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EFFECT OF BEVERAGE CONSUMPTION ON COLOR STABILITY OF CAD/CAM CERAMICS

Maha Kamal Sayed[*], Enas Fathelbab Abdelhalim[**] *and* Hanaa Saber Rabeae[***]

ABSTRACT

Statement of problem: color stability of ceramic restorations upon common beverage consumption assures its esthetics and clinical acceptability. This study was formulated to evaluate the effect of coffee consumption on color stability of different CAD/CAM ceramics used for esthetic restoration fabrication.

Materials and methods: A total of 45 discs were constructed of (IPS Emax CAD, Vita Suprinity & Vita Enamic) 10 mm in diameter and 1.5 mm thick. Samples were divided into three groups (15 discs each) according to the tested material then immersed in instant coffee solution for 12 days, at 37° C in dark environment. Ceramic discs of each material were optically connected with drop of distilled water to composite substrate background. The CIE L* a *b color parameters were recorded before immersion, and after immersion in coffee solution using a spectrophotometer. Data were recorded, tabulated, and statistically analyzed

Results: A statistical insignificant difference in mean values of (ΔE) was detected between tested ceramics immersed in coffee.

Conclusions: The color of the three tested ceramics changed on immersion in coffee; (ΔE) values were above 3.3, which is clinically unacceptable and unaesthetic.

Recommendations: Dentists should warn patients about the effects of dietary habits and staining beverages on dental ceramics.

KEYWORDS: Color stability, Emax CAD, Vita Suprinity, Vita Enamic, CAD/CAM ceramics.

[*] Dentist at Beni Suef ophthalmology Hospital, Ministry of health, Beni Suef, Egypt.
[**] Professor of Fixed Prosthodontics, Faculty of dentistry, Minia University, Minia, Egypt .
[***] Lecturer of Fixed Prosthodontics, Faculty of dentistry, Minia University, Minia, Egypt.

INTRODUCTION

Oral cavity is a complex environment, in which dental restorations are subjected to chemical and physical stresses, including temperature changes and chemicals from food and drinks. Mechanical and esthetic properties are the main features of the success of dental restorations. One of the major esthetic outcomes of dental restoration is color stability. Color stability of restorative materials is an important property that can be determined by different methods [(1)].

Nowadays, there are many different types of machinable esthetic restorative materials available for CAD/CAM technologies in the market. Lithium-disilicate CAD/CAM ceramic was introduced in the dental market in 2006 as IPS Emax CAD. It is a monolithic type of restoration, which is delivered in many shades. Zirconia reinforced lithium silicate glass ceramic: Vita Suprinity was introduced to the dental market in 2013 [(2)]. The new zirconium-reinforced lithium silicate ceramics has excellent esthetics, translucency, opalescence, fluorescence and high flexural strength. Polymer Infiltrating Ceramic Network or hybrid ceramic, Vita Enamic is a new hybrid restorative material consists of a dual network structure of feldspathic ceramic (86%) with resin matrix infiltration (14%). It combines the ideal properties of both ceramics and resin composites; the durability and color stability of ceramics, improved flexibility, low abrasiveness with a flexural strength 150–160 Mpa [(3)] and elastic modulus is more similar to the elastic modulus of dentin and adhesive luting cements resulting into a more uniform stress distribution of composite resins [(4,5)]. Tetric N Ceram composite; is a light curing nano hybrid composite based on nano optimized filler technology, which is responsible for its natural esthetic results.

Surface degradation of dental ceramics occurs when they are exposed to aqueous solutions, pH changes[(6)], change in temperature[(7)] and this can lead to undesirable effects on the restoration, including microbial plaque accumulation [(8)] and color stainability [(9)]. Coffee is one of the commonly consumed beverages worldwide. Coffee can cause significant changes in restorative materials color, as the acidic agents of the beverage might dissolve elements in ceramics due to their chelating effect, that affect both optical behavior and appearance of ceramics.

Twenty- four hours of exposure to beverage solution would simulate approximately 30 days of regular consumption [(10)]. Staining in vitro for 24 hours corresponds to 1 month in vivo [(11)].

