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Translucency of different pressable lithium silicate Ceramics with two thicknesses - An in vitro study –

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Abstract:
Background: *Dental ceramic restorations are widely spread nowadays due to their aesthetics and biocompatibility. In time, the colour and structure of these ceramic materials can be altered by aging processes. How does artificial aging affect the optical properties of ceramics?*
This study was to evaluate translucency of different pressable lithium silicate ceramics, with two thicknesses, before and after hydrothermal aging. Also the purpose of this study was to investigate the relationship between translucency and the thickness of different dental ceramics . A new material, zirconia-reinforced lithium disilicate , Vita Ambria was recently introduced for fabrication of monolithic anterior crowns to overcome the aesthetic drawbacks of traditional zirconia and also to improve the strength of the lithium disilicate.
Materials and Methods : *In this in vitro study , Fourty two wax specimens were machined from their respective blocks by using a low speed diamond saw (Buehler-Isomet 4000) , the fourty two sample were prepared and divided into 3 groups according type of ceramic used .*
Group A (Vita Ambria) , group E (Emax press) , group C (Celtra press) . Each group was further subdivided into two subgroups according to specimen thickness , subgroup I : specimens 0.3 mm thickness , subgroup II : specimens 0.5 mm thickness , the wax specimens were sprued and invested to be ready for the pressing procedure , after pressing is done ,finishing and glazing of the ceramic specimens was done , aging will be done by thermocycling . Translucency testing using spectrophotometer vita easyshade 4.0 was done before and after aging.
Results : *There was a significant difference between different groups . The highest value was found in Emax , followed by Vita ambria , while the lowest value was found in Celtra press.*
Conclusion: *The translucency parameter of dental ceramics was significantly influenced by both material and thickness. The translucency of all materials increased as the thickness decreased, although the amount of change was material dependent.*
Keyword *:Translucency , Emax press ,Celtra press, zirconia lithium silicate , hydrothermal aging .*

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I. Introduction

Ceramic Restoration have gained Fame and are now applied in daily practice(1). Their use which has been considered just an aesthetic treatment, has recently expanded, mainly due to the superior Optical properties of new glass ceramics and to the improvement of the cementation strategies. Porcelain laminate veneers of minimum thickness provide satisfactory esthetic results and biocompatibility(2).

A new addition to the lithium ceramic family is lithium silicate ceramic with the same basic components but with the new addition of 7.6% germanium dioxide improving properties like castability, thermal expansion and refractive index, and increasing the final density, resulting in a higher mechanical properties .Recently, 10% by weight zirconia has been added to lithium silicate ceramic (referred to as zirconia reinforced lithium silicate or ZLS) offering “a homogeneous, fine crystalline structure with an average crystal size of 0.5 μm compared to the needle-shaped crystals with an average size of 1.5 μm found in the lithium disilicate ceramic.

Currently, fixed dental prostheses (FDPs) of lithium-silicate (LD) ceramic have been recognized as an excellent option for dental rehabilitation, being indicated for manufacturing anterior and posterior monolithic crowns (3) .

There are two completely distinct protocols recommended regarding available processing techniques for their manufacture: one technique that is based on high vacuum injection, where ceramic ingots are pressed into a waxed crown inclusion in a special cast investment through the lost wax technique; and another based on the current principles of digital dentistry using CAD/CAM (Computer Aided Design/Computer Aided Machining) systems , which presents advantages of high precision, efficiency, and accuracy which have reduced processing time.[(4)]

The translucency of dental ceramics is complex, and many variables contribute the final appearance produced. Illuminant wavelength alters translucency; the higher the wavelength, the more translucent a material appears. Material thickness is another factor that affects the translucency.[(5)]

Pressable dental ceramics are supplied as ingots, which are melted at high temperatures and then pressed into a lost wax mold (hot pressing technique). The pressed restoration can either be made to anatomic contour or used as a substructure for veneering with a conventional feldspathic porcelain [(6)]

Popular pressable ceramics include lithium disilicate glass-ceramics such as e.max press (IvoclarVivadent AG) and the newly introduced Initial LiSi (GC), which uses high-density micronization technology (LDSHDM). This material depends on equally dispersed lithium disilicate microcrystals rather than larger size crystals to fill the entire glass matrix.[(7)]

