The Effects of Children's Drinks on the Color Stability of Various Restorative Materials

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Objective: *To evaluate the effects of exposure to various children's drinks on the color stability of different esthetic restorative material commonly used in pediatric dentistry.* ***Study Design***: *Cylindrical specimens (15x2mm) were prepared from four different restorative materials (Fuji IX, Fuji II LC, Dyract Extra, and Filtek Z250). For each material, 20 specimens were prepared and divided into four groups. Each group was stored in a different solution (distilled water, chocolate milk, cola, grape juice) for 24 hours. A colorimeter was used to measure the color of each specimen both before and after staining. Color change (ΔE*) was calculated, and data was analyzed using two-way ANOVA and Tukey HSD tests.* ***Results***: *For all restorative materials, the lowest ΔE* values were recorded for specimens stored in distilled water (0.42), followed by chocolate milk (0.88), grape juice (3.45) and cola (3.97). Among the four restorative materials tested, Fuji II LC showed the most color change (3.71) and Fuji IX the least (1.33). There were statistically significant differences among above groups (p<0.05).* ***Conclusions***: *ΔE* values were acceptable for all materials tested, with the exception of Fuji II LC. Therefore, the use of RMGIC should be avoided in anterior restorations in children due to esthetic reasons.*

Keywords: *Color stability, Drink, Restorative material*
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INTRODUCTION

A variety of esthetic restorative materials are available to restore anterior teeth in pediatric dentistry. These include glass ionomer cements (GICs), resin-modified glass ionomer cements (RMGICs), polyacid-modified resin composites (compomers) (PMRCs) and composite resins.[1,2] GICs are thought to possess cariostatic properties related to their sustained fluoride release and long-term adhesion to tooth structure;[3-5] however, they are less esthetic than resin-based materials and show poor abrasion and fracture resistance. In order to overcome these disadvantages, RMGICs were developed.[6] RMGICs consist of the same components as conventional GICs, but with the addition of resin for improved strength and esthetics.[5] PMRCs are closely related to composite resins, but have a higher fluoride release than composite resins.[5] Composites resins are highly esthetic, fracture- and wear-resistant and shrink on setting.[5] In terms of esthetics, composite resins are considered to have the advantage over other restorative materials.[7]

Color stability is one of the most important criteria related to esthetics.[8-10] Both intrinsic and extrinsic factors may be implicated in the discoloration of restorative material.[9,11] Although many studies have evaluated the role of common adult drinks on the staining of esthetic restorative material,[7,11-15] there is little information available about the effects of common children's drinks.[9,10,16,17] The aim of this study was to evaluate the influence of exposure to various children's drinks on the color stability of four types of esthetic restorative material commonly used in pediatric dentistry. The hypothesis for this study was that color stability of the esthetic restorative materials is related to type of the materials, and the type of staining solution.

MATERIAL AND METHODS

Staining agents and restorative materials

Four different solutions [distilled water (W), chocolate milk (CM), cola (C) and grape juice (GJ)] and four different restorative materials [Fuji IX, a glass-ionomer cement (GIC); Fuji II LC, a resin-modified glass-ionomer cement (RMGIC); Dyract Extra, a polyacid-modified resin

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Table 1. Materials used in the study.

Product	Material Type	Manufacturer
Fuji IX	Glass-ionomer cement	GC Corp, Tokyo, Japan
Fuji II LC	Resin-modified glass-ionomer cement	GC Corp, Tokyo, Japan
Dyract Extra	Polyacid-modified resin composite	Dentsply DeTrey GmbH, Germany
Filtek Z250	Composite resin	3M/ESPE, St. Paul, MN, USA
Cola	Soft drink	The Coca-Cola Co, Istanbul, Turkey
Chocolate milk	Milk	Danone, Istanbul, Turkey
Grape juice	Fruit juice	Dimes, Istanbul, Turkey

composite (PMRC); and Filtek Z250, a composite resin] were used in the study (Table 1).

