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Original Article

The effect of cold drinks on the coloration of resin-containing restorative materials

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Abstract

Aim: Resin-containing restorative materials are widely used in the restoration of teeth. Our aim in this study is to examine the color change of beverages consumed cold on resin-containing restorative materials.
Methodology: Samples were prepared using composite resins and resin-based CAD/CAM blocks. All prepared samples were kept in cold tea, cold coffee, coke, energy drink, and distilled water after polishing. The color values of the samples were measured with a spectrophotometer at the beginning, on the 1st, 7th and 30th days, and the color change values were calculated with the CIEDE2000 formula. Statistical analysis of color change values was performed using two-way analysis of variance (ANOVA) and Tukey multiple comparison tests ($p<0.05$).
Results: While there was no statistically significant difference in the color changes of the resin-containing dental materials at the end of the 1st day ($p>0.05$), at the end of the 7th and 30th days, cold tea caused the statistically highest color change ($p<0.05$). There was no statistically significant difference between the color change values of cold coffee, coke and energy drink on the materials in all time periods ($p>0.05$). Composite resins showed more color change than resin-based CAD/CAM blocks ($p<0.05$).
Conclusion: Cold tea causes the most discoloration on resin-based materials. While the resin-containing CAD/CAM blocks showed a color change under the AT value in all cold drinks, the composite resins showed a color change above the AT value in cold tea and coffee.

Keywords: CAD/CAM, composite resin, color change, cold drinks

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Introduction

In recent years, resin-containing restorative materials have been widely used by dentists to meet the aesthetic expectations of individuals, as they easily adapt to tooth color and meet the aesthetic expectations of individuals.

Resin-containing restorative materials can be used in the restoration of teeth with direct and indirect methods. Composite resins used as direct restorative materials today consist of nano-fillers (nanomers) and nanomer groups (nanoclusters) (1). It is stated that composite resins containing nano-fillers have a chameleon effect and provide a more effective color match with tooth tissues (2).

Depending on the developments in computer-aided design and manufacturing (CAD / CAM) technology, resin-containing CAD / CAM blocks have been introduced to the market. While these materials, which are used by indirect methods, are advantageous because of the advantageous properties of ceramics, such as durability and color stability, and superior physical properties of composite resins, such as improved bending and low abrasiveness (3), the fact that composite resin formulations have a much higher potential to be stained than ceramic due to temperature changes in the oral environment and coloring beverages, can also be seen as a disadvantage (4).

The color stability of the materials used in the restoration of teeth is seen as an important factor in ensuring the aesthetic expectation of the patients and in the success of the restorations. Undesired color changes in composite resins have been associated with water absorption, chemical reaction, diet, poor oral hygiene, and surface roughness of restoration (5,6). It is stated that the composition of the composite resin material and the properties of the particles that make up the resin composite, as well as the polishing and polishing procedures, have a direct effect on color sensitivity to external factors (7). In many studies, it has been reported that beverages such as coffee, tea, coke, and red wine cause different degrees of coloration on the surfaces of resin containing restorative materials (8,9). However, nowadays, with the developments in the ready-made food sector, it has become more common to consume these beverages as cold.

According to the Commission Internationale De L'éclairage (CIE) organization, instrumental techniques such as spectrophotometers, colorimeters or digital cameras are used to evaluate color changes in dental materials (10). Spectrophotometers measure the amount and spectral composition of light reflected from the object and convert them into measurable data. Value (L*) indicates the lightness-darkness of the color. a* is a measurement of redness or greenness, while b* is a measurement of yellowness or blueness (11). In the CIEDE2000 system, perceptibility threshold values (PT) are specified as $\Delta E_{00}>0.8$ and the acceptability threshold value (AT) as $\Delta E_{00}\leq 1.8$ (12).