Color, one of the most important determinates that affects the success of dental restorations. CIELAB color system is a standard method for measuring color differences which is based on color perception of the human eye [(12)]. (CIE) L*a*b*; The Commission Internationale de l'Eclairage is a color system, that is nearly a uniform color space. It is measured and expressed in term of three coordinate value (L*, a*, b*) that locate the object's color within the CIELAB color space. (L*, a*, b*) coordinates for lightness, white-black (L*), red-green (a*), and yellow-blue (b*).

The color differences in this system are calculated in the following formula:

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

Where ΔL*, Δa*and Δb* are difference in color parameters between two specimens measured for comparison [(13)].

Spectrophotometer is a sophisticated and accurate color measuring device that has good accuracy and reproducibility. The relative color differences of dental materials or tooth surfaces at baseline and after an intervention are detected by color change value (ΔE). There are debates regarding the clinically acceptable color change values (ΔE). Studies assumed that, ΔE ranges from (2 to 4) were considerded to be clinically acceptable[(14,15)]. More recent studies have referenced the acceptable threshold of ΔE=3.3. Others reported that; color change value ΔE which is less than 1, were

undetectable by naked eye; 1< ΔE < 3.3 perceived only by a skilled person and clinically acceptable; whereas, ΔE more than 3.3 was considered easily observed and clinically unacceptable [16,17,18,19].

The aim of this study was to evaluate the effect of commonly consumed beverage (Coffee) on color stability of three CAD/CAM ceramics; Lithium disilicate based glass-matrix ceramic (IPS Emax CAD), Zirconia reinforced lithium silicate ceramic (Vita Suprinity) and Polymer infiltrated hybrid ceramic (Vita Enamic), used for esthetic restoration fabrication. A hypothesis was postulated that, commonly consumed beverages (instant coffee solution) may have an effect on color stability of the three studied materials.

MATERIALS AND METHODS

Chairside CAD-CAM ceramic blocks of the tested materials (Emax CAD C14*, Vita Suprinity PC 14** and Vita Enamic EM 14***) were milled into cylinders (10 mm diameter), then cylinders were cut into discs 1.5 mm± 0.1 thick each, using a precision cutting machine**** under water cooling. A digital caliper was used to confirm the thickness. Discs were ultrasonically cleaned in distilled water.

IPS Emax CAD and Vita Suprinity discs were placed in Programat P310 furnace***** and crystallized according to the manufacturer's recommendations. To obtain smooth and flat surfaces, both sides of the discs were polished according to the manufacturer's recommendations******, *******, ******** by the same operator for standardization. Glazing was made on one surface only of each disc (experimental surface). Discs were stored in labelled containers containing distilled water and kept in incubator at 37°C********.

A *Tetric N-Ceram* composite shade A3******** substrate background (10 mm diameter and 2mm thick) was prepared using a split teflon mold. The mold was placed over the glass slab, and then composite resin was packed and adapted inside the hole of the assembled mold incrementally, each 1mm thick using a plastic instrument. The 1st increment was cured from the top surface in perpendicular way through the transparent glass slab for 20 seconds using a LED light curing Unit******** with a light intensity (1200-2000 mw/cm) and wavelength range of (420-480) nm, then a 2nd increment was packed and its surface was covered with a plastic Mylar strip********, to prevent polymerization inhibition by oxygen and then another glass slab was used to apply pressure on it, to obtain flat surface and optimum smoothness before curing.

After curing, the glass slab was removed and the specimen was cured again for another 20 seconds from all sides. Composite disc was polished according to manufacturer's instructions. A digital caliper******** was used to confirm the thickness of substrate disc.

One surface of each of the tested ceramic discs (n=15 each) was coated with a layer of a transparent nail polish to prevent beverage solution penetration to ceramic surface, thus leaving the glazed surface of the disc exposed to the beverage solutions (experimental surface). Discs were then immersed into labelled containers containing 20ml

* Ivoclar Vivadent, Schaan, Liechtenstein.

