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ORIGINAL RESEARCH ARTICLE

The Effects of Coffee and Energy Drink on Color Stability of Hybrid Ceramics

Işıl Sarıkaya [1,*] and Hande Yıldız Dilli [2]

[1]DDS, PhD, Department of Prosthodontics, Faculty of Dentistry, Tokat Gaziosmanpaşa University, Tokat, Turkey. and [2]DDS, Republic of Turkey Ministry of Health, Tokat Oral and Dental Health Hospital, Tokat, Turkey.

*Corresponding Author; sarikayaisil@gmail.com

Abstract

Purpose: The aim of this study was to compare the color stability of two different hybrid ceramic materials.
Materials & Methods: Using the precision cutting device (Micracut, Metcon, Turkey), 36 specimens (12 x 15 x 1 mm) were obtained from Vita Enamic (Vita Zahnfabrik, Germany) and Lava Ultimate (3M ESPE, St.Paul, USA) CAD / CAM blocks. After finishing procedures were completed, all specimens were stored in distilled water for 24 h. Then, the specimens were dried and the initial color measurements were made. L, a, b values were determined using a spectrophotometer (Vita Easy Shade, Vita Zahnfabrik, Germany). The specimens were then divided into 3 test groups and stored in coffee (Nescafe Classic, Turkey) (G2, G5), energy drink (Red Bull, Austria) (G3, G6), and in the distilled water as the control group (G1, G4), for 48 h. After 48 h, the specimens were washed with distilled water and dried. Second color measurements were made. ΔE00 values were calculated using the CIEDE 2000 color-difference formula.
Results: Data were analyzed by two-way ANOVA. Multiple comparisons were made with Bonferroni's test. There was a statistically significant difference between 2 ceramics ($p=0.035$). Generally, Lava Ultimate showed more color change than Vita Enamic. Among the beverages, coffee was significantly different for both ceramics than control and energy drink ($p<0.05$).
Conclusion: Lava Ultimate, showed more color change than Vita Enamic. Coffee has also been determined as the most colorant drink for both hybrid ceramics.

Key words: CIEDE 2000; Color stability; Hybrid ceramic.

Introduction

A restoration that can be considered as successful is expected to be survival as well as retain its original appearance in terms of esthetic. In the last 20 years, studies to strengthen the microstructure of dental ceramics have increased. For example, the addition of a crystalline structure to the glassy matrix of feldspathic porcelain increased its heat resistance. However, depending on the properties of the materials added to the structure, the optical properties of the ceramics have been also affected. Alumina and zirconia-supported systems are opaque while leucite reinforced systems are more translucent.[1,2] Lithium disilicate, a glass-ceramic, has been preferred for anterior full-crown restorations due to its superior esthetic and strength properties.[3,4]

Another popular esthetic restorative material in dentistry is resin composites. Compared to the brittle and rigid structures of ceramics, resin composites are less brittle. However, low color stability and higher wear rates limit the use of them. Due to the disadvantages of restorative materials, new biomaterials are being developed that can mimic the physical properties of natural teeth. "Polymer Infiltrating Ceramic Network (PICN)", also known as "hybrid ceramic", is a new generation restorative material that combines the ideal properties of both resin composites and ceramics.[5]

Hybrid ceramic materials can be milled and adapted more easily than glass-ceramic matrix or polycrystalline ceramics. They have a similar elasticity coefficient with traditional ceramics, can be repaired more easily with resin composite, and have a natural tooth-like mechanical and esthetic character.[5–9] Hybrid ceramic materials are also less abrasive to the opposite dentition.[10] Acidic beverages are abrasive for artificial restorative materials and tooth enamel.[11–15] There are limited data on the color stability of hybrid ceramics due to acidic

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Table 1. The materials and their properties used in the study.

Material	Composition	Translucency/Shade	Lot Number	Manufacturer
Vita Enamic	Feldspathic ceramic (86%), Acrylic polymer (14%)	HT/2M2	51040	Vita Zahnfabrik, Bad Säckingen, Germany
Lava Ultimate	Resin nanoceramic (79%), Polymer matrix (21%)	HT/A2	33140	3M ESPE, St.Paul, USA

energy drinks. Coffee is a popular beverage throughout the world.[16] It is reported that per capita coffee consumption in our country is 250 grams per year.[17] Coffee is reported as the beverage that causes the highest color change in many studies.[18–20]

The classic CIELab color formula developed by the Commission of Internationale de l'Eclairage (CIE) includes lightness, hue, and chroma; reported as L*, a*, and b*. L* stands for Lightness and takes a value between 0 and 100.[21] 0 represents black, 100 represents white. a* refers to saturation on the red-green axis, b* refers to saturation on the yellow-blue axis. Color differences are calculated with the help of these parameters as ΔE values with a formula. CIE introduced the CIEDE2000 color formulation in 2000 with the addition of two new parameters.[22] In this formulation, in addition to the Lab values, ΔR-value, which defines the interaction between saturation and hue difference for blue colors, and a* factor to improve the performance of gray colors were added.