Studies examining the effect of color change caused by cold drinks on restorative materials containing resin, which are widely used in the restoration of teeth, are limited. The aim of our study is to examine the possible effects of different beverages consumed cold on the color change of resin-containing restorative materials. Our null hypothesis is that beverages consumed cold will not change color on resin-containing restorative materials.

Materials and Methods

1. Preparation of samples

In our study, GrandioSO (Voco GmbH, Germany) and Estelite Sigma Quick (Tokuyama, Japan) composite resin and resin containing Brilliant Crios (Coltene, Switzerland) and Vita Enamic (Vita, Germany) CAD/CAM block were used (Table 1). Samples of 8×2 mm dimensions were prepared using silicon mold from the composite resin materials planned to be used in the study. In the preparation of the samples, composite resins were placed in the cavity on the silicone mold with a mouth spatula, and a 1 mm glass (coverslip) was placed on the mylar strip. Composite resin samples were polymerized for 20 seconds using a power of 1000 mW/cm^2, with the tip of the LED light device (DTE LUX E, Germany) in contact with the glass lamella.

Samples to be obtained by using resin-containing CAD/CAM blocks were prepared with a precision sectioning device (MICRACUT 201, Bursa, Turkey) with the dimensions of 12×7×2 mm under water cooling. A total of 160 samples were prepared, as 40 samples from each material. In the polishing process of the samples prepared with resin-containing materials, both surfaces were polished using a diamond polishing kit (Clearfil Twist Dia, Kuraray, Japan). Polishing was done under water cooling at 10.000 rpm for 20 seconds for all samples. After polishing, all samples were cleaned with deionized water for 10 seconds with an ultrasonic cleaning device (Pro-Sonic 600; Sultan Healthcare, New Jersey). The cleaned samples were held in distilled water at 37° C for 24 hours.

2. Color measurements

The initial color values of the samples prepared with composite resin and resin-based CAD/CAM blocks were measured under D65 lighting conditions using a spectrophotometer (Vita Easy Shade Advance, Germany). Then, the samples were divided into five groups (n:8) as cold coffee, cold tea, coke, energy drink, and distilled water. For time-dependent color change analysis of samples, they were inserted in cold coffee (Nescafe Xpress cold coffee, Turkey), cold tea (Lipton Ice Tea, Turkey), coke (Coca-Cola, Turkey), energy drink (Red Bull, Austria), and distilled water (control group). The beverages that were subjected to the study were added to the samples at +4 °C, and each beverage was replaced with a new one at the end of the 24-hour period. All samples were stored in an oven at 37 °C for 30 days.

The color values of the samples used in the study on the 1st, 7th and 30th days were measured under D65 lighting conditions using the same spectrophotometer device. Measurements were repeated three times for each sample, and the average values were recorded. The formula (ΔE_{00}) in the CIEDE2000 formula was used over the L*, a*, and b* parameters to calculate the color changes in the resin-containing restorative samples (13).

Table 1. Materials used and manufacturer information

Material	Material Type	Content	Manufacturer	Lot Number
GrandioSO	Nano Hybrid Composite	Glass-ceramic filler with an average particle size of 1 µm Functionalized silicon dioxide nanoparticles with a size of 20-40 nm Pigments (iron oxide, titanium dioxide)	Voco, Germany	2005147
Estelite Sigma Quick	Supranano Hybrid Composite	It has a filler (silica-zirconium) ratio of 82% by weight and 71% by volume. Bis-GMA, TEGDMA	Tokuyama, Tokyo, Japan	108E67
Brilliant Crios	Resin-Based (Composite)	%70.7 Amorphous silica (<20nm), barium glass (<1 µm) %29.3 Cross-linked methacrylate matrix (Bis-GMA, Bis-EMA, TEGDMA)	Coltene, Switzerland	I28711
Vita Enamic	Cad/Cam PINC Material	%86 Feldspathic porcelain, SiO_2 (%58-63), Al_2O_3(%20-23), Na_2O (%6-11), K_2O (%4-6)%14 Polymer (UDMA, TEGDMA)	VITA Zahnfabrik, Bad Sackingen, Germany	63460

Statistical analysis

Statistical data analysis was performed using SPSS 22.0 Statistical Program (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) and Tukey multiple comparison tests were used to evaluate the color change values of CAD/CAM materials and composite resins exposed to different beverages on days 1, 7, and 30 ($p < 0.05$).

