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Research Araştırma

The Effect Of Some Traditional Beverages On The Colour Stability Of The Resin Nanoceramic Material

Bazı Geleneksel İçeceklerin Rezin Nano Seramik Materyalinin Renk Stabilitesi Üzerindeki Etkisinin İncelenmesi

ABSTRACT

Objective: The aim of this study was to analyse the colouring effect of traditional Turkish beverages, which are frequently consumed in our society, on CAD/CAM resin nano ceramic block Material.

Materials and Method: A total of 20 samples were used resin nanoceramic CAD/CAM blocks (Cerasmart.GC Corporation, Tokyo, Japan) with dimensions of 12x10x2 mm3 . The surfaces of all samples were polished with 800, 1000 and 1200 grit silicon carbide abrasives (3M, St. Paul, USA) and rinsed. The specimens were randomly divided into 4 groups (n=5). The initial color values and time dependent color changes of the samples on 1st, 3rd and 7th days were recorded using a dental spectrophotometer (VITA Easyshade Advance 4.0, Vita Zahnfabrik, Germany). Statistical data were analysed using with the R WRS2 package (Wilcox & Schönbrodt, 2015). Significance level was taken as $p<0.050$.

Results: The samples kept in all solutions did not exceed the clinically discolouration ($\Delta E^*< 3.3$) at the end of 72 hours. After 1 week, the most colour change in the samples was detected in tea ($\Delta E^*= 4{,}40$), while no significant difference was found between the other groups ($\Delta E^*= 2{,}08$ - $1{,}02$). The colour changes in the samples were ranked as distilled water < turnip juice < Turkish coffee < tea.

Conclusion: After 1 week of immersion, the colour stability of Cerasmart resin nanoceramic block material was clinically affected by tea, while no noticeable colour change occurred in the other groups.

Key Words: CAD/CAM, Resin Nano Ceramics, Traditional Beverages.

ÖZ

Amaç: Bu çalışmanın amacı, toplumumuzda sıklıkla tüketilen geleneksel Türk içeceklerinin CAD/CAM rezin nano seramik blok materyali üzerindeki renklendirme etkisini analiz etmektir.

Gereç ve Yöntemler: Toplam 20 örnek, 12x10x2 mm3 boyutlarında rezin nanoseramik CAD/CAM bloklardan (Cerasmart.GC Corporation, Tokyo, Japonya) kesilerek elde edildi. Tüm örneklerin yüzeyleri 800, 1000 ve 1200 grit silikon karbid zımparalar (3M, St. Paul, ABD) ile cilalandı ve yıkandı. Örnekler rastgele 4 gruba ayrıldı (n=5). Örneklerin 1., 3. ve 7. günlerdeki başlangıç renk değerleri ve zamana bağlı renk değişimleri dental bir spektrofotometre (VITA Easyshade Advance 4.0, Vita Zahnfabrik, Almanya) kullanılarak kaydedildi. İstatistiksel veriler R WRS2 paketi kullanılarak analiz edildi (Wilcox & Schönbrodt, 2015). Anlamlılık düzeyi $p<0.050$ olarak alındı.

Bulgular: Tüm solüsyonlarda bekletilen örnekler 72 saatin sonunda klinik eşik değeri ($\Delta E^*< 3{,}3$) aşmamıştır. 1 hafta sonra, örneklerdeki en fazla renk değişimi çayda tespit edilirken ($\Delta E^*= 4{,}40$), diğer gruplar arasında anlamlı bir fark bulunamamıştır ($\Delta E^*= 2{,}08$ - $1{,}02$). Test edilen tüm içecekler için örneklerdeki renk değişimleri distile su < şalgam suyu < Türk kahvesi < çay şeklinde sıralanmıştır.

Sonuç: 1 haftalık daldırma sonrasında, Cerasmart rezin nanoseramik blok materyalinin renk stabilitesi çaydan klinik olarak etkilenirken, Türk kahvesi, şalgam suyu ve distile suya daldırılan örneklerde belirgin bir renk değişikliği meydana gelmemiştir.

Anahtar Kelimeler: CAD/CAM, Rezin Nano Seramikler, Geleneksel İçecekler.