In light of all this information, the study aimed to contribute to the literature by comparing the color stability of 2 different hybrid ceramic materials against coffee and energy drink. The null hypothesis of the study was that; "coffee and energy drink would not cause color change in hybrid ceramic materials".

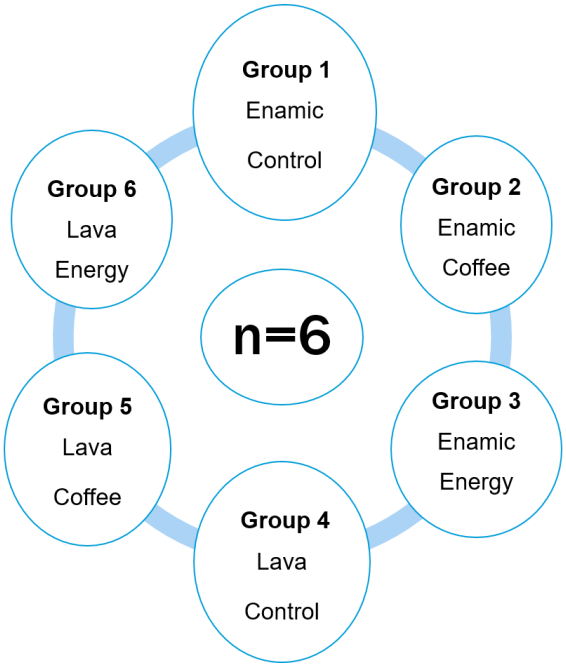

Figure 1. Schematic view of the groups.

Materials and Methods

The materials and their properties used in the study are listed in Table 1. Samples were prepared by slicing the hybrid ceramic blocks with the water-cooled diamond disc of 1x12x 14 mm on a precision cutting machine (201 MICRACUT, Bursa, Turkey) at low speed (200 revs/min). Both sides of the samples were ground with 600, 800, and 1200 grain silicon carbide abrasives (English Abrasives, London, UK) underwater cooling at 100 rpm. The Vita Enamic (VITA Zahnfabrik, Germany) samples were polished with Vita Enamic polishing kit (VITA ENAMIC Polishing Set, VITA Zahnfabrik, Germany) with the recommendation of the manufacturer. Lava Ultimate (3M ESPE, St.Paul, USA) samples were polished at 10.000 rpm with 12.7 mm diameter Sof-Lex polishing discs (Sof-Lex polishing discs, 3M ESPE, St.Paul, USA) according to the manufacturers' suggestions. Then, all samples were cleaned with deionized water in an ultrasonic cleaner (Pro-Sonic 600; Sultan Healthcare, NJ, USA) for 10 seconds and then dried with air pressure. Sample thicknesses were measured with a digital caliper (Absolute Digimatic, Mitutoyo, Japan).

The required sample size of 36 was determined by performing power analysis (G Power 3.0.10). Then the samples were randomly divided into 6 samples in each group. Groups were determined as; Group 1; Enamic control group, Group 2; Enamic coffee group, Group 3; Enamic energy drink group; Group 4; Lava control group, Group 5; Lava coffee group, and Group 6; Lava energy drink group (Figure 1). Group 1 and Group 4 were determined as control groups and samples were kept in distilled water, samples in Group 2 and Group 5 in coffee solution, samples in Group 3 and Group 6 in energy drink at 37 °C in the incubator for 48 h. According to the manufacturer's recommendations for the coffee solution, 300 ml boiled water to 3.6 g of coffee (Nescafe Classic; Nestle, Bursa, Turkey) was added and the solution was passed through filter paper after stirring for 10 seconds. Red Bull energy drink (pH=3.54; Red Bull GmbH, Am Brunnen, Austria) was prepared in 250 ml-solutions and was changed every 8 h. Then all samples were washed for 5 min with distilled water and blotting paper before color measurements and dried.

