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Research Article / Araştırma Makalesi

Evaluation of color Stability of Different Restorative Materials Used in Pediatric Dentistry

Farklı Restoratif Materyallerin Renk Stabilitesinin Değerlendirilmesi

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ABSTRACT

Background: The aim of this study was to evaluate the color changes of restorative materials (Filtek z550, EverX Posterior, Dyract XP, EQUIA Forte Fill), which are frequently used in pediatric dentistry, after aging with beverages (cola, cherry juice) that children and adolescents frequently consume in their daily life.

Methods: Four different restorative materials; nanohybrid composite (Filtek z550), glass fiber reinforced bulk fill composite (EverX Posterior), polyacid modified composite resin (Dyract XP) and glass hybrid glass ionomer cement (EQUIA Forte Fill) were used. A total of 120 samples were prepared for each material using plexiglass molds with a thickness of 2 mm and a diameter of 10 mm. A total of 30 samples from each group were divided into 3 group (n=10) to be immersed in cola, cherry juice and distilled water. After the initial color measurements, the samples were stored in beverages for 7th and 14th days. Color change values (ΔE) were calculated after 7th and 14th days.

Results: When the ΔE values of materials were examined, it was observed that EQUIA Forte Fill group had the highest color change and Filtek z550 group had the lowest color change.

Conclusion: The glass hybrid GIC showed the most distinct color change in all time periods and beverages. ΔE values in cola and cherry juice of all resin-based restorative materials tested were less than or equal to 3.3. Therefore, color changes were clinically acceptable as they were not visually perceptible.

Keywords: Bulk-Fill Composite Resin, Color Stability, Glass Hybrid Glass Ionomer Cement

ÖZ

Amaç: Bu çalışmanın amacı çocuk diş hekimliğinde sıklıkla kullanılan restoratif materyallerin (Filtek z550, EverX Posterior, Dyract XP, EQUIA Forte Fill) yaşlandırılan içecekler (kola, vişne suyu) ile yaşlandırıldıktan sonra renk değişimlerinin değerlendirilmesidir. çocuklar ve ergenler günlük yaşamlarında sıklıkla tüketirler.

Gereç ve Yöntemler: Dört farklı restoratif materyal; nanohibrit kompozit (Filtek z550), cam elyaf takviyeli bulk fill kompozit (EverX Posterior), poliasit modifiye kompozit reçine (Dyract XP) ve cam hibrit cam iyonomer siman (EQUIA Forte Fill) kullanıldı. 2 mm kalınlığında ve 10 mm çapındaki pleksiglas kalıplar kullanılarak her malzeme için toplam 120 numune hazırlandı. Her gruptan toplam 30 adet örnek kola, vişne suyu ve distile su içerisine daldırılmak üzere 3 gruba (n=10) ayrıldı. İlk renk ölçümlerinden sonra örnekler 7. ve 14. gün içeceklerde saklandı. 7. ve 14. günlerden sonra renk değişim değerleri (ΔE) hesaplandı.

Bulgular: Malzemelerin ΔE değerleri incelendiğinde EQUIA Forte Fill grubunun en yüksek renk değişimine sahip olduğu, Filtek z550 grubunun ise en düşük renk değişimine sahip olduğu görülmüştür.

Sonuç: Cam hibrit GIC, tüm zaman dilimlerinde ve içeceklerde en belirgin renk değişimini göstermiştir. Test edilen tüm reçine bazlı restoratif materyallerin kola ve vişne suyundaki ΔE değerleri 3.3'e eşit veya daha düşüktü. Bu nedenle, renk değişiklikleri görsel olarak algılanamadığı için klinik olarak kabul edilebilirdi.

