IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 21, Issue 5 Ser.6 (May. 2022), PP 12-16
www.iosrjournals.org

Color Reproduction of Lithium Disilicate Ceramics: The Effect of Surface treatment and ceramic thickness. (In vitro study)

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Abstract:
***Background**: The aim of the current study is to evaluate the color reproduction of lithium disilicate ceramics after two types of surface treatments (laser surface treatment and Hydrofluoric acid etching)*
***Materials and Methods**: twenty-eight specimens will be sliced into two thicknesses (0.3 & 0.5 mm). Then color reproduction is measured before and after the applied surface treatment.*
***Results**: Results showed a significant difference in color reproduction between different treatments with different thicknesses. Hydrofluoric acid etching had a significantly higher value than laser surface treatment. 0.3mm thick samples also had a significantly higher value than 0.5mm thick samples.*
***Conclusion:** Within the limitation of this in vitro study it may be concluded that Surface treatment has a great influence on the color change (ΔE), with laser surface treatment being superior to hydrofluoric acid etching. Also, Lower thicknesses of ceramics get affected by the type of surface treatment more than higher thicknesses*
***Key Word**: Lithium disilicate; Color change; Emax; Laser; Surface treatment.*

Date of Submission: 10-05-2022 Date of Acceptance: 25-05-2022

I. Introduction

Cosmetic dentistry is comprehensive oral care that combines both art and science to optimally improve dental health, esthetics and function. Its objective is to provide maximum esthetic outcome with minimum trauma to the dentition. IPS e.max CAD is the machinable form of lithium disilicate glass ceramic that was introduced in 2007 by Ivoclar Vivadent to be milled using CAD/CAM technology. It has become always the material of choice to fabricate esthetic restorations especially ceramic veneers because of its light diffusion property which is capable of replicating the natural tooth structure. (1) The final color of a ceramic restoration could be influenced by translucency, opalescence, fluorescence, surface texture, the number of porcelain firings. (2-3) Previous studies showed that the color of the underlying tooth and the luting cements can have great influence on the final appearance of the ceramic restoration. However, there is no existing knowledge about the surface treatments' effect on the translucency values of these esthetic restorations.

II. Material And Methods

In the existing in-vitro study, twenty-eight specimens were constructed from IPS e-max blocks (lithium disilicate glass ceramics) with two thicknesses (0.3 and 0.5 mm), color reproduction was evaluated after laser and acid etching.
Study Design: In-vitro study
Study Location: Study done in Department of Fixed prosthodontics, Ain-shams University, Egypt.

Study Duration: November 2021to March 2015.
Sample size: 28 specimens.
Sample size calculation: A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that the effects of different tested variables and their interaction are not significant. By adopting an alpha level of (0.05) a beta of (0.8) i.e. power=80% and an effect size (f) of (0.77) calculated based

on the results of a previous study, the predicted sample size (n) was found to be (28) samples. Sample size calculation was performed using G*Power[1] version 3.1.9.7.

Procedure methodology

Ceramic Sample preparation:

(A) Ceramic Sectioning

IPS e.max CAD Figure (1) was sectioned by low-speed diamond saw[2], Figure (2) with thickness of 0.3mm and 0.5 mm.

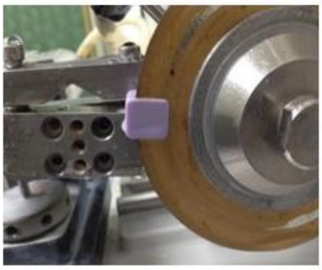

Figure 1

Figure 2

(B) Crystallization and glazing of IPS e.max samples:

- IPS e.max CAD crystal/Glaze paste was applied evenly on the sample using a brush.

Combination firing (Crystallization/glaze) was selected in compatible furnace.

(c) Ceramic Surface treatment

- Ceramic samples were held using a veneer stick and etched by HF acid for 20 seconds then rinse the ceramic thoroughly with water for 60 seconds to completely remove the etchant and dried using oil free air (Figure 3).

