

EFFECT OF INGOT THICKNESS AND TRANSLUCENCY OF LITHIUM DISILICATE GLASS CERAMIC AND FINAL SHADE: AN IN VITRO STUDY

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Introduction: laminate veneers can alter the final shade depending on factors like resin cement shade or material used. Other factors such as ceramic thickness and translucency will be discussed in this study.

Methods: The study sample consists of 60 discs made of lithium disilicate glass ceramic divided into four groups (HT, LT, MO, HO) according to their translucency, each group was subsequently divided into three subgroups (1, 0.75, 0.5 mm) according to their thickness. L, a, b values were measured for each disc. One-Way ANOVA was carried out with 95% confidence interval.

Results: Statistical analysis showed significant difference between all groups in L, a, b and ΔE parameters

Conclusions: MO, HO translucencies have the ability to mask substrate shade and giving value, whereas HT, LT translucencies have a slight ability in modification substrate hue without any noticeable change in value. Increasing ceramic thickness can aid in shade modification.

Keywords: Lithium disilicate, Lithium Compounds, Shade, Translucency, Thickness.

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Conflicts of interest:

The authors declare no conflicts of interest.

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EFFET DE L'ÉPAISSEUR DU LINGOT ET DE LA TRANSLUCIDITÉ DE LA VITROCÉRAMIQUE AU DISILICATE DE LITHIUM ET TEINTE FINALE : ÉTUDE IN VITRO

Introduction: La teinte finale des facettes stratifiées peut varier en fonction de facteurs tels que la teinte du ciment-résine ou le matériau utilisé. D'autres facteurs, tels que l'épaisseur et la translucidité de la céramique, seront abordés dans cette étude.

Méthodes: L'échantillon étudié comprenait 60 disques en vitrocéramique au disilicate de lithium, répartis en quatre groupes (HT, LT, MO, HO) selon leur translucidité. Chaque groupe a ensuite été divisé en trois sous-groupes (1, 0,75, 0,5 mm) selon leur épaisseur. Les valeurs L, a et b ont été mesurées pour chaque disque. Une analyse de variance à un facteur a été réalisée avec un intervalle de confiance à 95 %.

Résultats: L'analyse statistique a montré une différence significative entre tous les groupes pour les paramètres L, a, b et ΔE .

Conclusions: Les translucidités MO et HO ont la capacité de masquer la teinte du substrat et de modifier la valeur, tandis que les translucidités HT et LT ont une légère capacité à modifier la teinte du substrat sans modification notable de la valeur. L'augmentation de l'épaisseur de la céramique peut contribuer à modifier la teinte. Mots clés : Disilicate de lithium, teinte, translucidité, épaisseur.

Mots-clés: Disilicate de lithium, Teinte, Translucidité, Épaisseur.

Introduction

Cosmetic considerations are now regarded as essential in dental treatments, alongside the growing awareness of the importance of preserving dental tissues. Traditional preparation methods often compromise tissue conservation, making laminate veneers a highly effective, minimally invasive cosmetic treatment. However, enhancing the quality of materials used in their fabrication, particularly in terms of optical properties and durability, is crucial. Achieving a natural color match with minimal thickness and minimal preparation of dental tissues remains a key objective.

Lithium disilicate glass-reinforced ceramic (LS2) is one of the most important and widely used materials in the manufacture of laminate veneers due to its aesthetic and durability [1, 2]. LS2 are provided with various degrees of transparencies [3], whereas their mechanical properties had been improved to withstand small thicknesses of up to 0.3 mm.

The use of highly translucent porcelain provides a level of transparency similar to that of natural teeth. However, the presence of dark substrate might change the final shade. This issue becomes more pronounced if minimum thicknesses are used [4, 5]. Some contributing factors that help correct shade matching in such cases have been thoroughly studied, such as the use of opaque resin cement and the effect of cement layer thickness on final shade [6], whereas for the degree of transparency or thickness of the porcelain, only general guidelines were provided, without knowing the actual effect of increasing the thickness or changing the degree of transparency on the color components or the amount of color changes that occurs [7].