The behavior of the aesthetic dental restorations during their clinical use is essential. In vitro studies may simulate the oral environment to study the behavior of the restorations, based on the type of material and processing method, to achieve reliable restorations. The clinical success of the dental restoration is defined by its longevity, which is substantially influenced by the oral environment. For a reasonable estimation of the long-term stability of dental restorative materials in the clinical situation, artificial aging tests to simulate oral environmental variables, and thermal cycling should be designed.[(8)]

The oral environment contributes to long-time degradation. New ceramic materials with different microstructure draw the attention from this point of view because a material that is the most strength is not necessary to respond better to aging and have a higher survival rate.[(9)]

The translucency of dental materials is depended on many factors, such as the ratio of the crystalline/glass phases and the difference in the refractive index between these phases, the morphology of crystals, grain boundaries, pores, second-phase component, additives, and light scattering from the surface. High crystalline content is associated with high opacity when the two phases have different refractive indexes, but the high translucency of LDS glass-ceramics is attributed to the matching of the refractive index of the crystal phase to that of the glass matrix. The opacity of these materials is attributed to the interlocking microstructure of LDS crystals and their sizes.[(10)]

There are two methods to evaluate translucency and opacity of esthetic restorative materials; Absolute Translucency by direct transmittance of light, and Relative Translucency using either the contrast ratio (CR) or the translucency parameter (TP).[(11)]

The TP is defined as the color difference determined from the L*a*b* values, between a uniform thickness of a material over a white and black backing. It is calculated according to the equation: TP = [(LB– LW)2 + (aB– aW)2 + (bB– bW)2] 1/2 where L* refers to the brightness, a* to redness to greenness, and b* to yellowness to blueness. The subscript w refers to color coordinates CIELAB with the white backing and the subscript b refers to those with the black backing.[(12)]

VITA Easyshade is an intra-oral digital spectrophotometer for chairside shade assessment. It uses D65 illuminant for shade matching and has a database of all classic and 3D-master shades. Easy handling, the ability for good communication, and its availability as a portable device are some advantages.[(13)]

II. Materials and Methods

In this in vitro study, the specimens were prepared and divided into 3 groups according type of ceramic used :

- Group A: Specimens fabricated from (Vita Ambria by Vita Zahnfabrik, Bad Säckingen, Germany) pressing technique.
- Group C: Specimens fabricated from (Celtra press by Dentsply Sirona, Bensheim, Germany) pressing technique.
- Group E: Specimens fabricated from (IPS E.max press by IvoclarVivadent AG, Liechtenstein) pressing technique.

Each group was further subdivided into two subgroups according to specimen thickness:

- o Subgroup I: Specimen 0.3 mm thickness.
- o Subgroup II: Specimen 0.5 mm thickness.

Study Design: in vitro comparative study .
Study Location: This was a study done in Department of Fixed Prosthodontics, at Ain shams University, Cairo, Egypt.
Sample size: Fourty two wax specimens .
Sample size calculation: To determine the number of specimens that would be required for each test group, power analysis was conducted, according to the results of Maroulakos et al. 45 , the predicted sample size was found to be a total of 42 samples. A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that there is no difference would be found between tested groups. By adopting an alpha (α) level of (0.05), a beta (β) of (0.2) (i.e. power=80%), and an effect size (f) of (0.810) calculated based on the results of a previous study; the predicted sample size (n) was found to be (42) samples (i.e. 7 samples per group). Sample size calculation was performed using G*Power version 3.1.9.7.

