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Research / Araştırma Makalesi

Evaluation of Color Stability of Monochromatic Resin Composite Restorations After Repair Procedure

Monokromatik Rezin Kompozit Restorasyonların Tamir Prosedüründen Sonra Renk Stabilitesinin Değerlendirilmesi

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ABSTRACT

Backgrounds: The aim of the study was to evaluate the color stability after the repair procedure with current single-shade resin composites.

Methods: There were used one resin composite (Clearfill Majesty Esthetic) as substrate and two one-shade resin composites (Omnichroma, ZenChroma) as repair materials. For each of the 3 composites used in the study, 18 samples (2 mm thickness, 6 mm diameter) were prepared as a control group to compare the experimental groups. In addition, samples were prepared from conventional composite (1 mm thickness, 6 mm diameter) and these were also subjected to the repair procedure with monochromatic composites. The samples were prepared and immersed in coffee, rosehip tea and distilled water, and color changes (ΔE00) were observed over 30 days.

Results: The results showed no significant color change in distilled water, but both composites exhibited significant color changes in coffee and rosehip tea. Coffee caused the highest color change, especially in Omnichroma. Lower color change was observed in the repair groups of Omnichroma and ZenChroma compared to the control material.

Conclusion: These findings suggest that repairing restorations may be advantageous, particularly in terms of aesthetic concerns.

Keywords: Coffee, Color, Monochromatic resin, Dental restoration repair

ÖZ

Amaç: Çalışmanın amacı, güncel tek renkli rezin kompozitlerle yapılan tamir prosedürü sonrası renk stabilitesini değerlendirmektir.

Gereç ve Yöntemler: Substrat olarak bir rezin kompozit (Clearfill Majesty Esthetic) ve tamir materyali olarak iki farklı tek renk rezin kompozit (Omnichroma, ZenChroma) kullanıldı. Çalışmada kullanılan 3 kompozitin her biri için, deney gruplarını karşılaştırmak üzere kontrol grubu olarak 18 örnek (2 mm kalınlık, 6 mm çap) hazırlandı. Ek olarak, geleneksel kompozitten (1 mm kalınlık, 6 mm çap) örnekler hazırlandı ve bunlar da monokromatik kompozitlerle onarım prosedürüne tabi tutuldu. Hazırlanan örnekler kahve, kuşburnu çayı ve damıtılmış suya daldırıldı ve 30 gün boyunca renk değişimleri (ΔE00) gözlendi.

Bulgular: Distile suda önemli bir renk değişimi göstermezken, her iki kompozit de kahve ve kuşburnu çayında belirgin renk değişimleri sergilemiştir. Kahve, özellikle Omnichroma'da en yüksek renk değişimine neden olmuştur. Omnichroma ve ZenChroma tamir gruplarında kontrol materyaline kıyasla daha düşük renk değişimi gözlenmiştir.

Sonuçlar: Bu bulgular, restorasyonların onarılmasının özellikle estetik kaygılar açısından avantajlı olabileceğini düşündürmektedir.

Anahtar Kelimeler: Kahve, Renk, Monokromatik rezin, Dental restorasyon tamiri

Introduction

Due to the advances and developments in adhesive dentistry in clinical dentistry practices, resin composites are widely used today, especially in direct restorations.[1] In order for the composite restoration to be aesthetically acceptable, its properties such as texture and color should be as similar as possible to the surrounding tooth structure and there should be no difference that can be perceived by the human eye.[2]

Layering techniques have been developed in the application of resin composites to mimic and create a more realistic appearance, but this technique requires expertise and time on the part of the clinician. New techniques and materials have been developed to facilitate clinical protocols, shorten the time by simplifying the procedures, and assist in the color selection.[3] Recently, monochromatic universal resin composites have been produced for this purpose. Single shade Monochromatic universal resin composites match almost any color tone, thus eliminating the color selection step. When light illuminates the restorative material, it spreads across the surface of the filler particles and disperses in many directions. The potential of restorative materials to match the color of the surrounding tooth structure through reflections is called the blending effect. The blending effect is affected by the restoration size and the translucency of the restorative material. Chameleon effect and color adjustment potential are other common terms used to express the blending effect.[4]

One of the disadvantages of resin composites, which are widely used today and are constantly developing, is that they undergo significant color change in the oral environment. This color change usually occurs as a result of adsorption of coloring agents or deterioration of the resin surface over time. Many studies have reported that consumption of beverages such as tea and coffee can change the surface color of resin composites.[1, 3, 5] The color stability of the resin composite depends on factors such as monomer tipe, filler type and ratio.[1, 3]