Techniques for estimating color matching include the direct

visual method utilizing different color indices, or the use of a spectrophotometer (Such as VITA Easyshade, Spectroshade micro and digital color meter) [8, 9]. However, the latter is considered more capable of providing digital assessment for color dimensions and the extent of change it has undergone, thus facilitating its measurement and identifying the changes that have occurred. It is also characterized by remaining unaffected by the surrounding lighting [10, 11]. Most color studies are based on using this type of device to study the color dimensions and give them numerical values according to the CIE system, which defines the color dimensions with three coordinate values: (L, a, b), where (L) refers to a value within the range between 0 - 100, positive values of (a) represent the red chroma of the body and negative values of (a) represent the green chroma of the body, positive values of (b) represent the yellow chroma and negative values of (b) represent the blue chroma (Figure 1) [12, 13].

Studies indicated the importance of cement used in bonding in terms of thickness or color in concealing the color of the abutment and giving the restoration its final color [14-16]. Other studies indicated that there is a role for the transparency degree and thickness of the porcelain used in determining the final shade, without specifying the nature of this role and the resulting effects in details for these variables [17-19].

This study aims to determine the actual effect of lithium disilicate glass ceramic thickness and the effect of transparency degree on substrate color masking and the amount of color change that occurs.

Materials and Methods

The sample consisted of (60) lithium disilicate glass ceramic discs (Ivoclar Emax press), which were divided into four main groups according to the degree of transparency (HT, LT, MO, HO). Each group was divided into three subgroups according to their thickness (0.5mm, 0.75mm, 1mm) (Table 1).

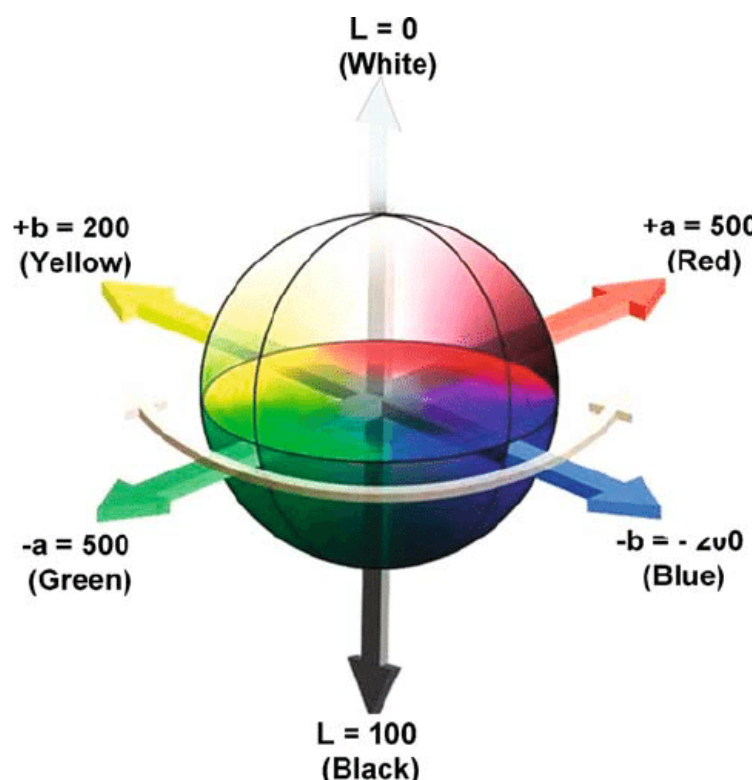


Figure 1. The CIELAB color space diagram

Table 1. Sample distribution.

Group name	Transparency	Thickness (mm)	Count
HT 1	HT	1	5
HT 0.75		0.75	5
HT 0.5		0.5	5
LT 1	LT	1	5
LT 0.75		0.75	5
LT 0.5		0.5	5
MO 1	MO	1	5
MO 0.75		0.75	5
MO 0.5		0.5	5
HO 1	HO	1	5
HO 0.75		0.75	5
HO 0.5		0.5	5
			60

Ceramic discs were designed using exocad software as cylinders with a diameter of 5 mm and three different heights: 0.5 mm, 0.75 mm, and 1 mm. these discs were milled as wax then injected using lithium disilicate glass ceramic ingots (Ivoclar Emax press) (B1 shade) according to the manufacturer's instructions (Figure 2).