Procedure methodology:
A total of Fourty two wax specimens were machined from their respective blocks by using a low speed diamond saw (Buehler-Isomet) to the required thickness of subgroup I (21 samples) 0.3 mm and subgroup II (21 samples) 0.5 mm .A digital caliper was used to verify the thicknesses .
The specimen wax patterns of the three glass ceramic materials (e.max press, celtra press and vita ambria) were sprued and attached to the base former with surrounding IPS silicone ring .Three different Investment materials were used according to the material type .
The mold then heated in a burnout furnace to 850 °C for one hour with the sprue hole down ,Once the preheating cycle has been completed, the cold Press ingot was inserted into the hot investment ring, then the powder-coated cold Alox plunger was placed into the hot investment ring, the investment ring was placed at the center of the hot press furnace using the investment tongs. Then start the selected program according to the selected material. (Programat EP 3010) .
After cooling to room temperature Rough divestment is carried out with glass polishing beads at 4 bar (60 psi) pressure until the objects are visible.
Investing, heat pressing and divestment procedures were carried out according to the manufacturer's instructions. The sprues and buttons were then separated from the pressed discs using a diamond cutting wheel saw .
Finishing of the ceramic discs was performed using a clinical dental handpiece with twist polishers (LUS05 Luster extra-oral twist porcelain polishing kit, Meisinger USA LLC). It is used for finishing, eliminating scratches, and smoothening surfaces as recommended by the manufacturer.
Specimens were cleaned with distilled water in the ultrasonic bath, to eliminate any remaining residue on the surface, and dried completely .
Glazing technique firing protocol was performed using a Programat EP 3010 Furnace which used for firing cycles and parameter set according to manufacturer's recommendations for each material. Finally, the thicknesses of the specimens were checked using a digital caliper.

Vita Easyshade4.0 :
Subgroups A E C (n=42) were measured for translucency using a Vita Easyshade spectrophotometer Advance 4.0 , For measuring translucency, the translucency parameter (TP) of three subgroups A E C (n=42) was detected using the Vita Easyshade spectrophotometer Advance 4.0 through diffuse reflectance method .
The TP was detected by calculating the color difference for each specimen of both thicknesses of 0.5mm and o.3mm when it was placed over a white background and then over a black background .Translucency parameters were determined for all specimens before and after thermal cycling.

Hydrothermal aging:
The specimens were submitted to 5000 thermocycles in a thermal cycling simulation machine to estimate 6 months of oral conditions. Subgroups A, C and E (n=42) were measured for color stability and translucency after hydrothermal aging using a Vita Easyshade spectrophotometer advance 4.0 and recorded similarly as before .

Statistical analysis:
Numerical data were presented as mean and standard deviation (SD) values. They were explored for normality by checking the data distribution, and using Shapiro-Wilk test. Data showed parametric distribution so three-way mixed model ANOVA was used for the analysis. Comparison of main and simple effects were done utilizing one-way ANOVA followed by Tukey's post hoc test for independent samples and paired t-test for paired samples. P-values were adjusted for multiple comparisons utilizing Bonferroni correction. The

significance level was set at $p \leq 0.05$. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows.

III. Results

1- Effect of different variables and their interaction:

Effect of different variables and their interaction on translucency parameter (TP) were presented in table (1) and figure (1) :

Material, thickness and aging all had a significant effect on translucency ($p<0.001$), while all the interactions were not statistically significant ($p>0.05$).

2- Effect of Material:

Mean, Standard deviation (SD) values of translucency parameter (TP) for different materials were presented in table (1) .

There was a significant difference between different groups ($p<0.001$). The highest value was found in Emax ,followed by Ambria , while the lowest value was found in Celtra. Post hoc pairwise comparisons showed Celtra to have a significantly lower value than other groups ($p<0.001$).

3- Effect of thickness:

Mean, Standard deviation (SD) values of translucency parameter (TP) for different thicknesses were presented in table (1)

0.3 mm thick samples had a significantly higher value than 0.5 mm thick samples ($p<0.001$).

4- Effect of aging:

Mean, Standard deviation (SD) values of translucency parameter (TP) before and after aging were presented in

Material	Thickness	Translucency parameter (TP) (mean±SD)		p-value
		Before aging	After aging	
Emax	0.3 mm	32.20±1.41	29.98±1.10	**0.007***
	0.5 mm	27.52±2.89	25.87±3.08	**0.011***
Celtra	0.3 mm	29.60±2.58	26.10±2.19	**0.023***
	0.5 mm	24.19±0.34	21.79±0.55	**<0.001***
Ambria	0.3 mm	31.24±1.08	29.69±0.85	**0.002***
	0.5 mm	26.54±1.54	23.64±1.10	**0.011***

table (1)

Value measured before aging was significantly higher than value measured after aging ($p<0.001$) .

