Effect of Different Storage and Acidic Media on the Color Stability of CAD/CAM Hybrid Ceramic

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Abstract

Objective: The purpose of this research was to show how different storage techniques and acidic conditions affected the color stability of CAD/CAM hybrid ceramic.**Materials and Methods:**80 widely accessible CAD/CAM hybrid ceramic samples. The samples will be divided into 4 groups (n=20 discs) based on the immersion solution type: coffee, Coca-Cola drink, or 4 percent acetic acid solution. In order to avoid the evaporation of the solutions containing 5 ml of the immersion solution for the previous four immersion solutions, each specimen was immersed separately in a closed individual vial with a cover. The vials were stored in an incubator at 37 °C for a 30-day test period. Using a reflecting spectrophotometer, Measurements will be made before immersion treatments and one month after the aging process has been completed. The significance threshold for the two-way ANOVA, Bonferroni, and paired sample t-tests used to evaluate the data was set at P=0.05.**Result:**The results showed that For ***Gr_1 (D Water)*** aged the mean ± SD values were (2.849± 0.7 ΔE) with a minimum value (1.36 ΔE) and maximum value (4.48 ΔE). For ***Gr_2 (Cola)*** aged the mean ± SD values were (3.855± 1.36 ΔE) with a minimum value (2 ΔE) and maximum value (5.64 ΔE). For***Gr_3 (Coffee)*** aged the mean ± SD values were (9.896± 1.71 ΔE) with a minimum value (7.07 ΔE) and maximum value (13.78 ΔE). ***For Gr_4 (Acetic A.) aged*** the mean ± SD values were (4.716± 1.14 ΔE) with a minimum value (3.01 ΔE) and maximum value (6.39 ΔE). Meanwhile the mean ± SD values. **Conclusion:**The color stability of hybrid CAD/CAM ceramics may be impacted by different immersion mediums with various polarities.

KeyWords: CAD/CAM Hybrid Ceramic, Color Stability.

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Introduction

Clinically, the long-term continuousness of any restorative material—a trait that is significantly impacted by both the material's inherent qualities and the environment to which it is exposed—is directly connected to the material's efficacy. The oral cavity is an intricate, watery environment where restorative materials come into touch with saliva and are susceptible to pH changes brought on by the ingestion of various meals and drinks. Such elements have reportedly been shown to affect the restoration's aesthetic and mechanical qualities while it is in use[1].The CAD/CAM aesthetic materials used in dentistry have dramatically improved over time. Ceramic blocks are strong and stiff, have outstanding aesthetics, and are biocompatible, but they are also fragile, have poor fracture toughness, and are challenging to manufacture. Additionally, restorations could wear down the natural teeth on the other side [2,3]. On theother hand, since resin composite blocks have a low brittleness index and are thus easier to work with, the manufactured restorations don't wear down the teeth next to them as much[2]. However, when exposed to various foods and drinks, the majority of resin-based restorations exhibit color changes[4,5]. One such color shift might be caused by inherent or external sources. Changes within the resin matrix itself have been linked to intrinsic variables.

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Extrinsic variables include exposure to drinks and colored solutions that cause stains as well as poor dental hygiene, poor eating and smoking habits, and adsorption or absorption of extrinsic stains [4,6]. To combine the advantages of resinous and ceramic materials, Vita Zahnfabrik invented VITA ENAMIC, a hybrid dental ceramic with a dual-network structure. A "double network hybrid" is created when the methacrylate polymeric network strengthens the dominant porous sintered feldspathic ceramic network (DNH)[2,3,7] or the polymer-infiltrated-ceramic-network (PICN) [8].Colorimeters and spectrophotometers may be used to measure color change. Instrumental measurement, whether in-vitro or in-vivo, makes it possible to investigate the various elements that may affect color stability. When comparing colors visually, individual variation is eliminated via instrumentation. The Commission Internationale de l'Eclairage (CIE) L*a*b* color scheme takes into account how the human eye sees color. The color space is largely homogenous and the brightness coordinates are white-black (L*), red-green (a*), and yellow-blue (b*). Mathematically, the term "color change" refers to the variation in L*a*b* coordinates between two separate specimens or the same specimen at two different periods (E). Aside from being generally stain-and surface-resistant, the therapeutic efficacy of polymer-infiltrated ceramic network (PICN) restorative materials has also been called into doubt in light of the surge in coffee and Coca-Cola use. Even though VITA ENAMIC is frequently used in inlays, onlays, as well as other applications, to our understanding, there isn't any information on how well these materials retain their color when exposed to liquids like coffee and coke or how these drinks affect the microhardness of their surfaces. The immersion solution won't significantly affect Vita Enamiccolor stability, according to the study's null hypothesis.