Figure 2. Wax discs and their preparation for LS2 injection

A computer-generated model was designed for the resin base in the form of a cylinder with a diameter of 5 mm and a thickness of

3 mm. This model was printed using a 3D printer. A silicone template was fabricated based on this model. This template was used to build 60 identical resin composite base using Ivoclar Tetric N Ceram (A3 shade).

Ceramic discs intaglio surfaces were etched with 10% hydrofluoric acid for 20 seconds, followed by washing and drying. Subsequently, Silane coupling agent (Bisco Dental, Porcelain Primer) was applied and allowed to dry for one minute. Transparent light curing resin cement (Bisco dental, Choice 2) was used to bond ceramic discs to resin bases. light curing was applied for 40 seconds using a (Eighteenth, Curing pen) with an intensity of 1500 mw/cm2 (Figure 3).

Shade spectrophotometer (VITA, easy shade 5th generation) was used to measure the color component of



Figure 3. Ceramic disc after bonding to resin base

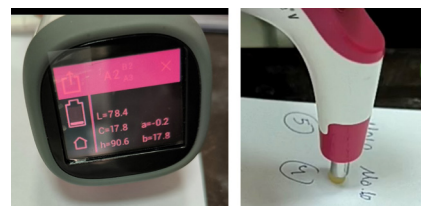


Figure 4. Using the Vita Easy shade device to measure the final color with the data as it appears on the device screen.

each ceramic disc and data were recorded (Figure 4).

In order to study the color, spectrophotometer (VITA, Easy shade 5th generation) was used. This device can measure the color digitally according to the color system established by the International Commission on Illumination (CIE) in 1978, characterized by three coordinate values: L, a, and b, which represent the color value (L), red intensity (a+ values), green intensity (a- values), yellow intensity (b+ values) and blue intensity (b- values). This device is considered one of the best researches means for digitally evaluating color, especially since it is not affected by surrounding lighting [8-11].

The Shapiro-Wilk test was conducted to confirm the normal distribution of the data. Statistical analyses, including One-Way ANOVA, Games-Howell post-hoc, and Tukey post-hoc tests, were performed with a 95% confidence level.

Results

A statistical analysis study was conducted for each of the color parameters b, a, L and ΔE using the same method. Means and standard deviations were calculated. Normal data distribution was confirmed by performing Shapiro-Wilk analysis.

Independent samples One-Way ANOVA was used to study the effect of transparency on color parameters' values according to disc thickness, and to study the effect of porcelain thickness on the values of

color coefficients according to the transparency; Tukey post-hoc test and Games-Howell post-hoc tests were also conducted to perform pairwise comparisons between groups. Statistically significant differences ($p < 0.05$) were observed at the 95% confidence level in the following cases: (Tables 2 and 3)

Color coefficient L

In the porcelain thickness group of 0.75 mm, statistically significant differences were observed between the transparency degree MO and the remaining transparency degrees (HT, HO, LT). Based on the algebraic sign the values of the coefficient L were higher when using transparency MO.

In the 1 mm porcelain thickness group: There were statistically significant differences between the degree of transparency HT and the degree of transparency LT. Based on the algebraic sign, the values of coefficient L were higher when transparency LT was used.