Figure 3

(D) LASER Application:

Er,Cr:YSGG laser with wave length 2780nm, pulsed lased-powered hydrokinetics, was used. Vapor and air were adjusted to 50% of the laser unit. (Figure 4)

[1] **Faul, Franz, et al.** "G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences." *Behavior research methods* 39.2 (2007): 175-191.

* [2] IsoMet™ 4000, BUEHLER. USA

Figure 4

(E) Color Measurement:
The apparatus used in measurements is Cary 5000 Spectrophotometer provided from Agilent Technologies (USA) Figure (5).

Figure 5

Statistical analysis

Numerical data were explored for normality by checking the data distribution using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed parametric distribution so; they were represented by mean and standard deviation (SD) values. Three-way ANOVA was used to study the effect of different tested variables and their interaction on color change and surface roughness. Comparison of main and simple effects were done utilizing multiple t-tests with bonferroni correction. The significance level was set at $p \le 0.05$ within all tests. Statistical analysis was performed with IBM[3] SPSS[4] Statistics Version 26 for Windows.

III. Result

Table (1): Descriptive statistics of color change (ΔE).

Material	Thickness	Treatment	Mean	SD	Median	Range
Group A: (IPS e.max)	**0.5 mm**	**Laser**	1.43	0.23	1.39	0.58
		Acid etching	4.08	0.33	4.03	0.76
	0.3 mm	**Laser**	2.11	0.36	2.20	0.93
		Acid etching	6.13	0.26	6.08	0.69

Effect of different variables and their interaction:
Effect of different variables and their interaction on color change (ΔE) were presented in table (2).
There was a significant interaction between thickness and type of treatment ($p<0.001$).
Effect of treatment on color change of IPS e.max glass ceramics:

[3] ® IBM Corporation, NY, USA.

[4] ® IBM Corporation, NY, USA.

1-IPS e.max:

- 0.5 mm:

Acid etched samples (4.08±0.33) had a significantly higher value than laser treated samples (1.43±0.23) ($p<0.001$).

- 0.3 mm:

Acid etched samples (6.13±0.26) had a significantly higher value than laser treated samples (2.11±0.36) ($p<0.001$).

-Effect of thickness on color change of IPS e.max glass ceramics:

1-IPS e.max:

- Laser:

0.3 mm thick samples (2.11±0.36) had a significantly higher value than 0.5 mm thick samples (1.43±0.23) ($p=0.010$).

- Acid etched:

0.3 mm thick samples (6.13±0.26) had a significantly higher value than 0.5 mm thick samples (4.08±0.33) ($p<0.001$).

Table (2): Effect of different variables and their interactions on color change (ΔE).

Source	Sum of Squares	df	Mean Square	f-value	p-value
Material	2.16	1	2.16	28.52	<0.001*
Thickness	22.05	1	22.05	291.13	<0.001*
Treatment	113.44	1	113.44	1497.62	<0.001*
Material*Thickness	0.14	1	0.14	1.86	0.183ns
Material*Treatment	0.01	1	0.01	0.13	0.718ns
Thickness*Treatment	4.42	1	4.42	58.29	<0.001*
Material*Thickness*Treatment	0.01	1	0.01	0.05	0.830ns