Results

In our study, while there was no statistically significant difference between the color change values of resin-containing restorative materials kept in cold drinks at the end of the first day ($p<0.05$), statistically significant differences were observed between the color change values of the resin-containing restorative materials ($p<0.05$) at the end of the 7th and 30th days (Table 2, 3, 4). While cold tea caused the most color change on resin-containing dental materials at the end of the 7th and 30th days ($p<0.05$), there was no statistically significant difference between the color change values of other beverages ($p>0.05$).

Although all samples produced less color change in distilled water compared to cold tea at the end of the 7th and 30th days, no statistically significant difference was observed between cold coffee, coke, and energy drinks in terms of color change ($p>0.05$).

Table 2. Examination of the color change (ΔE_{00}) of CAD/CAM materials at the end of the 1st day.

Material/Beverage	GrandioSO (ΔE_{00}±SD)	Estelite Sigma Quick (ΔE_{00}±SD)	Brilliant Crios (ΔE_{00}±SD)	Vita Enamic (ΔE_{00}±SD)
Coffee	0.5±0.1[a]	0.6±0.2[a]	0.3±0.1[a]	0.3±0.1[a]
Tea	0.7±0.2[a]	0.7±0.2[a]	0.5±0.2[a]	0.4±0.2[a]
Coke	0.5±0.1[a]	0.4±0.1[a]	0.4±0.1[a]	0.4±0.2[a]
Energy drink	0.5±0.2[a]	0.6±0.1[a]	0.3±0.2[a]	0.3±0.2[a]
Distilled water	0.4±0.2[a]	0.4±0.1[a]	0.3±0.2[a]	0.2±0.1[a]
p	0.046	0.256	0.399	0.111

* The limit of significance $p<0.05$

Table 3. Examination of the color change (ΔE_{00}) of CAD/CAM materials at the end of the 7th day.

Material/Beverage	GrandioSO (ΔE_{00}±SD)	Estelite Sigma Quick (ΔE_{00}±SD)	Brilliant Crios (ΔE_{00}±SD)	Vita Enamic (ΔE_{00}±SD)	p
Coffee	$1.3±0.2^{a.A}$	$1.2±0.1^{a.A}$	$0.6±0.2^{a.B}$	$0.6±0.1^{a.B}$	0.000
Tea	$1.9±0.3^{b.A}$	$1.8±0.4^{b.A}$	$1.4±0.^{3b.B}$	$1.1±0.3^{b.B}$	0.000
Coke	$1.1±0.3^{a.A}$	$1.1±0.2^{a.A}$	$0.7±0.2^{a.B}$	$0.6±0.2^{a.B}$	0.000
Energy drink	$1.2±0.2^{a.A}$	$1.1±0.1^{a.A}$	$0.7±0.2^{a.B}$	$0.6±0.2^{a.B}$	0.000
Distilled water	$0.8±0.3^{a.A}$	$0.7±0.1^{b.A}$	$0.4±0.1^{a.B}$	$0.4±0.1^{a.B}$	0.000
p	0.000	0.000	0.000	0.000	0.000

* The limit of significance between lines (a-b) and between columns (A-B). $p<0.05$

Table 4. Examination of the color change (ΔE_{00}) of CAD/CAM materials at the end of the 30th day.