In accordance with the philosophy of the 'minimally invasive approach', defective restorations should first be evaluated for the possibility of repair rather than replacement.[6] The repair procedure is the application of only the defective part of the restoration, its adjustment, surface preparation and then the repair with the composite. The advantages of this technique include lower cost, reduced clinical time and preservation of the tooth tissue, and reduced risk of pulp exposure.[7] Therefore, the repair of resin composite restorations is in line with the principles of minimal invasive approach. A higher acceptance rate of repair procedures among patients has also been reported, as anesthesia is usually not required.[8]

The aim of the study was to evaluate the color stability after the repair procedure with current single-shade resin composites. The tested first null hypothesis was the monochromatic composite resin material type has no effect on color change and the second null hypothesis was the solution in which the samples are kept has no effect on color change.

Materials and Methods

The resin composites and other materials that was used in the present study was presented at **Table 1**. The number of samples were determined by referenced article. 9 There were used one resin composite (Clearfill Majesty Esthetic) as substrate and two one-shade resin composites (Omnichroma, ZenChroma) as repair materials. For

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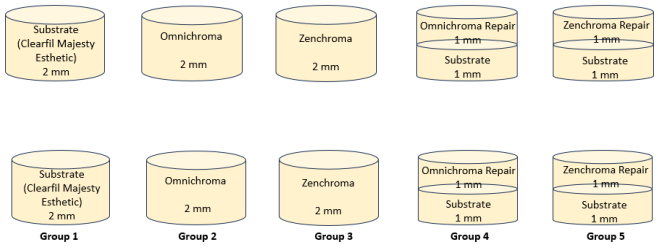
each of the 3 composites used in the study, 18 samples (2 mm thickness, 6 mm diameter) were prepared as a control group to compare the experimental groups. In addition, samples were prepared from Clearfill composite (1 mm thickness, 6 mm diameter) and these were also subjected to the repair procedure with monochromatic composites. The groups prepared in the study are shown as graphically in **Figure 1**.

Table 1. Resin composites tested in this study

Resin composites	Manifecturer/ Lot number	Type	Organic matrix	Inorganic filler	Filler wt/vol
Omnichroma	Tokuyama, Tokyo, Japan 1702SM1	Supra-nano spherical	UDMA, TEGDMA	260 nm spherical SiO_2, ZrO_2	79/68
ZenChroma	President Dental, Germany 2021005749	Microhybrid	Bis-GMA, Tetramethylene dimethacrylate, Diurethane dimethacrylate	SiO_2, glass powder and ultra-fine radiopaque filler	75/53
Clearfil Majesty Esthetic	Kuraray, Osaka, Japan 3Q0244	Nanohybrid	Bis-GMA, hydrophobic aromatic dimethacrylate, hydrophobic aliphatic dimethacrylate	silanized barium glass, pre-polymerized organic filler	78/66



The control samples were prepared as 6 mm diameter, 2 mm depth disks using using custom-made polytetrafluoroethylene molds and Mylar strips for each three composite (n=18). The samples were light-cured with a LED curing device for 20 seconds. For repair groups (n=18); in order to create a defect in the prepared 2 mm disc samples, mechanical abrasion was performed using a fine-grained diamond rond bur (1 mm depth). Then, the surfaces were roughened with 37% orthophosphoric acid (Proetch, Promida) (30 seconds). The acid was washed for 30 seconds. Universal bond (Clearfil S3 Bond, Kuraray) was applied to the rough surface with the manifacturer's instructions and light-cured for 20 seconds. Using single-shade resin composites (Omnichroma, Zen Chroma) in line with the predetermined groups, the specified composites were placed in a thickness of 1 mm and light-cured for 20 seconds, and the repair procedure was performed. Polishing discs (OptiDisc, Kerr) were applied according to the order of grain sizes from coarse to fine for finishing-polishing and the samples were immersed in distilled water for 24 hours.