Materials & Methods

The materials was synthesized into a total of 80 specimens (discs). The CAD/CAM blocks of hybrid dental ceramic (Vita Enamic; Vita Zahnfabrik) have been sectioned into disc-shaped specimens using a water-cooled low-speed diamond saw (IsoMet®; Buehler, Lake Bluff, USA) and a digital micrometer (DigimaticCaliper, Mitutoyo MC, Aurora, IL, USA) (10 mm 2 mm). To produce homogeneous surfaces, the specimens were polished for 60 seconds using 400, 600, 800-, and 1,200 grit silicon carbide sheets. After five minutes of soaking in distilled water, the samples were cleaned.

The samples were separated into four groups based on the kind of immersion solution used: distilled water immersion (control), coffee, Coca-Cola drink, 4 percent acetic acid solution, and thermocycling. Over the course of a 30-day test period, the specimens were submerged in liquids at room temperature. Daily changes to the staining solutions were made, and they were placed in vials with covers to avoid evaporation. Prior to and 30 days following aging operations, measurements were performed.

According to the immersion media, specimens were randomly allocated into 4 groups (n=20 discs) (Distilled water, Coca-cola, Coffee, and Acetic Acid solution).

The first solution, which served as the control group, was distilled water from Health Aqua in Alexandria, Egypt.

The second solution consisted of 1000 cc of room temperature Coca-Cola (Coca-Cola Co., Egypt).

The third option was coffee (Nescafe Classic, Nestle Egypt).

The fourth solution included 4% acetic acid.

Each specimen was immersed separately in a sealed individual vial with a cover to stop solutions containing 5 ml of the immersion solution for the previous four immersion solutions from evaporating. The vials were stored in an incubator at 37 °C for a 30-day test period. To avoid bacterial or yeast contamination, each specimen was cleaned with distilled water and immersed in a fresh solution every 48 hours. At the end of the 30-day immersion period, specimens were taken out of their vials and cleaned with gauze and distilled water. Before each measurement, the samples were carefully washed with distilled water and left to air dry. Prior to aging procedures, baseline evaluations of each specimen's color was performed. After the 30-day aging period, color was reevaluated.

The specimen color was measured using a reflected spectrophotometer (model RM200QC; X-Rite GmbH, Neu-Isenburg, Germany). The measuring port's aperture size was adjusted to 4 mm, and the specimens were placed in the center of the port. The measurements were made against a white background using the CIE standard illuminant D65 as the reference (Commission internationale de l'éclairage (CIE) L* = 88.81, a* = 4.98, b* = 6.09). A* stands for the color coordinate on the red/green axis, b* for the color coordinate on the yellow/blue axis, and L* stands for the level of lightness (0–100). The spectrophotometer was calibrated before

each measurement. Three measurements were taken for each specimen, and the average was recorded.
Following the various staining procedures as indicated for baseline measurements, the color of the specimens was evaluated. Each specimen's color change (E) was computed using the method below:
ΔE = [(L* after staining – L* baseline) ^{2} + (a* after staining – a* baseline) ^{2} + (b* after staining – b* baseline) ^{2}] $^{1/2}$

Results

Table (1) and Figure (1) provide a summary of the descriptive data for each group, including mean, standard deviation (SD), minimum, maximum, low, and high confidence intervals (95 percent CI) of the color changes.