Table (1): Mean, Standard deviation (SD) values of translucency parameter (TP) before and after aging within other variables

*; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

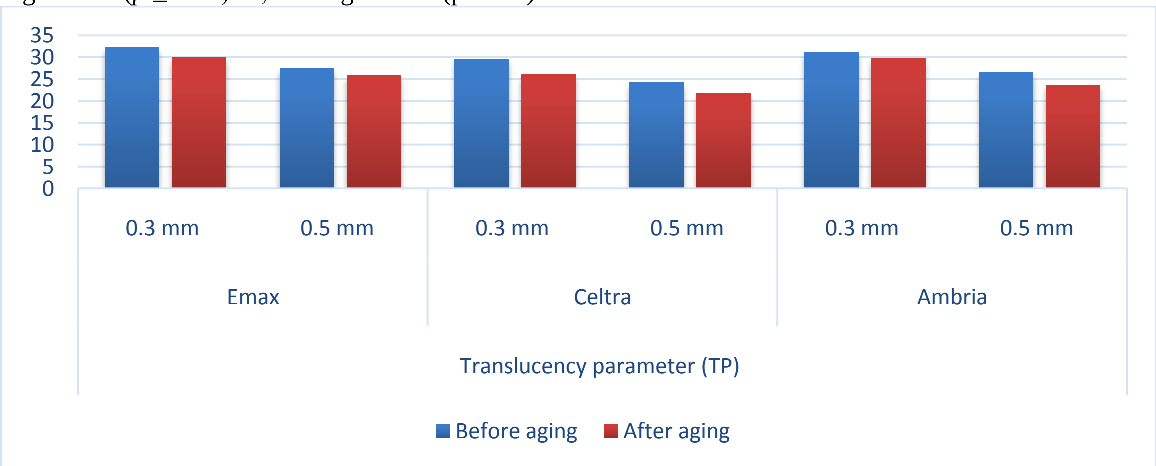

Figure (1): Bar chart showing average translucency parameter (TP) before and after aging within other variables

IV. Discussion

Ceramic veneers have superior properties in both esthetic and tooth preservations and are considered as minimally invasive treatment for indirect esthetic restoration.[(14)]

The objective of the current study were to investigate the effect of three different Pressable materials with different thicknesses on the translucency potential. The vita easy shade spectrophotometer was performed on the three different materials with two different thicknesses to measure the translucency.