** VITA Zahnfabrik, Bad Säckingen, Germany.

*** VITA Zahnfabrik, Bad Säckingen,Germany.

**** Isomet 4000, Buehler, Lake Bluff ,USA.

***** Ivoclar-Vivadent, Schaan, Liechtenstein.

****** Vita Zahnfabrik, Bad Säckingen, Germany.

******* Vita Zahnfabrik, Bad Säckingen, Germany.

******** Dentaurum, Germany

******** PS, Advanced Technology, Cairo, Egypt

******** Ivoclar Vivadent, Schaan, Liechtenstein.

******** Woodpecker B cure, china.

******** Maquira celluloid strips, brazil.

******** Insize, china.

of instant coffee solution prepared according to manufacturer's recommendations; 1.8 g of coffee* was poured into 150 ml of boiled water and kept in incubator at 37°C ** for 12 days (simulating 1 year of clinical service). To reduce the precipitation of particles in the staining solutions, stirring of the solutions was done twice a day. Every 48 hours, the beverage solution was replaced with fresh ones to prevent bacteria or yeast contamination. At the end of the immersion period, discs were rinsed with running water then ultrasonically cleaned in distilled water and then air dried**.**

A custom-made black box made of black card-board paper was fabricated with specific dimensions to accommodate the used portable spectrophotometer device *(X-Rite, model RM200QC)****. Clean dry coffee treated ceramic discs optically connected to substrate using a drop of distilled water were placed in a specimen holder inside the black box opposite to the center of the measuring head of a spectrophotometer, to eliminate the impact of external light.

The aperture size of the spectrophotometer was set to 4 mm and the specimen was exactly aligned with the device, and measurements were made according to the CIE L*a*b* color space relative to the CIE standard illuminant D65. The mean values of L*, a*, b* were calculated for each specimen and were repeated 3 times for each one. Color measurements of all discs recorded before immersion, and after immersion in staining coffee solution were used to calculate change in color (ΔE).

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

Where ΔL*, Δa*and Δb* are difference in color parameters of baseline and treated discs [13].

RESULTS

Collected data were recorded, tabulated, and statistically analyzed using SPSS program (Statistical Package for Social Sciences) software version 25. One Way ANOVA test for quantitative data between the three groups, followed by post hoc LSD analysis between each two groups. Table (1) showed insignificant statistical difference in mean values of (ΔE) between the three tested ceramics in coffee immersive solution.

TABLE (1) Range, mean and standard deviation of (ΔE) between tested ceramics in coffee immersive solution.

Ceramic type			P value			
Emax CAD (L) N=5	Vita Suprinity (Z) N=5	Vita Enamic (V) N=5	Among 3 groups	L vs Z	L vs V	Z vs V
(3.72-5.46) 4.69±0.84	(3.6-4.83) 3.91±0.52	(3.73-6.75) 5.12±1.24	*0.149*	*0.203*	*0.473*	*0.059*

One Way ANOVA test for quantitative data between the three groups, followed by post hoc LSD analysis between each two groups.
****: Significant level at P value < 0.05***

* Neu-Isenburg, Germany.
** Nescafe, Neśtle Egypt.
*** PS, Advanced Technology, Cairo, Egypt.

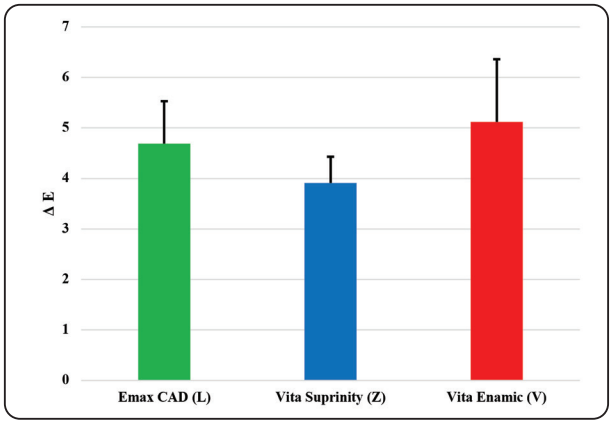

Fig. (1) ΔE of tested ceramics in coffee immersive solution.