Tab. 1. Color changes results (ΔE) displaying the mean, standard deviation (SD), and low, high, minimum, and maximum confidence intervals for each group CI

	Variable	***Mean***	***SD***	***Range***		***95% CI***	
				Min.	***Max.***	***Low***	***High***
Aging protocol	***Gr_1 (D Water)***	2.849	0.7	1.36	4.48	2.54	3.16
	Gr_2 (Cola)	3.855	1.36	2	5.64	3.26	4.45
	Gr_3 (Coffee)	9.896	1.71	7.07	13.78	9.15	10.6
	Gr_4 (Acetic A.)	4.716	1.14	3.01	6.39	4.22	5.22

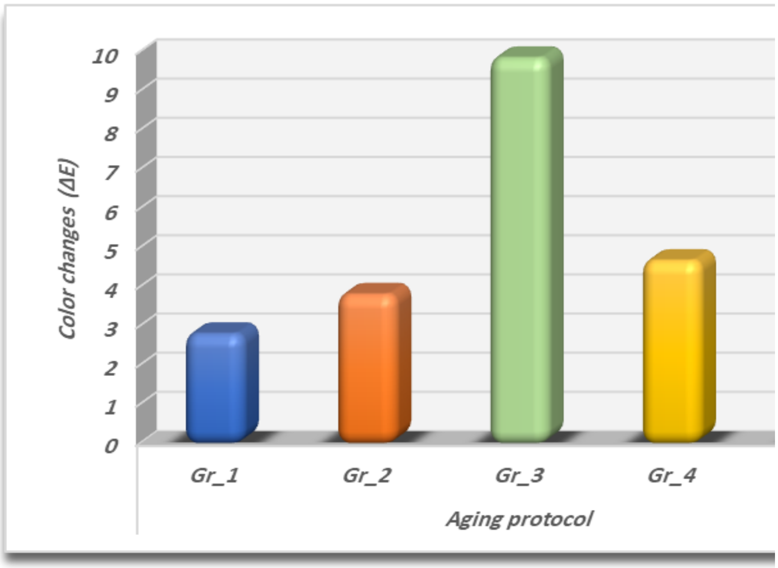

Fig. 1.A column chart of color changes mean values (ΔE) for each group

For Gr_1 (D Water) aged the mean ± SD values were (2.849± 0.7 ΔE) with a minimum value (1.36 ΔE) and a maximum value (4.48 ΔE). For Gr_2 (Cola) aged the mean ± SD values were (3.855± 1.36 ΔE) with a minimum value (2 ΔE) and maximum value (5.64 ΔE).For Gr_3 (Coffee) aged the mean ± SD values were (9.896± 1.71 ΔE) with a minimum value (7.07 ΔE) and maximum value (13.78 ΔE).For Gr_4 (Acetic A.) aged the mean ± SD values were (4.716± 1.14 ΔE) with a minimum value (3.01 ΔE) and a maximum value (6.39 ΔE). Meanwhile the mean ± SD values. It was found that Gr_3 (Coffee) aged recorded the highest color changes mean value (9.896± 1.71 ΔE) followed by Gr_4 (Acetic A.) aged and Gr_2 (Cola) aged means values (4.716± 1.14 ΔE and 3.855± 1.36 ΔE respectively) while Gr_1 (D Water) aged recorded the lowest mean value (2.849± 0.7 ΔE). The ANOVA test revealed that there was a statistically significant difference between all groups (p = 0.0001 0.05). Table (2), Figure (2), and the pair-wise Tukey's posthoc test revealed no statistically significant difference (p>0.05) between Grades 2 and 4.