The initial quantitative color measurements were performed using a contact-type spectrophotometer (Vita Easyshade V, Vita Zahnfabrik, Germany) providing CIE L*, a*, and b* coordinates. The color of each specimen was recorded as the average of four consecutive measurements. The spectrophotometer was calibrated in compliance with the manufacturer's instructions before each measurement. The samples were divided into three subgroups (n=6) and immersed in coffee, rosehip tea, and distilled water as control for 30 days. The rosehip (Rosehip Fruit Tea, Doğadan, Turkey) was prepared by dipping and removing it into 200 ml boiling water at 100ºC 5-10 times and waiting for 2-3 minutes. The coffee (Nescafe Classic, Nestle, Switzerland) was prepared by dissolving 2 grams of coffee in 200 ml of boiled water and waiting for 1 minute. The beverages were allowed to reach room temperature (24ºC) to eliminate the effect of thermal conditions on the composite before immersion and for standardization. The beverages were refreshed every 2 days to avoid microbial growth. After the beverage immersions, the samples were rinsed with distilled water for 10 seconds and gently dryed with absorbant papers. Final color measurements were performed and recorded. Color change (ΔE) values were calculated using the CIEDE 2000 (ΔE_{00}) formula;

$$\Delta E_{00} = [(\Delta L'/k_L S_L)^2 + (\Delta C'/k_C S_C)^2 + (\Delta H'/k_H S_H)^2 + R_T(\Delta C'/k_C S_C)(\Delta H'/k_H S_H)^2]^{1/2}$$

Statistical analysis of the data were performed with Two-way Analysis of Variance and post-hoc Tamhane tests were used for statistical analysis of the average ΔE_{00} values (p=0.05).

Results

The statistical analysis results of ΔE_{00} values are presented at **Table 2**. In distilled water groups, there were no significant difference between the composite and repair groups. (p>0.05) In coffee and rosehiptea groups, there were no significant difference with Omnichroma, ZenChroma and ZenChroma Repair groups. (p>0.05) Therefore, Substrate and Omnichroma Repair groups had no difference but these two groups had lower ΔE_{00} values then the other groups. (p>0.05)

Table 2. Color Change of Resin Composites (ΔE_{00}±SD)

Resin composites	Distilled water	Coffee	Rosehip Tea	p-value
Substrate	1,73±0,37^{bcd}	2,62±0,49^{bcd}	1,11±0,68^{d}	α = 0.822
				β = 0.990
				χ = 0.089
Omnichroma	1,28±0,11^{cd}	5,74±0,79^{a}	2,88±0,34^{bc}	α = **<0.001**
				β = 0.053
				χ = **<0.001**
Zenchroma	1,21±0,72^{d}	4,99±1,31^{a}	2,16±0,64^{bcd}	α = **<0.001**
				β = 0.754
				χ = **<0.001**
Omnichroma Repair	1,06±0,60^{d}	3,00±0,69^{b}	1,54±0,28^{bcd}	α = **0.005**
				β = 0.999
				χ = 0.118
Zenchroma Repair	1,06±0,29^{d}	5,17±1,56^{a}	2,97±1,72^{b}	α = **<0.001**
				β = **0.007**
				χ = **0.001**
a-d: There is no difference between the same lower letter in Table (interaction of composite* immersion media).				
α=distilled water vs. coffee, β= distilled water vs. rosehip tea, χ= coffee vs. rosehip tea				

Discussion

Distilled water does not contain color pigments. In order to determine the color change potential of the solutions, distilled water was used as a control group. Also, internal color change of the resin material can be observed after distilled water immersion.[5,10] Coffee, distilled water, wine and tea are frequently used as staining solutions in in vitro coloration studies. These solutions have the ability to stain tooth and composite surfaces.[11,12] In the current study, the color stability values of resin composites immersed in two beverages (coffee and rosehip tea) were evaluated. The null hypothesis that there would be no difference in color stability between resin composites and beverages were rejected. The highest color change values were observed in Omnichroma groups. Also, in the previous studies[13,16] that the beverage immersion procedure was similar, Omnichroma has shown similar ΔE_{00} values on control and coffee groups with the present study.[13, 14]

According to the manufacturer, Omnichroma is pigment-free and its color characteristics are based on its structural properties and smart chromatic technology that controls the optical properties of the material.[15] The uniform spacing and arrangement of Omnichroma's spherical particles facilitate light transmission through the restoration. Thus, the composite reflects the color of the space surrounding the restoration, resulting in better blending. The translucency of Omnichroma increases after polymerization due to the difference in the refractive index of the monomers before and after polymerization.[16] Restoration repair is a minimally invasive treatment method that involves adding a new restorative material to the damaged restoration for clinical acceptability.[17] Resin composites are indicated for use as restorative repair materials. For most composite materials, proper shade selection is critical to ensure good shade matching with the surroundings. However, shade matching can be very difficult due to the polychromatic nature of teeth and the unknown shade of the defective restoration in most clinical situations.[18] The present study, Omnichroma Repair groups of the two beverages

showed lower ΔE_{00} values than Omnichroma groups. Also, the substrate groups showed lover ΔE_{00} values than Omnichroma. Despite the high color change potential of the Omnichroma surface[19], it showed lower color change in the repair groups. It was reported that Omnichroma's color parametries effected by the background.[9] The translucency of omnichroma may be the cause of this result.

