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EFFECT OF FINISHING TECHNIQUE ON COLOR STABILITY OF DENTAL CERAMICS

Aliaa A. Al-Qousy*, Moustafa S. Mohammed**, Mohammed G. Hussein** *and* Cherif A. Mohsen***

ABSTRACT

Purpose: This research aimed to compare lithium disilicate glass ceramic and high translucent monolithic zirconia using different finishing techniques and after being exposed to a corrosive medium.

Materials and Methods: Two main ceramic materials, Lithium Di-silicate (IPS e.max CAD LT A3, C14) and High Translucent Zirconia (HTZ) from DD BioZx2 A3-HT, along with acetic acid as a corrosive agent was employed in this study. Forty ceramic discs(10x12mm) were classified into two groups (20 discs each) according to the type of ceramic used then each group was subdivided into two subgroups (10 discs each) according to the finishing procedure (glazed and polished) each disc was tested for color stability.

All discs were immersed in 4% acetic acid as a corrosive agent to study the effect of aging on color stability of glazed and polished ceramic.

Results: In terms of color stability (ΔE), both glazed and polished subgroups of E-max samples exhibited statistically significant differences after corrosion, favoring the superior color stability of glazed over polished ones (p-value=0.001). Similar trends were observed in HTZ samples, with glazed samples demonstrating better stability (p-value=0.003). Additionally, when comparing glazed samples between E-max and HTZ, the HTZ group showed significantly better color stability (p-value=0.001). The same pattern was found in polished samples, favoring HTZ over E-max (p-value=0.001).

Conclusions: Corrosion of samples exerted a notable impact on the color stability of the tested Lithium Di-silicate (E-max) and High Translucent Zirconia (HTZ) ceramics, irrespective of the finishing techniques employed. The method of finishing played crucial roles, with glazed HTZ samples demonstrating the least susceptibility to corrosion in terms of color stability.

KEYWORDS: Lithium disilicate, high trnslucent zirconia, glazing, polishing, corrosion

* Demonstrator, Fixed Prosthodontics Department, Faculty of Dentistry Assuit University,
** Lecturer, Fixed Prosthodontics Department, Faculty of Dentistry Assuit University
*** Professor, Fixed Prosthodontics department, Faculty of Dentistry Minia University.

INTRODUCTION

The quest for clinical materials that closely replicate the optical characteristics of dental elements has heightened the need for ceramic restorations. Due to their biocompatibility, clinical durability, and ability to mimic the color, translucency, and surface texture of dental enamel, ceramics have emerged as the preferred material in the field of esthetic restorative dentistry. [1]

Ideally, ceramic restorations should undergo minimal adjustment during clinical adaptation to prevent a loss of brightness and superficial smoothness typically achieved through glaze application. Nevertheless, some esthetic and functional adjustments are common at this stage, and the limited glaze layer may wear off, revealing a rough surface.[1]

To mitigate the risks of ceramic degradation, wear from opposing teeth, biofilm accumulation, gingival irritation, ceramic stains, and fractures, it becomes necessary to utilize polishing systems for surface roughness adjustments. These systems can effectively replicate the brightness and smoothness akin to glaze application, thereby enhancing the physical and mechanical properties of ceramics.[1]

Undoubtedly, color stability stands out as a crucial clinical consideration in aesthetic dental restorations, influencing both the survival rate and aesthetic appeal of ceramic restorations through its impact on color stability and translucency. La Commission Internationale de l'Eclairage (CIE) suggests assessing color difference by utilizing the CIE $L^*a^*b^*$ color parameters. Notably, there exists a scarcity of information regarding the influence of surface roughness on ceramic color after exposure to a staining agent in existing literature. [2]

The enhanced optical characteristics of contemporary ceramics facilitate a more accurate reproduction of the natural tooth's translucency and fluorescence. Nevertheless, for the overall success and durability of restorations, color stability is a critical factor alongside the aesthetic and mechanical attributes of the ceramic. Potential discoloration or diminished translucency, often triggered by staining beverages or intraoral conditions, can lead to dissatisfaction with the quality of the restorations.[3]

The growing adoption of CAD/CAM systems in dentistry has led to the development of diverse monolithic ceramic blocks, each possessing distinct flexural strength and esthetic characteristics. Alongside monochromatic blocks, the industry has introduced multi-colored CAD/CAM blocks to address esthetic disparities between the restoration and the natural tooth. These blocks aim to replicate the natural dentine and enamel by offering multiple chroma and translucency variations across different regions, extending from the cervical to incisal thirds. It's worth noting, however, that not all CAD/CAM blocks come with multicolor options.[3] In the clinical setting, adaptation procedures performed during the delivery of a patient's restoration result in the formation of a rough surface, necessitating intraoral finishing and polishing. These treatments are essential to minimize wear on opposing teeth by reducing the restoration's abrasiveness and ensuring hygiene by preventing bacterial adherence. Previous research indicates that finishing treatments contribute to increased color stability in restorations. Despite optimal color selection, materials may undergo clinically noticeable color changes in the oral environment. Various surface finishing treatments are applicable to esthetic CAD/CAM restorations, with glazing in a porcelain furnace being the most commonly preferred treatment before cementation. Recent studies have also demonstrated that a smooth and lustrous surface can be achieved through manual polishing in addition to glazing.[4]

The null hypothesis of this study posits that both surface finishing treatments and corrosion will have no impact on the color stability of the tested ceramics.