Tab. 2. Color changes results (ΔE) showing mean, standard deviation (SD), minimum, maximum, low, and high confidence intervals for each group CI; confidence intervals

Variable		***Mean***	***SD***	***Range***		***95% CI***	
				Min.	***Max.***	***Low***	***High***
Aging protocol	***Gr_1 (D Water)***	2.849	0.7	1.36	4.48	2.54	3.16
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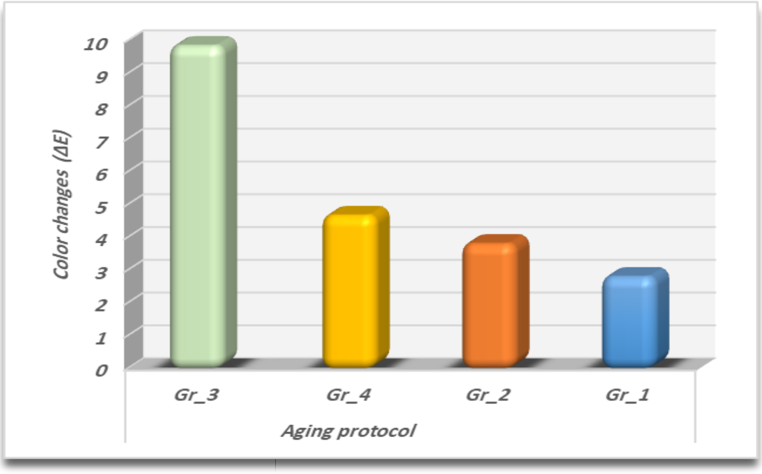

Fig. 2.A column chart of color changes mean values (ΔE) for each group ranked from higher to lower mean value

Discussion

To address the issues with resin and ceramic block materials when used exclusively, PICN was created as part of the continuous research in materials for CAD/CAM blocks. The demand for aesthetic materials that closely mimic the color of teeth as well as materials that preserve that color was driven by the rise in patient awareness.

Following immersion in liquids including Coca-Cola and coffee, which are recognized for their ability to stain resin-based restorative materials, the color changes were examined. Throughout the investigation, distilled water was utilized as the control. According to a theory, one month in the human body equals 24 hours of staining in a laboratory setting. Therefore, a four-week immersion duration was selected to roughly correspond to two and a half years of clinical aging [9-12].

Since the CIE lab system was utilized in this investigation to identify minute color variations, instrumental color measurement was chosen since it has the benefits of being objective and quantitative [12]. ΔE is a numerical distance that indicates the color change values between two colors' L*a*b* coordinates [13] [14]. Changes in color values were said to be imperceptible by the human eye at values of E 1, barely understandable by a trained individual at values of E 1.0 through E 3.3, and not clinically acceptable at values of E > 3.3 [11][13][15][16]

Discoloration is often brought on by water absorption by the resin component of the material. The kind of resin matrix employed has a significant impact on the material's ability to preserve its color. The company states that Vita Enamic is primarily made up of 66 weight percent hydrophobic urethane dimethacrylate (UDMA) and 33 weight percent hydrophilic trimethylene glycol dimethacrylate (TEGDMA). According to past studies, the water absorption of Bis GMA-based resins rose from 3 to 6 percent, whereas the fraction of TEGDMA increased from 0 to 1 percent. Due to enhanced water sorption caused by the higher weight % of TEGDMA in Vita Enamic blocks, any hydrophilic colorant may have been able to permeate the resin matrix. Since UDMA is more hydrophobic than BIS-GMA, it is more color stable. Dimethacrylates do, however, produce cross-linked networks that function as plasticizers by trapping unreacted monomers inside of them. This plasticization may facilitate higher water sorption by resulting in a more open structure. This may provide light on how Vita Enamic's higher levels of discolouration may have resulted from the resin matrix[13][15] [17-20].

