on proximal surfaces of anterior teeth.[3] Access to the cavity can be achieved from the labial or palatal surface of the tooth for different reasons. For each tooth, the distal cavity was set as the experimental, and the mesial cavity was set as the control. The palatal surfaces were not included in the preparation. After preparation, the cavities were washed and dried with water/air spray, then etched using 37% phosphoric acid (i-GEL N 4.3 syringe, I-dental, Lithuania) for 15 s. After acid etching, the eight surfaces were rinsed with water and air-dried. A universal bonding agent (Optibond All-In-One, Kerr, Italy) was applied to all surfaces of the cavities, and specimens were polymerized using an LED light-curing device (Bluephase 1200 mW/cm2; Ivoclar Vivadent AG) for 10 s. A monochromatic resin composite (Omnichroma, Tokuyama, Japan) was placed in a single layer and polymerized for 20 s. Polishing discs (Zenit Flex, President Dental, Germany) were used for 60 s. at 10,000 rpm to complete the composite restoration, according to the manufacturer's instructions. After finishing the composite restoration, each tooth was embedded in acrylic blocks and numbered. After 24 hours of immersion in 37°C distilled water, the first color of the restorations was recorded. Photographs were taken before the application of the whitening agent.

The specimens were randomly separated into two groups (n = 10) and exposed to various bleaching agent concentrations. Group 1 and Group 2 used 10% and 16% concentrations of the CP, respectively (Opalescence PF; Ultradent Products, Inc., USA). The whitening agent was applied to the distal half of the composite tooth assembly. Vaseline (Unilever, USA) was applied to the mesial half to prevent whitening of the control side and placed immediately back in the solution after each treatment.[8] According to the manufacturer's instructions, the 10% and 16% whitening gels were removed 10 h and 6 h after application, respectively. Before each measurement, specimens were washed with distilled water, softly brushed, and blot-dried with absorbent paper. All samples were then stored in fresh distilled water at room temperature through the process. For each group, photographs were taken after the 5th and 10th applications with the whitening agents.

The initial and post-treatment color measurements were made on the photographs. The distance between the lens and the acryl-embedded tooth was standard (10 cm)[3, 13]. For this purpose, standardization was made to take the photos from the same spot using a photo stand prepared before. The digital camera with a cross-polarizing filter (Nikon D7100, Nikon Corp., Tokyo, Japan) and a 62-mm lens (Nikon AF-S DX Nikkor 18-105 mm 1:2.8 G ED VR lens + polarizing filter) was used with a double speedlight flash (Wireless Remote Speedlight SB-R200, Nikon). All photographs were taken as digital images using the following specifications: exposure=1/125 s, ISO=200, f=25, distance=~10 cm, manual flash at half of its capacity, and focusing (1:1) in RAW format.[3] All images were collected on an SD memory card and transferred to the computer for color measurement. CIELab color coordinates (*, the lightness; a*, the red-green axis; and b*, the yellow-blue axis) were used to specify color differences between the initial and post-treatment measurements. The CIELab (L*,a*,b*) values were calculated using a digital colorimeter program[3] (Digital Colorimeter for Windows 10), which converts color values to CIELab parameters.[14] The color changes ΔE_{00} between the control and test groups were calculated using the formula CIEDE2000:[3, 7]

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{K_L S_L}\right)^2 + \left(\frac{\Delta C'}{K_C S_C}\right)^2 + \left(\frac{\Delta H'}{K_H S_H}\right)^2 + R_T \left(\frac{\Delta C'}{K_C S_C}\right)\left(\frac{\Delta H'}{K_H S_H}\right)}$$

Statistical analyses were carried out with SPSS software (IBM Corp). The Shapiro-Wilk test was used to examine the assumption of normality, and it revealed that the samples were distributed normally. ($p > 0.05$) The t test and one-way ANOVA were used for statistical analysis. For each test, a 95% confidence interval was employed ($p = 0.05$).

3. Results

Photographs of one sample of both groups before application, after the 5th application, and after the 10th application are shown in **Figure 2.** The mean ΔE_{00} values of groups after the fifth and tenth applications are shown in **Figure 3.**

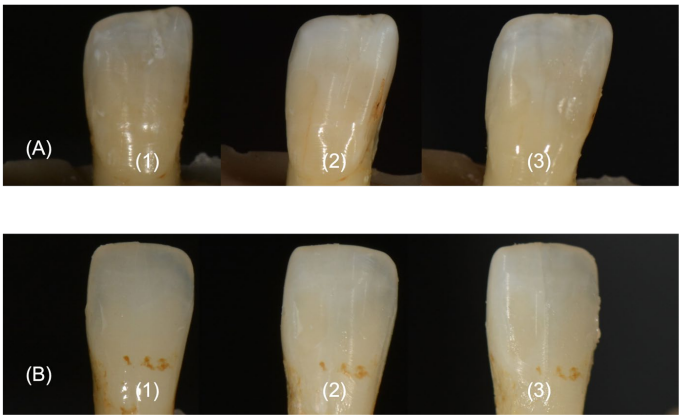

Figure 2. Photographs of samples before application, after the 5th application, and after the 10th application