Table 2. One-way ANOVA, the effect of translucency according to thickness

Variable	Thickness	Translucency		Mean difference	Sig.
Color coefficient L	0.75	HT	MO	-9.1	0.001
		LT	MO	-10.4	0.001
		MO	HO	12.16	0.001
	1	HT	LT	-5.54	0.001
Color coefficient a	0.5	HT	HO	2.1	0.002
		LT	HO	1.92	0.009
	0.75	HT	MO	1.36	0.001
			HO	1.88	0.001
		LT	MO	1.2	0.001
			HO	1.72	0.001
		MO	HO	0.52	0.028
	1	LT	MO	1.56	0.030
			HO	2.06	0.003
Color coefficient b	0.5	HT	HO	16.7	0.001
		LT	HO	15.84	0.015
	0.75	HT	MO	12.04	0.045
			HO	20.5	0.001
		LT	HO	17.22	0.045
	1	HT	HO	19.62	0.015
		LT	HO	20.5	0.001
Color Change ΔE	0.5	HT	MO	-8.51	0.001
			HO	-14.53	0.001
		LT	MO	-9.48	0.001
			HO	-15.5	0.001
		MO	HO	-6.02	0.001
	0.75	HT	MO	-10.67	0.001
			HO	-14	0.001
		LT	MO	-11.77	0.001
			HO	-15.1	0.001
	1	HT	LT	-3.34	0.004
			MO	-10.72	0.001
			HO	-19.17	0.001
		LT	MO	-7.38	0.001
			HO	-15.83	0.001
		MO	HO	-8.45	0.001

Significant when $p < 0.05$

Table 3. One-way ANOVA, the effect of thickness according to translucency

Variable	Translucency	Thickness		Mean difference	Sig.
Color coefficient L	HT	0.5	0.75	-4.42	0.004
		0.75	1	3.1	0.01
	LT	0.5	1	-4.44	0.01
		0.75	1	-3.78	0.027
	MO	0.5	0.75	-7.16	0.018
		0.75	1	6.1	0.044
Color coefficient a	HT	0.5	1	0.76	0.002
		0.75	1	0.6	0.009
	MO	0.5	1	0.54	0.01
Color coefficient b	HT	0.5	0.75	-3.6	0.001
		0.75	1	2.5	0.014
	LT	0.5	1	-2.84	0.002
Color Change ΔE	HT	0.75	1	2.22	0.018
	LT	0.5	1	-2.65	0.001
		0.75	1	-2.22	0.005
	MO	0.5	0.75	-2.71	0.033

Significant when $p < 0.05$

In the HT transparency group: statistically significant differences were observed between the thickness of 0.75 mm and the thicknesses (0.5 – 1 mm). Based on the algebraic sign, the values of the coefficient L were higher when using the thickness of 0.75 mm.

In the LT transparency group: statistically significant differences were observed between the 1 mm thickness and the thicknesses (0.5 – 0.75 mm). Based on the algebraic sign, the values of the coefficient L were higher when using the 1 mm thickness.

In the MO transparency group: statistically significant differences were observed between the thickness of 0.75 mm and the thicknesses (0.5 – 1 mm). Based on the algebraic sign, the values of the coefficient L were higher when using the thickness of 0.75 mm.

Color coefficient a

In the 0.5 mm porcelain thickness group: statistically significant differences were observed between transparency degree HO and transparency degrees (HT, LT).

In the 0.75 mm porcelain thickness group: statistically significant differences were observed between

all degrees of transparency except between (HT and LT).

In the 1 mm porcelain thickness group: statistically significant differences were observed between LT transparency degree and (MO, HO) transparency degrees.

In the HT transparency group: statistically significant differences were observed between the 1 mm thickness and the thicknesses (0.5 – 0.75 mm). Based on the algebraic sign, the values of the coefficient (a) were smaller when using the 1 mm thickness.

In the MO transparency group: statistically significant differences were observed between the 1 mm thickness and the thicknesses (0.5 mm). Based on the algebraic sign, the values of the coefficient (a) were smaller when using the 1 mm thickness.

Color coefficient b

In the 0.5 mm porcelain thickness group: statistically significant differences were observed between transparency degree HO and transparency degrees (HT, LT).

In the porcelain thickness group of 0.75 mm: statistically significant differences were observed between

transparency degree HO and transparency degrees (HT, LT), also between transparency degree HT and transparency degree MO.

In the 1 mm porcelain thickness group: statistically significant differences were observed between transparency degree HO and the transparency degrees (HT, LT).

In the HT transparency group: statistically significant differences were observed between the thickness of 0.75 mm and the thicknesses (0.5 - 1 mm). Based on the algebraic sign, the values of the coefficient (b) were greater when using the thickness of 0.75 mm.