df=degree of freedom*; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

IV. Discussion

Recently, the revolution in dental ceramics in respect to microstructure, optical properties and mechanical properties offered wide range of indications; Moreover, the increase in demand and interest in achieving ultimate esthetic paved the way to the use of ceramic restorations in anterior zone. [(4)] Due to its optical properties, increased masking capacity and strength properties, lithium disilicate was also selected in this study, allowing it to be used in thin sections without affecting both esthetically and functionally the final results. It is composed of needle-like glass ceramic crystals that comprises about two thirds of the glass ceramic volume. Because of the relatively low refractive index of lithium disilicate crystals, this material can be very translucent even with high crystalline content [(5)].Recently, minimally invasive veneer preparation designs have become popular. These involve less tooth reduction, partial coverage, and minimal porcelain thickness. Minimally invasive veneers have also been described as being mini, minimal, minimal thickness, ultraconservative, ultrathin, partial, or sectional veneers. A thickness of 0.3 mm has been reported for minimally invasive veneers, whereas conventional porcelain veneers generally range from 0.3 to 1.0 mm in thickness. [(6,7)] Therefore, thin ceramic thicknesses of 0.3 mm and 0.5 mm were used in this study. The IsoMet 4000 low speed precision saw was used in this study to cut materials with minimal sample deformation and low kerf loss. For standardization, all the specimens were manipulated by the same operator according to the manufacturers' recommendations. To simulate the clinical situation of laminate veneer restoration, one of the surfaces of the specimens was glazed while the other surface was subjected to the intended surface treatment. Different surface treatments were applied in this study on the CAD/CAM material surface to be evaluated and tested, these surface treatments include: acid etching (9.5% buffered hydrofluoric acid) followed by silane primer and laser treatment using Er,Cr:YSGG pulsed laser followed by silane primer. The first applied surface treatment was hydrofluoric acid etching. As acid etching is the most commonly employed technique to improve the bond strength. The HF surface treatment modifies the microstructures of CAD/CAM ceramic surface by partial dissolution of the glassy phase of the ceramic, forming micro porosities on the ceramic surface. [(8)] It increases the surface area by creating micro-pores into which uncured flowable resin penetrates to provide durable micro-mechanical interlocking. [(9)]However, HF etching can decrease the flexural strength of ceramics [(10)]. In addition to its high reactivity and toxicity, and thus, laser surface treatment was suggested.Understanding the optical properties of ceramic CAD/CAM restorative materials after surface treatment is valuable to improve esthetic outcome of the monolithic restorations [(11)]. Color differences can be evaluated visually or by color measurement devices. Most color measurement devices utilized in dentistry use the ΔE from the commission international d'Eclairage CIE ($L^*a^*b^*$) color system inherits the advantage of being repeatable, sensitive, objective, universally accepted, and can measure small color differences [12].A laboratory spectrophotometer was utilized in the current study instead of visual examination as a standard quantifying device for precise, reproducible and statistically utilizable results [13-14]. It is suggested that the visually perceptible but clinically accepted level of color change is ΔE values 2.75 for ceramics, thus, it was chosen as a reference for this study. [15] The results of the current study revealed that using hydrofluoric acid 9.5% concentration as a surface treatment for lithium disilicate based ceramics has recorded the highest color change (*ΔE)* values when compared with laser surface treatment, and this result was in co-ordinance with **Hafez et al** [16], who observed that applied surface treatments could affect the color of ceramics. Changes in roughness due to these treatments could affect the passage of light through the ceramic lowering its translucency. This could explain why hydrofluoric acid showed higher values of *ΔE.* All color change values (ΔE) of laser treatment were clinically acceptable, however hydrofluoric acid etching showed unacceptable higher color change values (ΔE) above 2.75. On the contrary **Turgut et al** [17] showed HF etching did not affect the optical properties of the ceramic veneers. and these may be attributed to using ultrasonic cleaning before the color measurements.In this study, it was found that the lower thickness had a significant higher color change values after surface treatment and this result was in accordance with **Turgut et al** [17] who showed that the color change of the ceramics increased after the surface treatments, particularly as the ceramics became thinner.This study found that 0.5 mm-thick specimens showed less color change than 0.3-mmthick specimens. Given that translucency of the ceramic material decreases with increasing thickness, 0.5-mm-thick specimens might mask the effect of surface treatments more effectively than thinner ceramic specimens.However, this study has some limitations based on its in vitro procedure. The results are related only to the type of ceramics and surface treatments used. Moreover, surface topography, bond strength and ceramic strength were not assessed which can influence the clinical application. Therefore, additional in vitro and clinical studies are recommended for predictable outcomes.

V. Conclusion

Within the limitations of this in Vitro study, it could be concluded that:

-Surface treatment has a great influence on the color change (ΔE), with laser surface treatment being superior to hydrofluoric acid etching.

-Lower thicknesses of ceramics get affected by the type of surface treatment more than higher thicknesses.

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