Specimen preparation

For each restorative material, 20 cylindrical specimens (15x2mm) were prepared using a brass mold. Materials were dispended, manipulated and polymerized according to the manufacturers' instructions except for Fuji IX. Light-polymerized specimens were polymerized for 20 seconds using a LED (Elipar Free Light II, 3M/ESPE, St. Paul, MN, USA; light intensity:1000mV/cm^2) and then irradiated for eight peripheral over lapping sectors for 10 sec each, with the light tip held approximately 1mm from the specimens. Fuji IX specimens were left for 5 min to set. Specimen surfaces were standardized by wet-grinding using a 300-rpm grinding machine (Buehler, Dusseldorf, Germany) and 600-, 800- and 1000-grit silicon carbide abrasive paper for 10 seconds each. Specimens were then rehydrated by storing in distilled water at 37°C for 24 hours in order to simulate the oral environment.[18,19] Following rehydration, specimens of each of the four restorative materials were distributed into 4 groups (n=5) and immersed in one of the four solutions (W, MC, C, GJ) for 24 hours at room temperature. Specimens were then rinsed with distilled water for 5 minutes and blotted dry with tissue paper.

Color change measurement

Specimen color was measured using a colorimeter (Minolta CR-300; Minolta Co, Osaka, Japan) before (baseline) and after exposure to staining agents. Since only differences in color were being tested, the choice of illuminant was not a factor. Prior to measurement, the colorimeter was calibrated according to the manufacturer's recommendations using the white calibration standard provided. Measurements were taken using the *Commission International de l'Eclairage* (CIE) $L^*a^*b^*$ system, which measures color relative to a standard illuminant (A) against a white background. L^* represents the lightness coordinate, with values ranging from 0 (black) to 100 (white); a^* and b^* represent chromaticity coordinates along a red-green and a yellow-blue axis, respectively, with positive a^* values indicating a shift to red, negative a^* values indicating a shift to green, positive b^* values indicating a shift to yellow and negative b^* values indicating a shift to blue. Measurements were repeated 3 times for each specimen, and the mean L^*, a^* and b^* values were calculated. Color change (ΔE^*) was calculated using the following equation:[20] $\Delta E^* = [(L_1^* - L_0^*)^2 + (a_1^* - a_0^*)^2 + (b_1^* - b_0^*)^2]^{1/2}$

Statistical analysis

Two-way analysis of variance (ANOVA) was used to calculate the effects of material, staining agent and the interaction between the two on color change. Comparison of means was performed using Tukey's HSD test (α=.05). All statistical analysis was performed using the statistical software SPSS for Windows, Version 12.0.1 (SPSS Inc, Chicago, Ill).

RESULTS

Two-way ANOVA showed the effects of restorative materials, staining agents and their interaction to be statistically significant (p=.0001) (Table 2). Mean color change values and standard deviations and differences between groups for GIC, RMGIC, PMRC and composite resin are given in Table 3.

Table 2. Two-way ANOVA for restorative materials and staining agents.

Variable (source)	Df	Sum of squares	Mean Squares	F	Probability
Staining agent	3	191.624	63.875	730.712	.0001*
Material	3	67.267	22.422	256.506	.0001*
Interaction	9	47.405	5.267	60.256	.0001*
Error	64	5.595	.087		

Df, Degrees of freedom.
*Significantly different at p<0.05.

Table 3. Color changes from restorative materials (mean and s.d.)

Groups	ΔE* (Fuji IX)	ΔE* (Fuji II LC)	ΔE* (Dyract Extra)	*ΔE* (Z250)*
Group W	0.5 (0.3)a,1	0.5 (0.2)a,1	0.4 (0.2)a,1	*0.4 (0.1)a,1*
Group CM	0.6 (0.2)a,1	1.5 (0.1)b,2	0.6 (0.3)a,1	*0.9 (0.9)b,1*
Group C	2.9 (0.4)b,1	6.7 (0.5)c,3	3.7 (0.3)b,2	*2.7 (0.3)c,1*
Group GJ	*1.4 (0.2)c,1*	*6.1 (0.6)c,4*	*3.6 (0.2)b,3*	2.6 (0.2)c,2

W, Distilled water; CM, Chocolate Milk; C, Coca-cola; GJ, Grape juice.
* Differences in superscript letters indicate statistically significant differences within columns, and differences in superscript numbers indicate significant differences within rows ($p<0.05$) (1, a= Best Values)

Among the solutions tested, the highest mean ΔE* for all the restorative materials tested was seen with cola, followed by grape juice, chocolate milk and distilled water. Significant variations in ΔE* values were observed among the four different restorative materials tested ($p<0.05$), with GIC (Fuji IX) demonstrating significantly less color change than the other materials and RMGIC (Fuji II LC). Differences in color change caused by distilled water and chocolate milk were significant for the RMGIC and composite resin groups, and differences in color change caused by cola and grape juice were significant for the GIC group ($p<0.05$).