Material/Beverage	GrandioSO (ΔE_{00}±SD)	Estelite Sigma Quick (ΔE_{00}±SD)	Brilliant Crios (ΔE_{00}±SD)	Vita Enamic (ΔE_{00}±SD)	p
Coffee	$2.0±0.2^{a.A}$	$1.9±0.3^{a.A}$	$0.8±0.1^{a.B}$	$0.7±0.1^{a.B}$	0.000
Tea	$2.5±0.2^{b.A}$	$2.4±0.3^{b.A}$	$1.7±0.2^{b.B}$	$1.5±0.3^{b.B}$	0.000
Coke	$1.5±0.3^{a.A}$	$1.4±0.2^{a.A}$	$0.8±0.1^{a.B}$	$0.7±0.2^{a.B}$	0.000
Energy drink	$1.7±0.3^{a.A}$	$1.5±0.2^{a.A}$	$0.8±0.2^{a.B}$	$0.7±0.2^{a.B}$	0.000
Distilled water	$1.0±0.3^{c.A}$	$0.9±0.3^{c.A}$	$0.5±0.1^{a.B}$	$0.4±0.1^{a.B}$	0.000
p	0.000	0.000	0.000	0.000	0.000

* The limit of significance between lines (a-c) and between columns (A-B). $p<0.05$

Cold beverages showed the least color change on the samples prepared with resin-containing CAD/CAM blocks (Brilliant Crios and Vita Enamic) at the end of 1st, 7th and 30th days, and the most color change on composite resin-based samples (GrandioSO and Estelite Sigma Quick). However, when the samples prepared from resin-containing CAD/CAM blocks were evaluated in terms of color change effect values, there was no statistically significant difference ($p>0.05$).

While composite resin samples (GrandioSO and Estelite Sigma Quick) showed a color change under the AT (acceptability) value in coke, energy drink and distilled water at the end of the 30th day, they showed a color change over the AT value in tea and coffee. Resin-containing CAD/CAM blocks (Brilliant Crios and Vita Enamic) showed color change below the AT value at the end of the 30th day (Fig. 1).