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INTRODUCTION

Ceramics and composites are the most popular materials used in dentistry (1). Although both materials have advantages over each other, they also have some limitations in terms of restoration longevity (2). Ceramics have great features in terms of durability, hardness, superior aesthetics and biocompatibility; however, they are fragile, difficult to machine and can cause wear on the opposite natural teeth (3). On the other hand, composites have some advantages such as easy machinability, low abrasiveness and elastic modulus similar to dentin, but their color stability, wear resistance and mechanical properties are much lower than ceramics (4). In order to bring together the physical and mechanical benefits of these two materials, resin matrix ceramics (RMCs) produced by computer aided design-computer aided manufacturing (CAD-CAM) technology has been presented to the industry as an alternative to traditional ceramics and composites (5).
RMC is a new microstructure created by incorporating ceramic and composite materials under high temperature and pressure. It provides strong mechanical properties and low shrinkage, reducing the amount and size of defects in the microstructure (6). RMCs, which have a similar Young's modulus to dentin, can be milled, shaped and polished intraorally (7).
RMCs can be divided into three subgroups based on their inorganic filler content; glass ceramics (Vita Enamic), zirconia-silica ceramics (Paradigm MZ100, Shofu Block HC) and resin nano-ceramics (Lava Ultimate, Cerasmart) (8). Cerasmart (GC Corporation, Tokyo, Japan), used in this study, contains 71% inorganic filler silica particles and 29% composite. It has the advantages of excellent wear resistance and flexural strength, lower wear rate on the opposing tooth compared to glass ceramics and less laboratory procedures as it does not require a second firing. In addition, it is easy to mill, adaptable and repolishable, and has sufficient resistance to discoloration (9).
In clinical practice, the performance of a restorative material is associated with the intrinsic qualities of the material and the intraoral conditions. The consumption of various foods and beverages can modify the mechanical and esthetic properties of intraoral restorations (10). This can cause deterioration of translucency of the restorations and discoloration (11).
There are many factors in the mouth that can cause discolouration. The causes of staining can be classified as internal or external depending on where the staining occurs. Internal staining is resulted from physico-chemical interactions in the deep layers of the restoration and can affect the entire structure. On the other hand, external staining can be caused by the absorption of pigments derived from plaque accumulated on the surface of the restoration, smoking habits, foods and beverages (12).
Color measurements in dentistry can be performed either visual of intrumental methods. The assessment of discoloration can be evaluated clinically or by using particular devices that exclude the subjectivity in visual colour perception. Spectrophotometers are commonly in use colour measurement devices that provide objective, rapid and reproducible colour analysis (13).
The aim of the study was to investigate the possible discolouration of a resin nanoceramic material with traditional Turkish beverages that are frequently consumed in our society. The null hypothesis of the study is that different solutions will not change the colour stability of Cerasmart blocks.

MATERIAL AND METHODS

Preparation of Rezin Matrix Ceramic Samples

A total of 20 Cerasmart 270 CAD-CAM blocks A2HT (CS) were cut to a dimension of 12x10x2 mm^3. The surfaces of all samples were polished with 800, 1000 and 1200 grit silicon carbide papers (3M, St. Paul, USA), cleaned for 10 min under water and air-dried. The prepared samples were pre-incubated in distilled water at 37°C for 24 hours. The final thickness of the samples was confirmed using a digital caliper (Alpha Tools, Mannheim, Germany). The samples were then randomised into four groups (n = 5).

Color Measurements

Black tea (Yellow Label Tea, Unilever, Istanbul, Türkiye), Turkish coffee (Kahve Dünyası Medium Roasted Turkish Coffee, Detay Kahve San. Ve Tic. A.Ş., Istanbul, Türkiye), turnip juice (Doğanay Acılı Şalgam Suyu, Adana, Türkiye) and distilled water for the control group were used to observe the colour change on the specimens. Only the liquid part of Turkish coffee was used. During the study period, all solutions freshly prepared and renewed after every 24 hours of immersion to prevent bacterial colonization. Before the colour measurements, the samples were rinsed with distilled water and dried.
Based on the studies in which a 24-hour coffee immersion period simulated 30 days of regular consumption (14,15), it was presumed that 7-day immersion of the samples in the beverages was equivalent to 7 months consumption.
On days 1, 3 and 7, the initial colour values and time-dependent colour changes of the samples were recorded with a dental spectrophotometer (VITA Easyshade Advance 4.0, Vita Zahnfabrik, Germany) on a standard

grey background under D65 lighting conditions. All measurements were taken three times by the same examiner on the central area of each specimen and averaged to avoid possible variations in colour values. The color change values (ΔE^*ab) were calculated according to CIE L*a*b* system using the following equation:

$$\Delta E^*ab = [(L1^* - L2^*)2 + (a1^* - a2^*)2 + (b1^* - b\,2^*)2]1/2.$$

According to the literature, ΔE^* values greater 3.3 were considered as clinically unacceptable color change (16).