Initial color measurements of the samples were carried out under D65 lighting conditions, before and after the solution with a clinical spectrophotometer (Vita Easy Shade Advance, Vita Zahnfabrik, Germany). All samples were evaluated on a white, black, and gray background. The measurements were repeated 3 times for each sample and the average was taken as a basis. Following the same way as the initial measurements, the final measurements were made on samples kept in coffee and energy drinks for 48 h. The ΔE_{00} value is calculated with the following CIEDE2000 color difference formula.

$$\Delta E_{00} = \left(\left(\frac{\Delta L^*}{K_L S_L} \right)^2 + \left(\frac{\Delta C'}{K_C S_C} \right)^2 + \left(\frac{\Delta H'}{K_H S_H} \right)^2 + R_T \left(\frac{\Delta C' \Delta H'}{S_C S_H} \right) \right)^{1/2} \quad (1)$$

Statistical analysis of the data was performed with a Two-Way ANOVA (SPSS for Windows, Version 21; SPSS Inc, Chicago, USA). Shapiro Wilk test was used to check normality. The mean difference was set significant at the 0.05 level. Bonferroni test (α=0.05) was used for multiple comparisons.

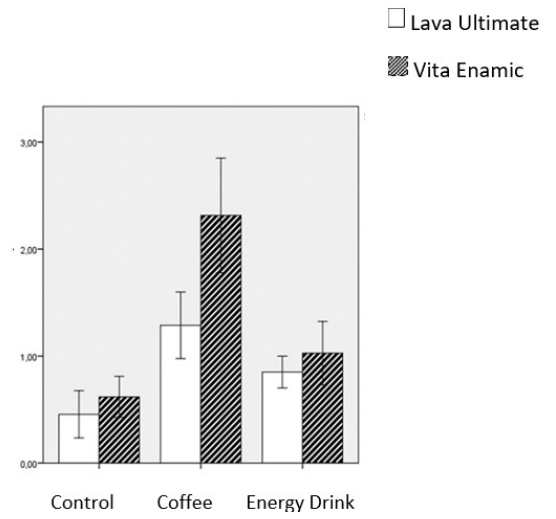

Figure 2. Bar graph with ±1 standard deviation regarding the distribution of ΔE_{00} value of the groups.

Table 2. The mean and standard deviation of the ΔE_{00} values of the groups.

	Vita Enamic		Lava Ultimate	
Control	G1	$0.46\pm0.22^{(a,x)}$	G4	$0.62\pm0.19^{(a,x)}$
Coffee	G2	$1.29\pm0.31^{(a,y)}$	G5	$2.31\pm0.54^{(b,y)}$
Energy Drink	G3	$0.85\pm0.15^{(a,y)}$	G6	$1.03\pm0.3^{(a,x)}$

*(ab): Intergroup comparison for ceramics, (xy): Comparison between groups for a beverage.
The same letters indicate that there is no statistically significant difference between the groups (p>0.05).

Results

According to the statistical results, it was found that there was no significant difference between the control groups-Group 1 (ΔE_{00}=0.46±0.22), and Group 4 (ΔE_{00}=0.62±0.19) (p>0.05). The greatest color change was observed for both ceramics in coffee groups. There was a statistically significant difference in Group 5 (ΔE_{00}=2.31±0.54) compared to Group 2 (ΔE_{00}=1.29±0.31) (p=0.01). In the energy drink groups, ΔE_{00} values increased in both ceramics. The color change of Group 6 (ΔE_{00}=1.03±0.3) was different than Group 3 (ΔE_{00}=0.85±0.15). But it is not statistically significant (p=0.333). The average ΔE_{00} values and standard deviations of the groups are listed in Table 2. The comparison of ΔE_{00} values of Lava Ultimate and Vita Enamic samples are presented in the bar graph in Figure 2.

Discussion

According to the results of the study; the color change was observed after storage in coffee and energy drink for both hybrid ceramics. Therefore the null hypothesis, which was established as "coffee and energy drink would not cause color change in hybrid ceramic materials" was rejected.

In the present study, the color change in Lava Ultimate (ΔE_{00}=2.31) among samples kept in coffee solution was found higher than Vita Enamic (ΔE_{00}=1.29). Considering that coffee consumers consume 3.2 cups of coffee per day and the average duration of drinking 1 cup of coffee is 15 minutes, the 48-hour keeping period selected in this study corresponds to the 2-month coffee consumption of the consumers.[19] Color measurements were made with a spectrophotometer suitable for clinical use in this study. In a study, it was reported that the Vita Easyshade spectrophotometer used in the present study gave 96.4 percent reliable results as a result of measurements made on ceramic scales with different color measurement devices.[23]

An energy drink was chosen to evaluate the color change due to its acidity and abrasive potential in the study.[12] An increase in ΔE values was observed in both ceramics which stored in the energy drink. Color change (ΔE_{00}=1.03) in Lava Ultimate was observed higher than Vita Enamic (ΔE_{00}=0.85). However, assuming that the clinical acceptability threshold of color perception is 2.7, the values obtained are below this threshold value.[24]