A: 10% CD Groups **B:** 16% CD Groups 1: Before Application, 2:After The 5th Application, 3: After The 10th Application

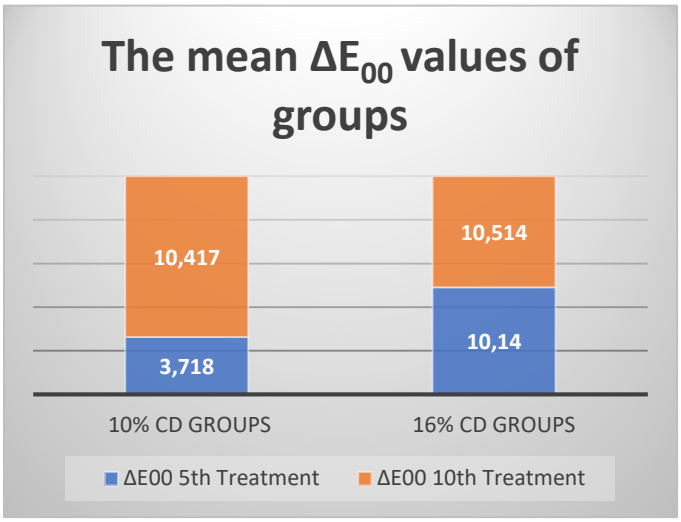

Figure 3. The mean ΔE_{00} values of groups after the 5th and 10th application

The means and standard deviations of the ΔE_{00} values obtained for all samples in the multiple comparison test results of monochromatic composite resin restorations are shown in **Table 2** for the various CP concentrations and various numbers of treatments. According to this study, with 10% CP, there was no significant difference after the 5th treatment of bleaching ($p > 0.05$), whereas a statistically significant difference was found at the end of the 10th treatment ($p = 0.028$). With 16% CP, a statistically significant difference was found after the 5th treatment of bleaching ($p = 0.004$), but there was no significant difference between the 5th and 10th treatments ($p > 0.05$). Depending on the CP concentration, after the 5th treatment, a statistically significant difference was found between 16% and 10% CP ($p = 0.000$), but no statistically significant difference was found after the 10th treatment ($p > 0.05$).

4. DISCUSSION

Hydroxylapatite molecule (OHAp), which consists of 98% of dental enamel crystallites' structure, is their primary component of the enamel. Also, it contains a variety of trace substances, like chloride, fluoride, citrate, titanium, and carbonate.[15] Hydrogen peroxide is commonly used in tooth whitening. It can be applied to the enamel surface in the form of hydrogen peroxide, or it occurs through a chemical reaction when CP or sodium perborate is used. As a strong oxidizer, hydrogen peroxide results in the production of free radicals such as hydrogen peroxide anions and reactive oxygen molecules. As these reactive molecules enter the tooth, the long-chained, dark-colored chromophore molecules are theoretically broken down into smaller, less-colored, more diffusible forms. Supposedly, the bleaching compounds penetrate the dentine's surface. Therefore, the bleaching process is dependent on the agent's ability to interact with the requisite chromophore molecules, as well as the duration and frequency of exposure to the agent.[16]

AlHabdan et al.[17] investigated the color match of the monochromatic resin and discovered that restorations looked lighter immediately after bleaching. Mohamed et al.[18] evaluated the color matching ability of omnichroma in anterior restorations and discovered that after bleaching, the composite resins matched the tooth structure, and the monochromatic resin composite changed to a lighter shade. Similarly, in our study, it was determined that a bleaching effect was obtained on the OM resin composite restorations at the end of the 5th treatment at a concentration of 16% CP. When the CP concentration was 10%, a color change was observed only at the end of the 10th treatment. Accordingly, the null hypothesis was rejected.

Durand et al.[7], using CIEDE2000 (ΔE_{00}), investigated the color coordinates and translucency adjustment of monochromatic and multi-shade resin composites and reported that the results were dependent on the dental material and that Omnichroma possessed superior lightness, color, hue, and translucency properties among the studied materials. According to Lucena et al.[5], optical properties, translucency, and opacity values differ significantly between one shade and multishade resins. Color properties are based on structural colors, using intelligent chromatic technology to control the optical properties of the resin composite[2]; thus, a color change after bleaching was observed in this study. Canay and Cehreli[19] compared the efficiency of 10% hydrogen peroxide and 10% CP on the color of light-polymerized hybrid, polyacid-modified, and macro-filled composites. According to their study, the hydrogen peroxide-treated composites showed a clinically detectable color change, and the color differences of the polyacid-modified composites were higher than those of the other composites. Even low concentrations of bleaching materials were found to affect the color of the light-polymerized restoratives.