MATERIALS AND METHODS

Sample Grouping:

Forty ceramic discs (10x12mm) were divided into two groups (20 discs each) according to the type of ceramic used (Lithium di-silicate: (IPS e.max CAD A3, C14) and High Translucent Zirconia (HTZ) (DD BioZx2 A3).

Then each group was subdivided into two subgroups (10 discs each) according to finishing procedure (glazing and polishing) then color parameters (L*,a* and b*) for each disc was measured using easy shade spectrophotometer.

All discs were then immersed in 4% acetic acid as a corrosive agent to study the effect of aging on color stability of glazed and polished ceramic.

Disc fabrication

A ceramic cylinder was designed, 10mm diameter and 12mm in length by the aid of CAD system software (exocad GmbH, Darmstadt, Germany). The size of zirconia cylinders was made 12.5 ×15mm to compensate the shrinkage that will occur after sintering, as the Shrinkage Ratio of the used blocks was 0.25. The shape of the cylinder was confirmed and exported to the CAM system. After sintering, discs with a 2 mm thickness and 10 mm diameter were created by cutting cylinders with an IsoMet 4000 micro saw (Buehler Germany precision cutting, Germany). A digital caliber (Mitutoyo, Mitutoyo America Corporation, California) was then used to measure the thickness of each disc.

Finishing of the Samples (subgroups)

Glazing:

Glazing of E-max and HTZ samples: The glazing procedure was carried out using an oven (Programat P310 G2; IvoclarVivadent, Schaan, Liechtenstein) with IPS Ivocolor Glaze Paste (IvoclarVivadent, Schaan, Liechtenstein).

Polishing:

E-max CAD polishing: The specimens underwent finishing and polishing procedures using Eve Diapol, EvE Ernst Vetter GmbH (Rastatter Str, Pforzheim, Germany). According to manufacturer instructions, initially, finishing with the green discs (medium) with approximately 35 microns particle size was done. Subsequently, the grey wheel (fine) with a particle size of 4–8 microns was used for pre-polishing and smoothing. Finally, for high-luster polishing, the pink wheel (extra fine) with a particle size of about 1-2 microns was used. Every step of the process took one minute, and the recommended speed was 7000 rpm. Polishing was executed using a straight handpiece (NSK EX-6B, Japan), mounted to a specialized device **(Fig.1)** to ensure standardization of grinding pressure, direction, and rate applied to the samples. [5]

HTZ Polishing: The polishing process involved utilizing the OptraFine ceramic polishing kit (Ivoclar Vivadent) in the following sequence (according to manufacturer instructions): light blue silicone points for initial finishing at 15,000 rpm, followed by dark blue silicone points for polishing at 15,000 rpm.

Fig. (1): Handpiece holder

The final step included using a nylon brush along with diamond polishing paste for ultimate polishing at 10,000 rpm. Each polishing point was applied for duration of 40 seconds. [6]

Color measurement

The discs were positioned on a neutral grey backdrop, and the CIELAB coordinates were gauged for each specimen utilizing an Easy Shade spectrophotometer (Vita, Bad Säckingen, Germany). By positioning the Easy Shade tip at a 90-degree angle to the sample's surface, three measurements were obtained for each specimen at the center, and the average was recorded. Following the measurement of each specimen, recalibration of the Easy Shade was performed. **(Fig. 2)**

The color difference (ΔE) values were assessed by determining the difference in color parameters of the specimens before the corrosion test, employing the formula:

$$\Delta E^* = [(L_1^* - L_2^*)^2 + (a_1^* - a_2^*)^2 + (b_1^* - b_2^*)^2]^{1/2}$$ [8]

The numerical labels "1" and "2" correspond to the color coordinates before and after the corrosion test, respectively. In this context, L* denotes brightness, a* represents redness-greenness, and b* indicates yellowness-blueness. The ΔE values serve to assess whether alterations in the overall shade are noticeable to the human naked eyes. Color differences exceeding 1.0 are visually detectable but clinically acceptable and values surpassing 3.3 are deemed clinically unacceptable. [8]

Fig. (2): Easyshade spectrophotometer

Aging procedure

Initially, the specimens underwent a thorough cleaning process involving three washes with ethyl alcohol, followed by drying by face tissue (Fine, Egypt). Subsequently, they were immersed in a 4% acetic acid solution at a temperature of 80°C, adhering to the ISO 6872 [7] standards for evaluating the hydrolytic resistance of dental ceramic materials. This immersion was sustained for a duration of 16 hours. Afterward, the specimens were allowed to cool to room temperature and then extracted from the solution. Following this, the samples underwent rinsing with distilled water and alcohol before being dried. [7]

Color parameters of the specimens were measured again after the corrosion using the same spectrophotometer.