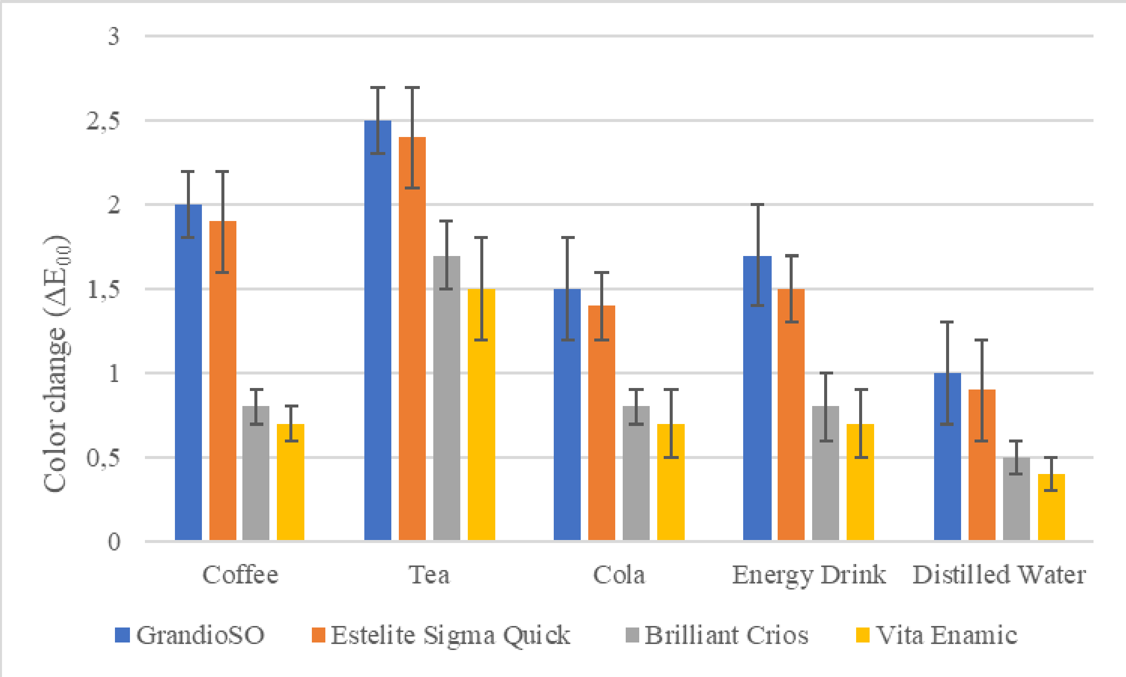

Figure 1. Examination of the color change (ΔE_{00}) of CAD/CAM materials at the end of the 30th day.

Discussion

Dental restorative materials can be exposed to color changes that may affect their aesthetic properties with the consumption of various foods and beverages that we use in our daily life (14). These unpredictable discolorations and susceptibility to staining have been one of the main reasons for the replacement of esthetic restorations.

It has been revealed that beverages with different contents are one of the factors affecting the color stability of dental restorative materials. It has been shown that complex events occurring in the oral cavity cause changes over a period of time in the color of the material used to restore the tooth (15). In terms of beverages that individuals commonly consume daily, and in studies examining the coloration of these beverages, especially anterior region restorations, it was observed that distilled water, coke, coffee and red wine were generally used (16). However, studies examining the effects of the habits of individuals using cold beverages in summer on restorative materials are limited in the literature. In our study, coke, cold coffee, cold tea, energy drink and distilled water were used, and our null hypothesis was rejected according to the result of the color change of the cold drinks on the resin-containing materials.

In recent years, spectrophotometer is widely used in measuring tooth color. In many studies, it is stated that spectrophotometers give more reliable results than calorimeters because they are not affected by object metamerism (17). It is stated in the literature that the clinical spectrophotometer device Vita Easy Shade V can be used safely (18). Therefore, in our study, the clinical spectrophotometer device (Vita Easyshade V) was used to measure the color of the samples in base shade mode.

CIELAB is calculated with the formula ΔE_{ab} using the color change values L*, a*, b* in the materials. In 2001, a new formula CIEDE2000 (ΔE_{00}) updated by CIE was introduced. (13) The CIEDE2000 formula was preferred in our study as Gómez-Polo et al stated in their study that CIEDE2000 (ΔE_{00}) formula was more sensitive in measuring color changes than the CIELAB (ΔE_{ab}) formula (19).

It is stated that color changes in the dental materials are related to many factors, both internal and external (20). Although it is stated that beverages taken with daily diet may show different color changes on dental materials, it is stated that red wine, coffee and tea constitute the most color change (9). The fact that coffee contains yellow coloring pigment is effective in the color change of composite resins (21). Tea caused the most color change on all composite resins in our study.

In the study of Malekepour et al. (22) in which they evaluated the coloring effect of coffee, tea, coke, distilled water, and lemonade on the 1st, 7th, and 14th days with micro-hybrid composite resin materials (Z100 3M ESPE, A2 shade, USA), the color change values between coffee and tea beverages were similar to each other after 14 days of immersion. This situation was similar to another study examining the effect of tea on coloration (23). As seen in the literature, the coloration effect of tea can be considered as a result of the chemical interaction of the denatured materials and tannins it contains (24). It has also been reported that the coloring feature of coffee is related to the easy absorption of the colorant particles in its structure (25). Our study supports this study, and after 30 days of immersion, a statistically significant difference was observed in the coloring of cold tea compared to other beverages.

The coloring ability of tea may depend on the presence of tannic acid (24). According to studies, it is believed that the presence of citric acid in coke may have a significant effect on the decomposition of composite resins and that the wear mechanisms of dental composite restorations are accelerated by chemical softening (26). However, the lack of yellow coloring material contained in cola may be the reason why it does not produce many colorations compared to tea (27).