The development of dental ceramic techniques offered a veneer thickness of about 0.3–0.5 mm, decreasing tooth reduction amount and ensuring it to be within the enamel structure and effective bonding(15)
Different thicknesses were studied to test the relationship between translucency and thickness as it was said that the relationship between contrast ratio and the thickness is linear.(16)
A lot of procedures were implemented in the current study to securely protect the target as well as aid in its standardization. Square-shaped specimens were fabricated instead of veneers, to guarantee that the light is reflected at the same level and distance from the specimen surface to the lens of the spectrophotometer, and to eliminate any other factors which may affect translucency as surface curvature, cement shade or natural tooth discoloration.(17)
Vita Easyshade spectrophotometer was used to measure all samples as recommended by previous studies(18,19,20)it is simple, easy and accurate. Dozić et al (21)reported that Vita Easyshade was the most reliable appliance of shade matching in both in vivo and in vitro situations.
A white and a black background were elected to analyse the samples; the black one represents the clinical situation on the anterior teeth and the white one is used for the posterior teeth (22)(23)
Studies that evaluate the optical properties of the ceramics often immersed the samples in artificial saliva and other beverages, but additional studies used thermocycling the materials at different temperatures and for several cycles simulating the oral environment.(24)
For this study 5,000 cycles were elected to represent 6 months of oral environment. A study conducted by Acar et al(25)in which the color difference and translucency after thermocycling was evaluated after 5,000 cycles corresponding to 6 months of clinical services.
Translucency of the tested materials in the current study has significantly decreased for all ceramic materials with each incremental increase in specimen's thickness, that goes in accordance with other studies, who reported the significant decrease in the translucency parameter of ceramics materials with increasing specimens the thicknesses.(26)
Antonson and Anusavice (2001) investigated that translucency of dental ceramics is a function of ceramic thickness. They found a positive linear correlation between contrast ratio and thickness.(27)
Wang et al. (2013) who reported that the translucency of dental ceramics was greatly affected by two important factors which are the material type and it's thickness. the translucency of all materials increased exponentially as the thickness decreased(28). Which also in agreement with Shamseddine et al. (2017) who reported that as we increase the thickness between 0.6 and 0.8 mm and between 0.6 and 1 mm there is a difference in the TP(29)
Heffernan et al. (5)concluded that the range of translucency in ceramics at clinically relevant thicknesses resulted from different crystalline composition.
All of these previous studies came in agreement with our study which confirmed a significant increase in translucency was also found as a result of the decrease in thickness.
The results from this study showed that the colour coordinates of the samples before and after thermocycling differed from each other and that thermocycling had a significant impact on translucency, These materials were chosen because of their frequent use among practitioners. Colour measurements of the samples with spectrophotometer showed that all tested materials had different colour coordinates even though they were all chosen A1 LT and this means that the colour coordinates are more related to the material. These results were also found in the literature(30)Of the hot-pressed materials before thermocycling, the ceramic that had higher translucency is Emax Press glazed and the lowest is Celtra Press glazed. Emax Press has lithium disilicate crystals with a dimension between 3–5 µm and it is easy to be polished and light can pass easily. Celtra Press contains 10% zirconia particles that increase opacity and decreases translucency.
It was found in our study regarding translucency parameter (TP) that lithium disilicate glass ceramic showed higher mean of translucency than zirconia-reinforced lithium silicate glass ceramic.
This was in agreement with some previous studies which reported that Lithium disilicate have a higher TP than Zirconia Lithium Silicate (31)(32)(33)
Wang et al. reported TP values of the glass-ceramics that ranged from 2.2 to 25.3 and the zirconia ceramics from 5.5 to 15.1 (28), which is similar to the results of our study that declared TP for Lithium disilicate glass-ceramic glazed specimens was (28.89±3.24) followed by Ambria (27.78±3.19), while the lowest value was found in Celtra-press (25.42±3.33) Significantly higher rate of translucency in lithium disilicate glass ceramic in comparison to the zirconia ceramics.
This was also found in Baldissara et al., Kur- tulmus-Yilmaz et al. and many others(34, 35), this finding can be attributed to the crystalline content of zirconia in order to achieve a greater strength results, but at the same time the inhomogeneity of crystals causes different refractive indices and therefore poor translucency.
Other studies agreed and reported that ZLS exhibits lower translucency than Lithium disilicate ceramics both before and after thermocycling(36,37), probably due to the larger crystal dimensions and the higher firing temperature of Lithium disilicate ceramics.(32)

They attributed the difference in translucency to the difference in the crystalline content of the materials, where increasing the crystalline contents often result in greater opacity.
However, the results of the current study were not consistent with Eladawy et al [83]who found that translucency parameter (TP) of zirconia-reinforced lithium silicate glass ceramic showed higher mean of translucency than lithium disilicate glass ceramic.
Also Awad et al [39]and Arif et al [33]found a higher TP for ZLS (Celtra Duo; Dentsply Sirona) than LDS (IPS e.max CAD; IvoclarVivadent AG).
Similar TP values was found with Yildirim [18] as no statistically significant difference were found for both the LDS and ZLS groups (P =.055). This finding could be attributed to the similar composition of LDS and ZLS ceramics.
The null hypothesis that translucency was not influenced by the type or thickness of ceramics was rejected .
Among the limitations in this study is that only three pressable Ceramic brands were compared. Other ceramic material available on the market may behave differently under simulated oral aging.
Although thermocycling was used to age the samples to simulate the intraoral condition, it does not replicate the intraoral environment holistically and what the restorative materials are exposed to other than the thermal factor.
Another limitation in this study is relying on disc shaped specimens to evaluate the material properties rather than more clinically relevant restorations and different prosthetic designs.
Further in-vitro studies together with long-term in-vivo investigations are needed to confirm the clinical implications of these findings.

V.Conclusion

Within the limitations of this in vitro study the following conclusions could be drawn:

1. The translucency parameter of dental ceramics was significantly influenced by both material and thickness. The translucency of all materials increased as the thickness decreased, although the amount of change was material dependent.
2. Decreasing the pressable Ceramic materials thickness to 0.3 mm revealed better translucency than 0.5 mm thickness.
3. The translucency of three studied materials were significantly affected by hydrothermal aging.
4. Lithium Disilicate material showed better translucency than the zirconia reinforced glass ceramics.
5.

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