Statistical Analysis

The collected data were systematically tabulated and subjected to statistical analysis. Mean and standard deviation values were computed for each group in every test. To compare the mean differences over time, a Two-way ANOVA was conducted.

RESULTS

Means and standard deviations of the color stability (ΔE) was measured for both material groups, lithium disilicate (E-max) and high translucency zirconia (HTZ) and among the subgroups according to finishing technique (glazing and polishing). Results are presented in tables (1,2) and figures (2,3)

i- ΔE of (E-max samples)

Before and after corrosion with 4% acetic acid for glazed and polished subgroups, results showed that there was statistically significant difference between the 2 subgroups (glazed/polished) p-value=0.001

Where the glazed subgroup show more color stability than polished one. .(table,1 fig,3)

ii- ΔE of (HTZ samples)

Before and after corrosion with 4% acetic acid for glazed and polished subgroups, results showed that there was statistically significant difference between the 2 subgroups (glazed/polished) p-value=0.003

Where the glazed subgroup showed more color stability than polished one. (table,1 fig,3)

TABLE (1) ΔE of (E-max and HTZ groups)

ΔE Mean ± SD	Method		P-value
	Glazed	Polished	
E-max group	2.21 ± 0.11	2.85 ± 0.38	0.001*
HTZ group	0.63 ± 0.22	1.25 ± 0.21	0.003*

The * symbol indicates statistically significance difference
****; significant (p<0.05) ns; non-significant (p>0.05)***

The results of both samples are clinically acceptable < 3.3

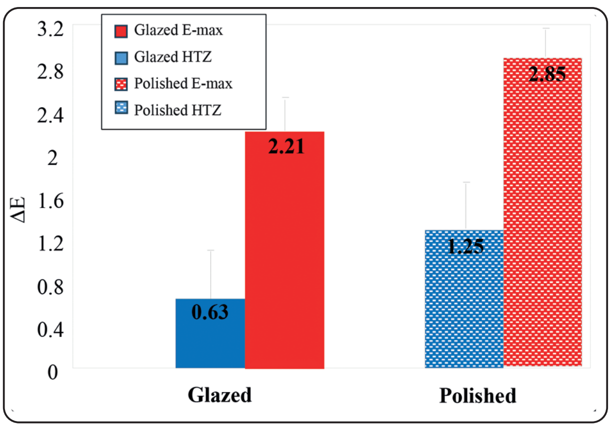

Fig. (3): ΔE (Glazed / polished samples of both material groups)

iii- ΔE of the (glazed samples)

Before and after corrosion with 4% acetic acid for glazed E-max and HTZ materials, results showed that there was statistically significant difference between the glazed samples of both materials (E-max/HTZ) p-value=0.001

Where the glazed HTZ group shows more color stability than glazed E-max one. (table,2 fig3)

iv - ΔE of the (polished samples)

Before and after corrosion with 4% acetic acid for polished E-max and HTZ materials, results showed that there was statistically significant difference between the polished samples of both materials (E-max/HTZ) p-value=0.001

Where the polished HTZ group show more color stability than polished E-max one. (table,2 fig4)

TABLE (2) ΔE of (Glazed / polished samples of both material groups)

ΔE Mean ± SD	Material		P-value
	E-max	HTZ	
Glazed samples	2.21 ± 0.11	0.63 ± 0.22	0.001*
Polished samples	2.85 ± 0.38	1.25 ± 0.21	0.001*

The * symbol indicates statistically significance difference
****; significant (p<0.05) ns; non-significant (p>0.05)***

The results of both samples are clinically acceptable < 3.3

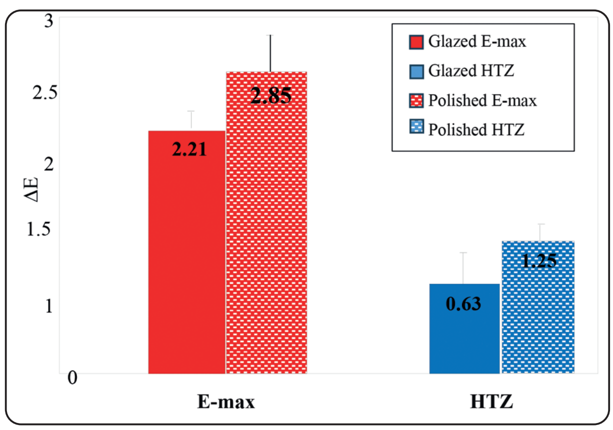

Fig. (4): ΔE of (E-max and HTZ groups)