DISCUSSION

In pediatric dentistry, long term color stability of restorative materials is important not only because of esthetics and the additional costs associated with replacement of restorations, but because the multiple visits needed for replacement might lead to behavior management problems and increase dental anxiety in children.[8]

Staining of oral tissues and restorations is known to be affected by dietary factors. Consumption of soft drinks is known to have increased in recent years, and is especially high among younger individuals. Other drinks frequently consumed by children include fruit juices and milk, which may include aromatic substances such as chocolate, banana and strawberry flavorings added to encourage consumption among children. Many studies have evaluated the effects of cola on the color stability of restorative materials;[9,10,16,17] however, the effects of chocolate milk and grape juice has not been reported. Therefore, the present study measured the stability of GIC, RMGIC, PMRC and composite resin after exposure to various children's drinks (chocolate milk, cola and grape juice).

Spectrophotometry and colorimetry have both been used to measure color change in dental materials.[21-23] For this study, the CIE L*a*b* system was chosen to measure differences because of its ability to detect small differences in color.[24]

Measurements of reflective surfaces are affected by both the actual color of the material surface and the lighting conditions under which it is measured. In the present study, a standard illuminant (A) was used against a white background. Since color differences were being tested, the choice of the illuminant was not important. Color measurement is also affected by the thickness and smoothness of the specimen surface.[25] In the present study, all specimens were uniformly prepared to a thickness of 2 mm. However, because this study measured the change in color between 2 points in time (baseline and after 24-hour exposure to staining solutions), the thickness of the specimens was not important.

The present study found a GIC (Fuji IX) to be the most resistant to staining, followed by a composite resin (Filtek Z250), a PMRC (Dyract Extra) and an RMGIC (Fuji II LC). This result is in agreement with previous studies which found that conventional GIC has greater color stability than RMGIC and PMRC.[7,8]

Differences in color stability among restorative materials can be ascribed in part to the size of the colorant particle and the constituents of the restorative material (water and monomer). Discoloration may be related to both surface adsorption and absorption of colorants. Fine colorant particles may be deposited into the pits of the light-polymerized restorative materials.[24] Water content of restorative materials is another determining factor in color stability. It has been suggested that the higher water content of conventional GIC when compared to RMGIC allows the former to absorb less water, making it less susceptible to staining.[7] Previous studies[26,27] have shown the higher water sorption of RMGIC in comparison to conventional GIC to be due to the rapid water sorption of HEMA, a significant resin component found in RMGICs. It has also been suggested that materials containing hydrophobic monomers, such as composite resin, are more stain-resistant than materials containing hydrophilic monomers, such as RMGICs.[8]

The staining potential of drinks and solutions vary according to their composition and other characteristics.[7,12] In the present study, for all the restorative materials tested, the greatest changes in color were observed following immersion in cola, followed by grape juice, chocolate milk and distilled water. These findings may be explained by the differences in acidity among these drinks, which have pHs of 3.0 (cola), 4.2 (grape juice) and 6.9 (chocolate milk). The acidic pH of cola and grape juice may have had an effect on the structure of the restorative materials tested.

This study considered color change values (ΔE) ranging from 2.2 to 4.4 to be clinically acceptable. A limit of $\Delta E^* \leq 3.3$ has been interpreted as a clinically acceptable color change by many studies.[28-30] In the present study, all restorative materials except for the Fuji II LC (RMGIC) had changes below this limit, so their changes were considered minimal. Each immersion solution were taken into account for ΔE values, color change values for Fuji II LC (RMGIC) and for Dyract Extra (PMRC) following immersion in cola and grape juice were considered visually perceptible as well as clinically unacceptable ($\Delta E^* > 3.3$).

The present study has certain limitations, namely, it does not simulate the role of saliva or oral clearances in retarding the long-term build-up of stains in the oral environment. Saliva dilutes the concentration of the ingested beverages, often functioning as a buffer for the beverage's pH. In contrast to the oral environment, where solutions are mixed with saliva, which dilutes their concentration and changes their pH, in the present study, samples remained in contact with undiluted staining solutions for 24 hours.

CONCLUSIONS

Within the limits of this study, the following conclusions were drawn:

1. The degree of color change in the restorative materials tested varied according to the children' drink to which they were exposed.
2. For all materials, exposure to cola and grape juice resulted in significantly higher rates of color change than exposure to chocolate milk and distilled water.
3. Fuji IX showed the most resistance to staining, and Fuji II LC showed the least resistance.

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