Statistical Analysis

The sample size was determined as 20 samples with 95% confidence (1-α) and f=4.427 effect size by using G*Power V3.1.9.7 programme. Data were analyzed using with the R 4.1.0 (R Core Team, 2021) and the WRS 2 (V1.1-6; Mair, P. Wilcox, R., Patil, I., 2024) packages. Normal distribution of the data was analyzed using the Shapiro-Wilk Test. Robust Two-Way ANOVA method was used to compare non-normal distributed ΔE values according to beverage and time. Significance level was taken as $p<0.05$.

RESULTS

As a result of the study, it was observed that the colour changes of the resin nanoceramic material showed statistically significant differences depending on time and colouring beverages (Table 1). Paired group comparisons between study groups were made and the results are presented in Table 2. The colour change at the end of the first 24 hours ranged between 0.54-1.57. The samples kept in all solutions did not exceed the clinical threshold of acceptable colour change ($\Delta E^*<$ 3.3) and no statistically significant difference was found between the groups. After 72 hours, the samples kept in all solutions did not exceed the clinically acceptable colour change limit ($\Delta E^*<$ 3,3) in parallel with the first 24 hours; however, a significant difference was found between tea with turnip juice and the control group. After seven days, the samples kept in tea showed the highest colour change (ΔE^*= 4.40), whereas the colour changes for the samples kept in Turkish coffee, turnip juice and distilled water did not exceed the clinically acceptable colour change limit (ΔE^*= 2,08 - 1,02). Findings of the study showed that the most significant discolouration was seen in tea at seven days, while the other groups did not demonstrate statistically significant differences between them. In all three time intervals, the highest colour change was seen in tea, followed by Turkish coffee and turnip, while the lowest colour change was found in distilled water.

Table 1. Comparison of ΔE values for beverage and time.

	Q	p
Beverage	37.127	**<0.001**
Time	15.36	**<0.001**
Beverage*Time	43.892	**<0.001**

* Q: Robust ANOVA Test Statistic

Table 2. Descriptive statistics and multiple comparison results of ΔE values by beverage and Median (minimum - maximum); a-c: No difference between main effects with the same letter; A-C: No difference between interactions with the same letter.

	Tea	Turkish Coffee	Turnip juice	Control	Time Effect
24 hours	1.57 (0.88 – 2.82)^{ABC}	1.08 (0.57 – 2.49)^{BC}	0.54 (0.46 – 0.83)^{ABC}	0.55 (0.2 – 0.79)^{C}	0.81 (0.2 – 2.82)
72 hours	3.22 (1.81 – 3.74)^{AB}	1.34 (1.19 – 1.96)^{ABC}	0.94 (0.71 – 1.75)^{C}	0.46 (0.22 – 0.94)^{C}	1.23 (0.22 – 3.74)
1 week	4.4 (3.16 – 4.97)^{A}	2.08 (0.9 – 4.31)^{ABC}	1.8 (1.01 – 2.81)^{ABC}	1.02 (0.9 – 1.38)^{C}	1.94 (0.9 – 4.97)
Beverage effect	3.16 (0.88 – 4.97)^{a}	1.36 (0.57 – 4.31)^{b}	0.94 (0.46 – 2.81)^{bc}	0.79 (0.2 – 1.38)^{c}	1.15 (0.2 – 4.97)

Clinically successful and long-lasting restorations are associated with their colour stability in addition to their aesthetic and mechanical properties. Conditions in the