DISCUSSION

A successful esthetic restoration is the main goal that both dentist and patient are seeking for. Esthetic appearance is defined as; healthy, natural, beautiful, and confident smile.

Coffee was selected due to its high popularity in our daily diet and they are known to have the potential of staining dental restorations. Coffee consists of acidic contents with PH =5.8 and it is a hot caffeinated beverage that causes discoloration to all ceramic restorations[20], and different acids can decalcify the tooth structure[21], and can cause ceramic degradation due to their chelating effect [8,22-24].

Shade (A3) was used as substrate background to mimic a common natural non discolored dentition shade [25].The composite substrate was made at dimension 2 mm thickness to closely mimic the clinical situation resembling the dentine structure[26].

In this study, 12 consecutive days was selected for the immersion period to simulate 1 year of beverage consumption [27,28]. Specimens were immersed in the beverage solution in an incubator at 37°C to mimic oral conditions [29].

Clean dry ceramic discs were positioned on the composite substrate disc and optically connected to it using a drop of distilled water respectively, to enhance the optical contact during color measurements with the spectrophotometer, minimizing the loss of light through the margins of the specimens (edge-loss) [30,31,32]. Each specimen was placed in a specimen holder inside the black box opposite to the center of the measuring head of a spectrophotometer with the aid of the custom-made black box to eliminate the impact of external light [31,33].

The results of the present study revealed that, there was insignificant statistical difference in mean values of (ΔE) between tested ceramics (L, Z & V) in coffee. (ΔE) values were; Emax CAD (4.69±0.84), Vita Suprinity (3.91±0.52) & Vita Enamic (5.12±1.24).

All tested ceramics showed (ΔE) values above 3.3 after immersion in coffee, which is clinically unacceptable and unesthetic. These findings supported the postulated hypothesis, as commonly consumed beverages affected the color stability of the three tested CAD/CAM ceramics.

The findings were in agreement with [34-40]. This may be due to, Lithium disilicate ceramics are highly dense material constitute of crystalline minerals and glass matrix. Vita Suprinity has a smooth surface due to its fine microstructure [41] and it is dense and hard ceramic material. The chelating effect of beverages containing acids can cause degradation, ionic disintegration and release of alkaline lithium and aluminum ions resulting in; dissolution of the ceramic silicate network creating some degrees of surface roughness, resulting into producing more entrance of the stains and discoloration of the ceramic [8,22-24].

The structure of Vita Enamic consists of ceramic and polymer/organic part, so it may have some disadvantages including discoloration due to existance of polymer chains in their structure. One of the polymers complications is their staining tendency. Polymers uptake water and so, they tend to absorb the pigments of staining solutions, due to

degradation of their organic matrix [36-39]. Besides, coffee contains yellow colorants and can cause extrinsic discoloration resulting in significant color changes in resins and dental porcelains [34,35]. Yellow colorant molecules with low polarity are attracted to the polymer/organic part and responsible for the staining liability and discoloration [36,38]. Materials immersed in solutions with pH ranging from 4 to 6 were reported to have higher sorption values, the pH of (Nescafe coffee) is 5.8, resulting in the increased sorption causing higher color change [38].

The findings disagreed with [36,42-50], who reported that Emax CAD, Vita Suprinity or Vita Enamic showed clinically acceptable color change (ΔE) following immersion in coffee. This may be due to difference in methodology regarding technique used for sample preparation, ceramic brands, ceramic thickness, immersion time, immersion technique and immersion solution brands or concentration.

CONCLUSIONS

Within the limitation of this study, the following can be concluded;

1. Emax CAD, Vita Suprinity and Vita Enamic exhibited high discoloration exceeding the clinically acceptable threshold, after being subjected to simulated 1 year of drinking coffee.
2. Coffee affected the color stability of fixed esthetic restorations made of Emax CAD, Vita Suprinity and Vita Enamic.

RECOMMENDATIONS

Dentists should warn patients about the effects of dietary habits and staining beverages on dental ceramics.

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