Anahtar Kelimeler: Bulk-Fill Kompozit Rezin, Cam Hibrit Cam İyonomer Siman, Renk Stabilitesi

Introduction

Various restorative materials are used in pediatric dentistry, especially composite resins, glass ionomer cements (GIC), polyacid modified composite resins. The clinical success of these materials depends on both functional and aesthetic results.[1] Composite resins are widely used in clinical applications due to their good aesthetic and mechanical properties and developments in bonding procedures.[2] Bulk fill composites have properties such as being applied in a single layer of 4-6 mm thickness, low polymerization shrinkage, sufficient abrasion resistance and good aesthetics.[3, 4]

GICs are also frequently used in pediatric dentistry clinics due to their positive properties such as fluorine release and good adhesion. Equia Forte Fill is a GIC in which highly reactive small glass particles of different sizes are added to conventional GICs. Thus, it is claimed that the material is more durable, long-lasting and more aesthetic.[5] Polyacid modified composite resins have been developed to overcome the negative properties of glass ionomer cements, such as technical precision, sensitivity to plaque and organic acids from food. Polyacid modified composite resins combine the high esthetics, ease of application and long working time of composite resins with the fluorine release properties of glass ionomer cements [6] and behave more like composite resins.[7]

Coloring of restorations can be due to a variety of reasons. These include the accumulation of plaque and surface stains on the tooth caused by external factors, surface or subsurface color changes, a superficial degradation or slight penetration, and reaction of staining agents within the superficial layer of resin composites.[8] The oral environment is exposed daily to environments that affect the surfaces of their restorations and potentially cause discoloration.

The aim of this research was to evaluate the color changes of restorative materials (Filtek z550, EverX Posterior, Dyract XP, EQUIA Forte Fill), which are frequently used in pediatric dentistry, after aging with beverages (cola, cherry juice) that children and adolescents frequently consume in their daily life.

The null hypothesis of this study was that storage in different beverages and duration of storage would not affect the color stability of restorative materials.

Materials and methods

In this research, four different restorative materials; nanohybrid composite (Filtek z550), glass fiber reinforced bulk fill composite (EverX Posterior), polyacid modified composite resin (Dyract XP) and glass hybrid glass ionomer cement (EQUIA Forte Fill) were evaluated. Technical profiles of restorative materials were shown in **Table 1**.

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Table 1. Materials used in this study

Materials	Manufacturer	Type	Shade	Composition
Filtek z550	3M ESPE, St. Paul, USA	Nanohybrid universal restorative	A2	Bis-GMA, Bis-EMA, PEGDMA, TEGDMA, UDMA, surface-modified zirconia/silicafillers nonagglomerated/nonaggregatedsurface-modified silica particles 20 nm
EverX Posterior	GC, Tokyo, Japan	Fiber-reinforced bulk fill composite	A2	Bis-GMA, PMMA, TEGDMA, Shot E-glass fiber filler, Barium glass
Dyract XP	Dentsply, Konstanz, Germany	Compomer	A2	UDMA, TEGDMA, Trimethacrylate resin, carboxylic acid Camphorquinone, butylated hydroxy toluene (BHT), UV stabilizer, strontium aluminosodium-fluoro-phosphor-silicate glass, highlydispersed silicon dioxide, strontiumfluoride, iron oxide and titanium dioxide pigment
EQUIA Forte Fill	GC, Tokyo, Japan	Glass hybid GIC	A2	Floro-alumino-silicate glass, Polyacrylic acid, Polyacrylic acid powder pigment, Polyacrylic acid, Distilled water, Polybasic carboxylic acid
EQUIA Forte Coat	GC, Tokyo, Japan	Light-Cured Self-Adhesive Wear Resistant Resin Coat		

A total of 120 samples, 30 for each material, were prepared using plexiglass molds with a thickness of 2 mm and a diameter of 10 mm. For EverX Posterior, Filtek z550 and Dyract XP; After placing mylarstrip on both surfaces of the plexiglass mold, restorative materials were placed by slightly overfilling. Excess material was removed by applying pressure with the glass sheet. The samples were then polymerized with an LED light curing unit (Elipar S10, 3M ESPE). For EQUIA Forte Fill; EQUIA Forte capsules mixed for 10 seconds in the capsule mixer were placed in molds using the GC capsule applicator. After the mixed cement was placed in the prepared plexiglass mold by slightly overfilling, mylarstrip was placed on both surfaces. During curing, pressure was applied with glass layer to prevent air bubble formation and to obtain a smooth surface. After the EQUIA Forte Fill samples were removed, a layer of EQUIA Forte Coat was applied to the cement surface with a micro brush and a LED light curing unit (Elipar S10, 3M ESPE) with a wavelength of 430-480 nm was polymerized.