DISCUSSION

mouth and staining beverages can cause deterioration in the translucency of restorations and patient dissatisfaction (11). Various beverages consumed in daily life expose dental restorations to staining. In our study, the staining effect of traditional beverages, which are frequently preferred in daily use in Turkish society, on the resin nano ceramic block material was investigated. The results of the study showed that the perceptible colour changes were observed after the 7th day, thereby the zero hypothesis of the study was rejected. After one week of immersion of Cerasmart block material in various traditional beverages, it was observed that clinically unacceptable ΔE values in black tea, whereas no clinically unacceptable discolouration observed in samples immersed in Turkish coffee, turnip juice and distilled water. There are several studies indicating that colorant beverages can cause discolouration in CAD-CAM materials (17,18). Alharbi et al. reported that Cerasmart samples exposed to coffee and tea solutions for 24 days showed higher discolouration in tea than coffee (19). Quek et al. also reported that CAD-CAM composites (Shofu Blok and Vita Enamic) showed higher discolouration in tea than coffee after one week (20).

Ergücü et al. (21) reported that tannic acid was responsible for the colouring effect of tea. On the other hand, the yellow colouring pigments of coffee, which have different polarities and a strong affinity for polymers, reported to cause colouring in resin structures (22). Although both tea and coffee contain yellow colourants, their staining mechanisms are slightly different from each other. The adsorption of high polarity dyes on the surface of the material is responsible for the colouration caused by tea. The colouration induced by coffee, is caused by the adsorption of colouring agents with smaller molecular size and absorption into the organic matrix of the material (23,24).

Bisphenol A-glycidyl dimethacrylate (BIS-GMA) matrix, commonly found in composite materials, has been reported to show a remarkable water absorption rate. In contrast, urethane dimethacrylate (UDMA), which is widely used in hybrid composite resins, lack the hydroxyl side group. Therefore, the material is considered to consist of a less hydrophilic, more viscous matrix and the colour stability of the material is increased (25). Due to its low water absorption and solubility, UDMA has been shown to cause less staining than Bis-GMA (26). Therefore, the higher sensitivity of Cerasmart, which does not contain Bis-GMA but contains UDMA matrix, to the colouration in tea can be explained with adsorption of tea on the surface of the material, but the coffee does not diffuse into the matrix. In another study, ΔE values of Cerasmart 30 day coffee exposure exceed the clinical threshold ($\Delta E^* < 3.3$) (27). In this study, the samples were exposed to solutions at 37°C, while in our study, resin nano ceramic block samples prepared by considering the habit of hot tea and coffee consumption in daily life were exposed in black tea and Turkish coffee at an initial temperature of 60 ± 5°C and kept at room temperature. It has been reported that hot beverages are consumed at temperatures close to 60 °C in daily life and that beverages consumed at high temperatures affect the colour stability of the material (28,29). Therefore, this difference may be due to the difference between the temperatures of the solutions.

In this study, Turkish coffee did not cause clinically unacceptable discolouration after one week of exposure. While granular coffees, which were preferred in most of the literature studies, dissolved in water (30,31); traditional Turkish coffee does not dissolve directly in water, but some of it precipitates (32). For this reason, it is thought that the staining ability of Turkish coffee in our study may be lower than the other studies examined the staining caused by coffee.

In a study conducted on microhybrid composite resins, it has been reported that turnip juice caused the most discolouration, while Turkish coffee caused clinically detectable discolouration after 1 week immersion (33). In another study of temporary restorations, Turkish coffee was found to cause the most discolouration and turnip juice the least. The colour change induced by turnip juice has been stated to be caused by natural colourants such as purple carrot and turnip radish (34). In our study, the resin nano ceramic material showed a high color stability against Turkish coffee and turnip juice as a result of the 7-day immersion period.

Limitations of our study include the inability to fully simulate the intraoral environment, the rinsing effect of saliva after intraoral surface contact with dyes, and the removal of dyes from the surface by brushing. In addition, dietary habits and oral hygiene may also effect the results of the study. Therefore, more comprehensive studies should be conducted to determine the color stability of the materials and the results should be supported by clinical evidence.

CONCLUSION

Within the limitations of this study, the color stability of resin nano-hybrid material immersed in different solutions was affected by the immersion time in the coloring solutions. At the end of 1 week in the solutions, the samples were discolored respectively in the solution of black tea, Turkish coffee, turnip juice, distilled water. While the color change in black tea was higher the clinically acceptable threshold value ($\Delta E^* > 3,3$), the discoloration of samples kept in Turkish coffee, turnip juice and distilled water did not exceed the color change limit ($\Delta E^* < 3,3$).

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