Reinhardt et al.[12] compared different bleaching materials and reported that Opalescence PF used at 15% concentration was more effective for whitening than the others. In that study, with CP at 16% concentration, a significant change was observed after the 5th treatment, and at 10% concentration, a significant change was found following long-term treatment (10th treatment). Similarly, Estay et al.[20] compared hydrogen peroxide gel at different concentrations and found that both were effective, and Farawati et al.[21] reported that the highest CP concentration did not result in the greatest change in ΔE_{00}, however the efficacies of different concentrations were similar. In our study, the effects of 10% and 16% whitening agents as a result of appropriate time use are similar.

Color matching is of great importance for composite restorations. Because the perceptibility of color differences is clinically important, the Commission Internationale de l'Eclairage (CIE) recommends the calculation of color differences based on the CIELAB color parameters.[1, 14] The CIELab color system includes parameters L*, a*, and b*. The parameter L* corresponds to luminosity, while a* and b* correspond to hue. The value of a* reflects saturation on the red-green axis, and the value of b* reflects blue-yellow saturation. From the individual changes in each parameter, the color difference is obtained as a single value.[14, 22] In an attempt to reduce the difference between the computed and perceived color changes, the CIEDE2000 formula was improved.[14] A color change with a ΔE_{00} of less than 1.1 (the perceptibility threshold) cannot be observed by the human eye; a ΔE_{00} between 1.1 and 3.3 can be identified and is found clinically tolerable; while a ΔE_{00} greater than 3.3 (the acceptability threshold) is considered clinically unacceptable.[12,23] In this study, the ΔE_{00} of all samples after the 10th bleaching treatment was found to be at or above the acceptability threshold. Ozturk et al.[24] also reported color differences after the bleaching process on three different resin matrix ceramics and resin composite (A2) samples and found that the ΔE_{00} values of the composite resin group were higher than the acceptability threshold. This might have occurred as a result of degradation of the pigments and surfaces of the samples.

Digital single-lens reflex (DSLR) cameras and cross-polarization filters are reliable tools for obtaining high-resolution images for objective color analysis. Additionally, digital photos have advantages in ease of access and storage and in regulating the white balance.[3,14] Cross-polarizing filters, which reduce or eliminate specular reflections to counteract the frequency of white opacities in flash photography, also assist in identifying color changes in shade guides.[14,22]

This study was limited due to the small sample size and the limited types of composites and whitening agent materials. Furthermore, the color measurement procedure was limited to only photography. Diet may also influence the color change of composite restorations. Diet is not included in the present study. More studies are needed to increase the variety of composite resins, bleaching materials, and color measurements. However, the current study will provide information to clinicians to predict the prognosis of restorative treatment considering a bleaching procedure. In future studies, a wider range of composite resins, bleaching materials, and color measurement techniques must be applied to produce more comprehensive results. However, the current study will provide information to clinicians to predict the prognosis of restorative treatment considering a bleaching procedure.

5. Conclusions

Within the limitations of this study, it was determined through digital color measurements that the color of restorations was changed at the end of the 5th and 10th treatments when using 16% and 10% concentrations of CP, respectively. Accordingly, bleaching materials of both concentrations were effective but required a different number of treatments. Based on the chromatic properties of the monochromatic resin composite, the explanation for the color change in restorations may be due to adaptation following the lightening of the underlying hard tissue. Hence, when dealing with a monochromatic resin composite before the bleaching process, clinicians should be able to inform patients about the procedure.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu makale, sempozyum ya da kongrede sunulan bir tebliğin içeriği geliştirilerek ve kısmen değiştirilerek üretilmemiştir.

Bu çalışma, yüksek lisans ya da doktora tezi esas alınarak hazırlanmamıştır.

Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

This article is not the version of a presentation.

This article has not been prepared on the basis of a master's/ doctoral thesis.

It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

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Finansman / Grant Support

Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir. | The authors declared that this study has received no financial support.

Çıkar Çatışması / Conflict of Interest

Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: MU (%40), GP (%40), PG (%10)
Veri Toplanması | Data Acquisition: MU (%60), ÖY(%20), BK (%20)
Veri Analizi | Data Analysis: MU (%100)
Makalenin Yazımı | Writing up: MU(%70), ÖY (%15), BK (%15)
Makale Gönderimi ve Revizyonu | Submission and Revision: MU(%70), ÖY (%15), BK (%15)

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