Vita Enamic'scolor change levels (9.896±1.71), as assessed after immersion in coffee, are clinically unsatisfactory. Coffee's yellow colorant seeping into the microstructure of both materials might be the cause of the discoloration. Materials submerged in solutions with a pH range of 4 to 6 showed higher sorption values, according to reports. Nescafe coffee has a recorded pH of 5.4, which may have led to enhanced sorption and a greater color shift [13] [19]. The compatibility of the yellow colorant with the resin matrix may be the cause of the increased discoloration seen with Vita Endemic. The dye polarity determines the extent of dye penetration into the resin matrix. Coffee's low polarity solution may have allowed for deeper colorant penetration into the resin matrix because of its yellow colorant [9] [13][16] [19].

The findings of this investigation confirm the null hypothesis, according to which Vita Enamic'scolor stability after age would vary considerably from that of samples taken before aging.

Because resins have a stronger propensity to stain in moderately acidic medium (cola drinks), with their higher acidity, would have a lower staining impact on resin-containing ceramic materials, the findings for immersion in Coca-Cola demonstrated a statistically significant difference. In reality, compared to other dark beverages, tests have shown that cola drinks cause the least amount of staining of resinous materials, despite their acidity [21].

These ions may minimize the breakdown of the resin surface since it has been discovered that they have a similar effect on tooth surfaces. Another factor that could decrease the impact of cola's stains on resins is this one[22].

Our findings are consistent with earlier research by E. Eldwakhly et al., This revealed, as proven in their investigation in VE groups, that cola drinks had a lower staining influence on ceramic objects containing resin[23].

Prior research by (eltorky, shakal, and Elshahawy, 2022) found that hybrid ceramics had an unsatisfactory color change when submerged in 4 percent acetic acid (E = 5.97 3.29> 3.3). Polymer-containing materials may discolor more than pure ceramic materials as a result of this. Polymers may more easily absorb the pigments present in the staining solution as well as water. The potential of acidic environments to soften resin-based restorative materials, which influence surface roughness and alter color perception, and the possibility of segregating the weaker polymer matrix from the ceramic network may also be responsible for this. Previous studies have also shown that composites containing polymers display a clinically discernible color shift in a variety of staining solutions. However, different research found that adding synthetic stomach acid caused a hue shift that was deemed imperceptible[24].

According to recent research by Dalia A. Saba et al., who discovered that following immersion of hybrid ceramics in coffee, Vita Enamic (E = 3.832 and 4.805), exhibited a clinically unacceptable alteration, the findings regarding immersion in coffee demonstrated a statistically significant difference[25]. In a different investigation, Vita Enamic samples exposed to coffee demonstrated significant color changes, according to Rana S. et al. The average Vita Enamic E value was 7.96. It was determined that this was higher than the clinically acceptable limit. [26] Furthermore, E. Eldwakhly, et al. (354), demonstrated that immersion in coffee caused the most alteration to be seen. Only immersion in coffee and ginger for VE (VITA ENAMIC®; VITA Zahnfabrik, H. Rauter GmbH & Co. KG, Bad Säck- Ingen, Germany) led to changes that were over 1.2, or detectable[27] 4925

The main limitation of this research is that there are discrepancies between both the clinical environment and the in vitro environment, such as water consumption, PH level, temperature changes, occlusion, the amount of saliva, and the nature of it varying from person to person, the frequency of tooth brushing, and the allowance staining of both sides of the tested porcelain samples. In clinical situations, one surface of the restoration is bonded to a tooth structure, and only the other surface is stained. Therefore, further in-vivo research should be done to improve the connection with clinical contexts. The result statistics may be impacted by all of these factors. Despite these drawbacks, the current study's findings nonetheless contribute to the body of knowledge by analyzing the impact of several regularly consumed drinks on the color of hybrid ceramic materials.

Conclusion

The final results may be made, within the constraints of this in vitro study:

1. Vita Enamic's color may be negatively impacted by coffee, which might damage aesthetics.

2. The color stability of CAD/CAM ceramics may be impacted by various immersion mediums with various polarities.

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