The discoloration potential of resin composites is affected by factors such as the type of organic matrix, filler type, filler sizeand filler volume, degree of monomer conversion, water absorption, oral hygiene, chemical reaction, contact with coloring agents, and surface properties of the restoration.[1,20] The inorganic filler ratios of the composites used in our study are similar. (Table 1) It has been reported that the zirconium/silica filler particle-organic matrix interface can facilitate the development of water diffusion pathways within the resin composite material.[21] Omnichroma contains silicon dioxide and zirconium dioxide, while Zenchroma contains silicon dioxide as filler particle. (Table 1) It was observed that these composites showed higher ΔE_{00} values in both beverages than Clearfill, which contains barium glass and pre-polymerized organic filler. Also, in the previous studies, Omnichroma and Zenchroma has shown similar ΔE_{00} values.[14, 22] The result may be caused by filler type. The clinically acceptable value for color change in dental materials is $\Delta E_{00} \leq 1.8$.[23]

In recent years, the search for a healthy life has increased the popularity of herbal teas.[24] It is known that herbal teas are beneficial to health and their consumption is increasing.[25] Rosehip is a food with high nutritional value and is considered beneficial for human health. Rosehip fruits contain vitamins C, P, A, B1, B2, E and K. Jam, marmalade, fruit juice and tea are made from rosehip fruits. Rosehip is anti-inflammatory and contains vitamin C and lycopene. Thanks to its nutritional structure, rosehip supplements have been reported to have positive effects on some chronic diseases such as osteoarthritis, rheumatoid arthritis and cancer. [24,26] In the present study, it was observed that ΔE_{00} values in the rosehip tea groups used in our study were lower in each group, although not statistically significant.

The two beverages showed higher ΔE_{00} values than distilled water in all groups. Samples immersed in coffee solution showed a more obvious color change compared to samples immersed in rosehip tea and distilled water. This result may be due to the adsorption and absorption of yellow stains with low polarity.[27] This low polarity of yellow stain[28] can penetrate into deeper layers of resin composite[29], which is in agreement with many studies. [28, 30] There are also studies in the literature evaluating the color change of the relevant composites when kept in beverages such as black tea, red wine and cola. [13, 14, 22] In these studies also, delta E values similar to our study were found in the control groups.

One of the factors affecting the coloration in resin composites is surface conditioning procedures. Different polishing procedures were not evaluated in our study, which is one of the limitations of our study. In addition, the fact that oral factors (temperature and humidity changes, tooth brushing, etc.) were not simulated can be considered among the limitations.

Conclusion

Within the limitations of this study, it can be said that;

- coffee caused more discoloration compared to rosehip tea and distilled water,
- Omnichromaand ZenChroma exhibited lower color changes in repair groups,
- coffee caused the highest color change, especially in Omnichroma.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu makale, 24. Uluslararası Restoratif Diş Hekimliği Derneği Kongresi'nde sözlü olarak sunulan ancak tam metni yayımlanmayan "Monokromatik Kompozit Rezinlerle Yapılan Tamir Restorasyonlarının Renk Stabilitelerinin Değerlendirilmesi" adlı tebliğin içeriği geliştirilerek ve kısmen değiştirilerek üretilmiş hâlidir.

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

This article is the version of the presentation named "Evaluation of Color Stability of Monochromatic Resin Composite Restorations After Repair Procedure", which was presented orally at the 24th International Congress of the Society of Restorative Dentistry, but whose full text was not published, by improving and partially changing the content.

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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Çıkar Çatışması / Conflict of interest

Çıkar çatışması beyan edilmemiştir.

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Veri Toplanması | Data Acquisition: AS (%65), NAY (%35)
Veri Analizi | Data Analysis: NAY (%65), HEC (%35)
Makalenin Yazımı | Writing up: EÖ (%100)
Makale Gönderimi ve Revizyonu | Submission and Revision: EÖ (%100)

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