The acceptable threshold ΔE value, which is still accepted in current studies, is a controversial issue.[25] In different studies on dental ceramics, reference values varying between ΔE values 2 and 4 were taken.[26] Ghinea et al.[27] reported that 50% of observers would accept ΔE_{00}=2.23 color difference under clinical conditions, and observers could detect ΔE_{00}=1.25 color difference. Assuming the clinical acceptability threshold of 2.24, Lava Ultimate samples kept only in coffee solution have clinically unacceptable ΔE_{00} (ΔE_{00}=2.31) values. Ghinea et al.[27] also reported that the CIEDE2000 color-difference formula provides a better value than the CIELab formula for evaluating color difference, perceptibility, and acceptability thresholds for dental ceramics. In another study conducted with the same hybrid ceramic materials with this study, an increase in ΔE values was observed after keeping in coffee solution.[20] The amount of color change (ΔE^*=3.4) in Lava Ultimate was higher than that of Vita Enamic, which is above the accepted threshold (ΔE=2.7). Structural differences can affect the prone of staining. The color stability of ceramics is better than resin composites.[28] Despite Lava Ultimate is structurally closer to resin composite because of intents embedded in a resin matrix.[29] Vita Enamic is structurally closer to dental ceramic as a glass-ceramic in a resin- interpenetrating matrix is typically composed of a dual network: a feldspathic ceramic network (86% by weight, 75% by volume) and a polymer network (14% by weight, 25% by volume). The specific composition of the ceramic parts are 58% to 63% SiO_2, 20% to 23% Al_2O_3, 9% to 11% Na_2O, 4% to 6% K_2O, 0.5% to 2% B_2O_3, and less than 1% of Zr_2O and CaO. The polymer network is composed of urethane dimethacrylate (UDMA) and triethylene glycol dimethacrylate (TEGDMA) and its structure are similar to feldspathic ceramics.[5] As a result, Lava Ultimate appears to be disadvantageous compared to Vita Enamic in terms of coloration. One of the reasons for this can be considered as the different content of TEGDMA. Both hybrid ceramic materials used in the present study contain UDMA and TEGDMA. TEGDMA increases water absorption as it facilitates the transition of the coloring agent to the resin matrix.[30] Additionally Lava Ultimate contains bisphenol A-glycidyl methacrylate (Bis-GMA) and Ethoxylated bisphenol A dimethacrylate (Bis-EMA).[31] Gajewski et al.[32] reported that the water absorption of Bis-GMA was higher than UDMA, TEGDMA, and Bis-EMA. For this reason, its Bis-GMA monomer is held responsible for the color change of Lava Ultimate due to its high water absorption.[33]

Color stability studies about the effects of energy drinks have seen concentrated on resin composites.[34-36] To the authors' knowledge, there is a lack of study about hybrid ceramics on color stability of energy drink. Sagsoz et al.[37] evaluated the color stability of four different CAD/CAM ceramics, three resin ceramics (Lava Ultimate, Vita Enamic, and Cerasmart), and one light-cured resin composite after polishing with different polishing techniques on immersion on distilled water, tea, coffee, and fermented black carrot juice. It was found ceramic materi-

als exhibited better color stability than resin composites. They also investigated that Lava Ultimate's color change was greater than Vita Enamic, in line with the results of the current study.

Acar et al.[18] was studied color change with thermocycling for 5000 cycles in coffee on Vita Enamic, Lava Ultimate, Lithium disilicate glass-ceramic (IPS e.max CAD), and Filtek supreme ultra universal composite samples with different thickness. It was found resin nanocomposite (Filtek supreme) showed the highest color change followed by Lava Ultimate, Vita Enamic, and lithium disilicate ceramic. If we ignore the thermal aging that was not present in our study, similar to our study, Lava showed more staining than Enamic. The staining values of both of the ceramics were found to be clinically acceptable. The limitation of the study was that it was an in-vitro study. Results should be supported by clinical studies. Studies on energy drinks in the literature have focused on resin composites. There is no data for comparing the result of the present study on the coloring of hybrid ceramics due to energy drinks. In vivo and in vitro studies should be conducted on this subject.

Conclusion

In the energy drink solution, the ΔE_{00} value increased in both hybrid ceramics. Color change in Lava Ultimate was found statistically significantly higher than Vita Enamic. For both hybrid ceramics, coffee caused higher color change than the energy drink. It can be concluded that although with a very low pH value the energy drink could damage the surface integrity of the restorative material, it did not produce as much color change as coffee, possibly due to the lack of yellow colorants.

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Author Contributions

All authors have contributed to; conception and design of the study, data collection and analysis, writing the manuscript, approval of the final version to be submitted.

Conflict of Interest

The authors declare that they have no conflict of interest, the authors do not have any financial interest in the companies whose materials are included in this article.

Authors' ORCID(s)

I.S. 0000-0002-2172-4724
H.Y.D.0000-0002-8200-7585

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