Then, color values of the samples were made with a spectrophotometer (VITA EasyShade Compact, USA) according to CIE Lab scale. The average of the L*, a*, b* values obtained by taking three measurements from each sample was recorded. The color change value (ΔE) for each sample was calculated using the following equation.

$$\Delta E^* = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

$$\Delta E^* = [(L1^* - L0^*)^2 + (a1^* - a0^*)^2 + (b1^* - b0^*)^2]^{1/2}$$

After the initial color change measurements were completed, the samples taken from each restorative material were divided into 3 groups to be stored in cola (n=10), cherry juice (n = 10) and distilled water (control group, n = 10). All of the samples were stored at 37°C in the presence of 100% relative humidity for 14 days. After the samples removed from the beverages were washed with distilled water and dried before the measurement, color measurements were made on the 7th and 14th days.

The data were evaluated using SPSS 23.0 (Statistical Package for Social Science Version: 23) program. Since parametric test assumptions were not provided, Kruskal-Wallis test and Mann-Whitney U test were performed and $p < 0.05$ was accepted as significance level.

Results

The color change after the materials were immersed in different beverages at different times are given in **Table 2**. When the ΔE values of materials were examined, it was observed that EQUIA Forte Fill group had the highest color change and Filtek z550 group had the lowest color change.

Tablo 2. Statistical evaluation of restorative materials, color changes (ΔE) after liquid immersion at different beverages

		Cola	Cherry Juice	Distilled Water
Dyract XP	ΔE1	2.99 ± 0.53^{A,a}	2.49 ±0.32 ^{A,a}	2.38 ± 0.23 ^{A,a}
	ΔE2	3.20 ±0.46 ^{A,a}	3.22± 0.48 ^{A,b}	3.25 ± 0.36 ^{A,a}
	p value	**0.241**	**0.013***	**0.053**
EVP	ΔE1	1.51 ± 0.26^{A,a}	3.52 ± 0.21^{B,a}	1.53 ± 0.33 ^{A,a}
	ΔE2	2.04 ± 0.^{52A,b}	3.56 ± 0.^{28B,a}	1.81 ± 0.37 ^{A,a}
	p value	**0.037***	**0.610**	**0.169**
EQUIA Forte Fill	ΔE1	6.10 ± 0.38^{A,a}	12.64 ± 1.79 ^{B,a}	5.03 ± 0.67 ^{A,a}
	ΔE2	8.25 ± 0.56^{A,b}	14.46 ± 1.61 ^{B,a}	5.63 ± 0.94 ^{C,a}
	p value	**0.005***	**0.074**	**0.139**
Filtek z550	ΔE1	1.08 ± 0.31^{A,a}	1.90 ± 0.38 ^{A,a}	1.49 ± 0.51 ^{A,a}
	ΔE2	1.19 ± 0.27^{A,a}	2.26 ± 0.15 ^{A,b}	1.28 ± 0.08 ^{A,a}
	p value	**0.445**	**0.037***	**0.441**

** Different capital letters represent the statistical difference between groups in the same row. Different lowercase letters represent statistical difference between groups in the same column.*

When the ΔE1 (difference between baseline and 7th day) and ΔE2 (difference between baseline and 14th day) values of materials were examined; while a statistical difference was observed in cherry juice in Dyract XP and Filtek z550 groups, a statistical difference was observed in cola in EverX Posterior and EQUIA Forte Fill groups.

Discussion

The null hypothesis was rejected. Different levels of color change were observed after the restorative materials were stored in different beverages for 7th and 14th days.

In pediatric dentistry, the long-term color stability of restorative materials is important not because of the added costs associated with the aesthetic appearance and replacement of restorations, but also because frequent dentist visits for replacement can lead to behavioral management problems and increase dental anxiety in children.[9] Restorative materials are vulnerable to various adversities such as the acidity of different diets and beverages.[10] Frequent consumption of coloring and acidic beverages, such as cola and fruit juice, can affect color stability through the absorption and adsorption of coloring agents into the resin matrix of the restorative materials.[11, 12]

Subjective errors can be eliminated by using tools such as spectrophotometer and colorimeter to measure the color change.[13] The American Dental Association recommends the use of the CIE Lab color differential system in the evaluation of chromatic differences[14] and this system has advantages such as being very suitable for detecting small color changes, repeatability, and sensitivity.[15] Therefore, spectrophotometer and CIE Lab system were used in this study.