DISCUSSION

The current research explored how corrosion impacts the color stability of two ceramic types, distinguished by either glazing or polishing as finishing methods. In this study, the ceramic variants underwent exposure to a 4% acetic acid solution at 80ºC for a truncated duration, enabling the identification of early surface alterations. To comply with ISO 6872, which is the standard for hydrolytic stability tests on ceramic materials, the time factor was increased from 16 to 18 hours to account for the time needed to reach the suggested temperature.

Acetic acid was selected for its pH value (pH 2.4), which closely resembles the pH values of certain beverages, juices, and those encountered in dental plaque.[9] Additionally, acetic acid is a commonly utilized acid for domestic applications. [10]

The current ISO 6872:1995(E) standard employs 4% acetic acid as the chemical agent for assessing the chemical solubility of ceramic materials through an 18-hour reflux process. [7]

Dental computer-assisted design and computer-assisted manufacturing (CAD-CAM) technology are extensively utilized to streamline the production of ceramic restorations, with the goal of reducing the number of clinical visits as well as the amount of production time needed. Because ceramic restorations are more biocompatible and have greater chemical stability than traditional metal-ceramic restorations, clinicians prefer using them. [11,12,13]

Several studies have confirmed that various chair-side ceramic polishing systems yield surfaces as smooth as those achieved through glazing. [14,15]

A spectrophotometer was used in this in vitro investigation because of its ability to produce objective measurements without the subjective influence of colour. [16]

The null hypothesis of this study was rejected, as elucidated in the subsequent discussion.

The findings of this study align with those of Shereen et al. (2020) [17], where samples exhibited clinically undetectable color changes before and after thermodynamic aging. Additionally, the results are consistent with the findings of other researchers [18,19,20], who observed statistically significant changes in the color coordinates of IPS e.max CAD due to aging, although these changes remained within the clinically acceptable range. [8]

They attributed this phenomenon to the inherent characteristics of the material itself rather than the chosen shade. The heightened color stability observed in zirconia samples may be attributed to their polycrystalline microstructure, which imparts strength and fracture resistance. Furthermore, they noted that glazing ceramic samples significantly contributed to maintaining color stability and protecting the restoration from stains.[5,21] These findings are in concordance with the outcomes of El-Sharkawy et al. (2020), who reported adverse effects of staining drinks and coffee on both the color stability and translucency of lithium silicate and disilicate materials. Their study also demonstrated that the glazing procedure resulted in fewer color changes after exposure to corrosive media. [5]

Glazing tends to generate smoother surfaces than mechanical polishing processes, which could explain the greater colour stability seen in glazed ceramics. The smoother surfaces resulting from glazing are associated with less stain retention after exposure to various beverages. Al-Wahadni and Martin(1998)[16] underlined that the glazing process improves optical qualities and surface smoothness by efficiently sealing open pores on the surface during firing. Thus, less biofilm accumulates on a flat surface. On the other hand, surface imperfections that permit liquid penetration may be the cause of the greater colour change seen in the finishing and polishing group, while glazed materials have an impermeable layer that lessens liquid penetration. [22]

The findings of the current study present a contrast to the results reported by Eltorky et al. (2022), where lithium disilicate samples exhibited greater color stability and less stainability compared to zirconium samples. [23]

Additionally, the present results contradict those of Kurt et al. (2019) [24] , who asserted that monolithic zirconia was more susceptible to discoloration from coffee, as indicated by ΔE values of 5.602.

Given the limitations inherent in this in vitro study, it is crucial to emphasize the need for further research into the optical and various mechanical properties of monolithic CAD-CAM restorative materials. Specifically, studies should aim to simulate the diverse variables present in the intraoral environment to provide definitive clinical recommendations.

CONCLUSIONS

1- Color stability of all tested samples was affected by corrosion in relation to the method of finishing with the least affected was glazed high translucency zirconia samples.

2- Corrosion of samples reduces color stability of both tested materials with different finishing techniques.

3- Glazing produces better results regarding the color stability of ceramics.

RECOMMENDATIONS

Given the limitations inherent in this in vitro study, it is advisable to consider glazing as a preferred method for ceramic finishing. In vivo investigations assessing clinical complications, biocompatibility, wear, micro-leakage, color stability, adhesion of these materials to tooth structures, dental cements, and the overall survival rate are essential for the validation of their clinical utility.

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