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EFFECT OF FINISHING TECHNIQUE ON TRANSLUCENCY OF DENTAL CERAMICS

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ABSTRACT

Purpose: This research aimed to compare translucency of 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) then each disc was tested for translucency parameter.

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

Results: In terms of translucency parameter (TP), both glazed and polished subgroups of E-max samples exhibited statistically no significant difference after corrosion (p-value=0.149). Similar trends were observed in HTZ samples (p-value=0.853). Additionally, when comparing glazed samples between E-max and HTZ, Results showed that there was no statistically significant difference between both materials (E-max/HTZ) p-value=0.067. While for the polished samples there was statistically significant difference between both materials (E-max/HTZ) favoring the superior translucency of polished E-max samples over HTZ ones. p-value=0.029.

Conclusions: The translucency parameter (TP) of the studied materials is not significantly affected by the finishing procedure (mechanical polishing or glazing). But compared to glazing, mechanical polishing produced better translucency outcomes for the examined samples. Also corroded E-max exhibits superior translucency in comparison to HTZ.

Keywords: Dental ceramics, emax, HTZ, finishing, glazing, polishing, corrosion, translucency.

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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.[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 impact the translucency of the tested ceramics but with no statistically significant difference when comparing the two materials, regardless of the finishing method employed.

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 translucency 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)

1. 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).

2. 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 prepolishing 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. 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]

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]

Evaluation of translucency parameter

Translucency is the property of a substance that permits the passage of light but disperses the light so that an object cannot be observed clearly through the material, i.e., a state between complete opacity and transparency. Based on the CIE L*a*b* system, the translucency of a material is usually determined with the translucency parameter (TP). TP refers to the color difference of a uniform thickness of a material over black and white backgrounds, which corresponds directly to the visual assessments of translucency. The greater the TP value, the higher the actual translucency of a material. If the material is absolutely opaque the TP value is zero and if the material is totally transparent TP=100.

The TP of the corroded samples was obtained by calculating the color difference between the specimen over the white background and that over the black background by the following equation:

$$TP = [(Lb - Lw)^2 + (ab - aw)^2 + (bb - bw)^2]^{1/2}$$ [9]

Where 'b' refers to the color coordinates over the black background and 'w' refers to those over the white.

The color parameters L*a*b* was obtained by measuring the samples using easyshade spectrophotometer (fig. 2).

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 one-way ANOVA was conducted. A p-value less than 0.05 was considered significant.

Fig. (1): Handpiece holder

Fig (2): Easyshade spectrophotometer

RESULTS

The mean and standard deviation of the Translucency Parameter (TP) was measured for both material groups, lithium disilicate (IPS E-max CAD) and high translucency zirconia (HTZ) and among the subgroups according to finishing technique (glazing and polishing). The results measured and presented in tables: (1,2) and figure (3)

i- TP of (E-max samples)

Results showed that there was no statistically significant difference between the subgroups (glazed/polished) p-value=0.149 (table, 1 fig, 3).

ii- TP of (HTZ samples)

Results showed that there was no statistically significant difference between the subgroups (glazed/polished) p-value=0.853. (table,1 fig,3)

iii- TP of the (glazed samples)

Results showed that there was no statistically significant difference between the glazed samples of both materials (E-max/HTZ) p-value=0.067 (table, 2 fig, 3)

iv- TP of the (polished samples)

Results showed that there was statistically significant difference between the polished samples of both materials (E-max/HTZ) p-value=0.029.

Where the polished E-max group shows more translucency than polished HTZ group. (Table, 2 fig 3)

Table (1): TP of (E-max and HTZ groups)

TP Mean ± SD	Method		P-value
	Glazed	Polished	
E-max group	14.67 ± 1.27	15.79 ± 1.68	0.149
HTZ group	13.76 ± 0.21	13.85 ± 1.4	0.853

Table (2): TP of (Glazed / polished samples of both material groups)

ΔE Mean ± SD	Material		P-value
	E-max	HTZ	
Glazed samples	14.67 ± 1.27	13.76 ± 0.21	0.067
Polished samples	15.79 ± 1.68	13.85 ± 1.40	0.029*

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

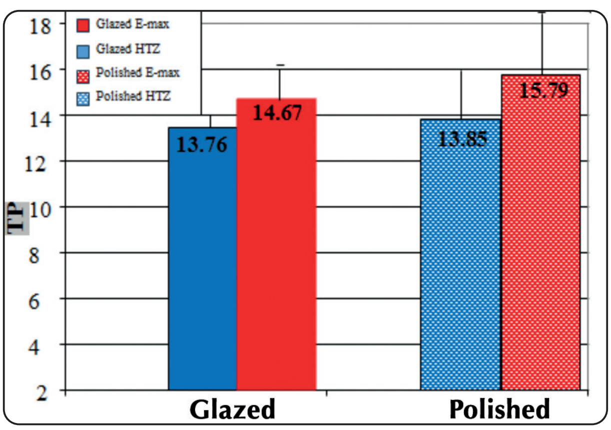

Fig (3): TP of E-max and HTZ groups, glazed and polished subgroups

DISCUSSION

The current research explored how finishing technique impacts the translucency of two ceramic types, distinguished by either glazing or polishing as finishing method. 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[7], 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. [10] Additionally, acetic acid is a commonly utilized acid for domestic applications. [11]

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]

Aging of the tested ceramics has been done after finishing of the ceramic samples to resemble the effect of oral environment on the ceramic restorations.

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. [12,13,14]

Type of surface finishing is an important factor in color stability. [15] Several ceramic materials and polishing systems are now available. In the current study, polishing was performed for the specimens according to manufacturer's instructions, and regarding the evidence proving that surface luster and translucency is improved with properly polished surfaces. [16]

Several studies have confirmed that various chair-side ceramic polishing systems yield surfaces as smooth as those achieved through glazing. [17,18]

A spectrophotometer was used in this in vitro investigation because of its ability to produce objective measurements without the subjective influence of color. [19]

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

The present results agreed with El-Sharkawy (2020) [20], who reported that the staining drinks and coffee have a negative effect on translucency of lithium silicate and disilicate materials. Also they showed that the mechanical polishing showed a better translucency results for both matrials; This could be attributed to the glaze layer may reflect part of the incident light prisms, so the amount of light passing through the materials is decreased. [20].

The results of TP evaluation also agreed with Demirel (2022)[21] who showed that the lithium disilicate samples showed the highest values of TP along the study. They explained that chemical composition and crystalline structure have a greater influence on translucency. [21]

This result of current study was in contradiction with Alp G et al (2018) [22] who found that the glazed e-max group presented higher translucency than polished surfaces. Difference between the current study and those in the study by Alp G et al may be due to the differences between the evaluated thicknesses of the tested material.

Finally, the present study was in contrast with Roxanaet al (2023) [23] as they showed that after aging; an increase in TP values was reported for lithium disilicate and zirconium samples. An increase in translucency, explained by the reduction of light scattering from the boundaries of the cubic phase particles as during the aging process. Also they stated a lower TP values of polished Ceramill Zolid fx; An explanation for the decrease in TP of polished CeZ would be that the high roughness of the material negatively affects the appearance of the surface. [23]

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- Commonly the finishing technique (mechanical polishing/glazing) has statistically no significant effect on the translucency parameter (TP) of the tested materials.

2- Mechanical polishing showed better translucency results than glazing of the tested samples.

3- Corroded E-max has a better translucency than corroded HTZ.

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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