In the coloration study conducted by Quek et al. using coke, tea, coffee, red wine, and distilled water, it has been found that resin-based CAD/CAM blocks (Shofu HC Block, Lava Ultimate, Vita Enamic) cause less coloration compared to direct (Filtek Z350XT) and indirect (Shofu Ceramage) composite resin materials (28). The cold drinks we used in our study showed less coloration on resin-based CAD/CAM blocks than direct composite resins.

Along with studies showing that the degree of coloration of composite resin materials is affected by various factors such as insufficient polymerization, water absorption, chemical reactivity, diet, oral hygiene, and surface roughness of the restoration (23), there are also studies available that associate the color change of dental composite resin restorations mainly with the organic part of the materials (8). By evaluating these obtained data, CAD/CAM resin-based or PICN (polymer infiltrated ceramic network) materials with reduced organic phase have been introduced to the market. Resin-containing CAD/CAM blocks showed higher staining resistance properties in all painting solutions compared to direct composite resin materials. The results obtained in the studies are that the processing procedure used for the production and polymerization of CAD/CAM blocks makes them more resistant to staining (29, 30). In our study, the coloration values of CAD/CAM blocks were lower than direct composite resin materials, supporting this situation.

As a result of the increase in the amount of resin contained in dental materials, the amount of water absorption increases, creating hydrolytic degradation in the material. Substances separated from the structure of the material by hydrolytic degradation can cause physical and optical properties to change (31).

In addition, as Bis-GMA causes rigid network formation, it is stated that composites whose main monomer content is Bis-GMA shows less water absorption than composites containing TEGDMA and more than composites containing UDMA and Bis-EMA (32). Despite the presence of TEGDMA and Bis-GMA in the organic matrix of the composite resins, we used in our study, nanohybrid composite resin materials (GrandioSO) were more colored than supranano composite resin (Estelite Sigma Quick). The composition and size of the filler particles is an important factor affecting the surface roughness of composite resins and is therefore related to extrinsic coloration. Therefore, it is expected that a smoother surface and less surface discoloration will occur in composite resins with relatively small particle sizes (20). In the study of Güler et al., nanohybrid resins were less colored than other composite resins (33). In our study, the supranano composite resin was less colored than the nanohybrid composite resin, which supports the effect of particle size on coloration.

Perceptibility threshold (PT) and acceptability threshold (AT), which are important factors for evaluating the color stability of dental materials, are indicated in the literature as 50:50% PT ΔE_{00}:0.8 and 50:50% AT ΔE_{00}:1.8 (12). Studies show that hot tea and coffee show a color change over the AT value on composite resins. In our study, cold tea and coffee also caused the composite resins to show a color change over the AT value (34).

Aydın et al. stated in their study that resin-containing CAD/CAM blocks showed a color change over the AT value with hot tea and hot coffee, while coke, energy drink and distilled water showed a color change under the AT value (9). In our study, the color change on the resin-based CAD/CAM blocks remained below the AT value with cold tea, cold coffee, coke, energy drink and distilled water.

In addition to the beverages tested in this study, the restorative materials used in the mouth encounter saliva containing various proteins and enzymes, different oral hygiene habits, smoking, and functional or parafunctional forces. It should be noted that the factors affecting the color change may vary from person to person. Therefore, it would be beneficial to conduct clinical studies in order to fully understand the effects of cold drinks on restorative materials.

Conclusions

1. The color change on the resin-containing restorative materials of cold drinks showed a statistically significant difference after the 7th day.
2. Cold tea caused more discoloration on resin-containing restorative materials than cold coffee, coke and energy drink.
3. Cold drinks caused less color change on resin-containing CAD/CAM blocks than composite resins.
4. Cold tea and coffee caused the composite resins to show a color change over the AT value.
5. All cold drinks produced a color change on the resin-containing CAD/CAM blocks under the AT value.

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