It has been reported that daily consumption of acidic beverages causes discoloration on both the material and the tooth surface and adversely affects the restorative materials.[16] This study evaluates the color stability of four restorative materials (Dyract XP, EverX Posterior, EQUIA Forte Fill, Filtek z550) used in pediatric dental practice after stored to different beverages commonly consumed by children and adolescents.

In the literature, it has been reported that the clinically acceptable limit of the ΔE value is 3.3.[17] According to results of our study, the highest ΔE value was observed in EQUIA Forte Fill in all beverages on the 7th and 14th days. Although EQUIA Forte Fill is a glass hybrid GIC, the total ΔE value was not acceptable under all conditions. EQUIA Forte Fill showed higher ΔE value in cola compared to cherry juice and distilled water on both 7th and 14th days. This color discoloration can be explained by the hydrolysis and surface degradation of the material as a result of exposure to acid. Because the coloration due to pigment adsorption and absorption increases with the increase of acidity of the liquids.[18] Culina et al.[19] evaluated the color stability of high viscosity glass ionomers and glass hybrid GICs and reported that the glass hybrid GIC group showed higher color change after exposure to acid than fruit juice. Baliga et al.[20] evaluated the effect of stored of resin-modified GIC and giomer materials in different beverages for 1 and 4 weeks on

color change, and observed a more significant color change in resin-modified GICs. They reported that metal polyacrylate salts were more sensitive to coloration due to their polyacid content. The more pronounced color change observed in EQUIA Forte Fill in our study can also be explained by the degradation of polyacrylate salts.

According to the findings of this research, although Dyract XP showed higher ΔE values than EverX Posterior and Filtek z550 groups, acceptable ΔE values were observed in all beverages. Mustafa et al.[21] evaluated the solubility and water absorption of a resin-modified GIC and a high-viscosity conventional GIC and they found that a resin-modified GIC showed lower solubility. The researchers reported that with the increase of the resin content, the material formed a more stable polymeric structure and thus became more resistant to solubility and water absorption. The lower resin content of compomers compared to the composite groups may cause the polymeric structure to not be fully stabilized and thus be more susceptible to coloration.

In our study, the lowest color change was observed in the Filtek z550 group in all beverages on the 7th and 14th days. Filtek z550 is a light-activated nano-hybrid composite containing Bis-GMA, TEGDMA and silica/zircon as the resin matrix. In studies, it has been reported that the presence of TEGDMA and Bis-GMA in the materials causes high hydrophilic capacity and greater sensitivity to water absorption compared to UDMA.[22] It has also been reported that a composite with large filler particles is more sensitive to discoloration than a composite with small filler particles.[23] Ertaş et al.[24] evaluated the color changes of nano and microhybrid composites after being stored in different beverages and they reported that smaller particles were shaved and smaller gaps remained on the surface in nanohybrid composites compared to microhybrid composites. Therefore, with this advantage, nanohybrid composites became more resistant to coloration. This explains why the Filtek z550 group showed lower discoloration and liquid absorption compared to all other composites in our study.

EverX Posterior bulk fill composite showed a similar ΔE value compared to the Filtek z550 group on 7th day, but showed a more disticnt color change in cherry juice on 14th day. Although the resin matrix content of EverX Posterior bulk fill composite is similar to nano-micro composites, the absence of hydrophobic monomers such as UDMA may be the reason why it is more susceptible to water absorption and color change. In addition, the glass filler particles contained in EverX Posterior cannot absorb water into the mass of the composite resin, it only affect water adsorption on the surfaces of the material.[25] Karadaş et al.[26] evaluated the color stability of bulk-fill and nano-hybrid composites and reported that nanohybrid composites contain nano sized filler particles, thus increasing the hydrolytic stability and durability of the restorative material.

Conclusion

In line with the limitations of this study;

- Color beverage affected the color of restorative materials,
- Resin-based materials were more resistant to color change than GIC.
- The glass hybrid GIC showed the most distinct color change in all time periods and beverages.
- ΔE values in cola and cherry juice of all resin-based restorative materials tested were less than or equal to 3.3. Therefore, color changes were clinically acceptable as they were not visually perceptible.

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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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: İİ (%60), BKE (%40)
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Veri Analizi | Data Analysis: İİ (%100)
Makalenin Yazımı | Writing up: İİ (%60), BKE (%40)
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