In the LT transparency group: statistically significant differences were observed between the thickness of 0.5 mm and the thickness (1 mm). Based on the algebraic sign, the values of the coefficient (b) were greater when using the thickness of 1 mm.

Color Change ΔE

In the 0.5 mm porcelain thickness group: statistically significant differences were observed between all degrees of transparency, except for between degrees (HT and LT).

In the 0.75 mm porcelain thickness group: statistically significant differences were observed between all transparency degrees except for between degrees (HO, MO) and (HT, LT).

In the 1 mm porcelain thickness group: statistically significant differences were observed between all degrees of transparency.

In the HT transparency group: statistically significant differences were observed between the thickness of 0.75 mm and the thickness of (1 mm). Based on the algebraic sign, the color change ΔE was greater when using the thickness of 0.75 mm.

In the LT transparency group: statistically significant differences were observed between the 1 mm thickness and the remaining thicknesses. Based on the algebraic sign, the color change ΔE was greater when using the 1 mm thickness.

In the MO transparency group: statistically significant differences were observed between the thickness of 0.5 mm and the thickness (0.75 mm). Based on the algebraic sign, the color change ΔE was greater when using the thickness of 0.75 mm.

Discussion

There is a growing emphasis on the cosmetic aspects of dental treatments, accompanied by increasing awareness of the importance of preserving dental tissues. Porcelain veneers are among the most commonly used conservative approaches to achieve desirable cosmetic outcomes. However, achieving precise color matching remains one of the most challenging aesthetic considerations. Factors affecting the final color are the color of the dental abutment, the color of the cement, and the type of porcelain used [14-16] in addition to the thickness of the applied porcelain and its degree of transparency [17-19]. Which have

not been studied sufficiently to give the clinical practitioner the ability to make the appropriate decision in various cases.

The aim of this research is to study the effect of the thickness of the used porcelain. Several thicknesses were chosen (0.5 - 0.75 - 1 mm), which are the most commonly used thicknesses in the manufacturing of laminate veneers [20]. This research also utilized lithium disilicate glass ceramic, which is considered the most reliable material in most clinical cases [1].

This research also aims to study the effect of different degrees of transparency: high transparency (HT), low transparency (LT), medium opacity (MO), and high opacity (HO). These transparencies cover most indications in daily dental practice.

The composite base had a color that differ from which was used for ceramic discs in terms of hue and value, in order to illustrate the differences that may occur in the final shade. The composite base was made in A3 shade, while the shade of the ceramic discs was B1.

For more accurate fabrication approach, the ceramic discs were not made by direct waxing then injecting the ceramic. Rather, the ceramic discs were digitally designed and manufactured with the exact thickness then injected with Ivoclar Emax press lithium disilicate glass-ceramic according to the manufacturer's instructions.

The resin bases were also digitally designed and 3d printed to the same dimensions as the ceramic discs but with a thickness of 3 mm. A silicone template was made for the 3D printed model and used to make 60 composite resin bases.

Ceramic discs were bonded to composite resin bases by light curing resin cement. Dual cured or chemically cured resin cement weren't used due to the presence ammonia group which would change cement shade and affect the final color [21, 22]. A transparent color for resin cement was chosen for the same reason.

According to the research results, a change in color was observed, especially when using MO, HO transparencies, this effect increased as the thickness increased. These two transparencies had the ability to modify the color value, which is considered the most important factor for color perception. As for the transparencies HT and LT, they had a simple role in modifying the hue of the color.

Transitioning from high transparency to high opacity results in an increase in the L value, indicating higher color value or brightness. Increasing the thickness also leads to the same result.

Additionally, the transition from high transparency to high opacity led to an increase in the values of a, b. The increase in thickness had the same effect, that is, high transparencies HT, LT tend to increase the blue and green components, especially in low thicknesses. As for transparencies MO, HO, the yellow and red component increases, especially with increasing thickness.

The results of this study were similar to the study of Lee et al. [18] in terms of inability of high or low-transparency porcelain to mask the abutment color with thicknesses as small as 0.5mm. Lee's study did not include larger thicknesses or other opacity degrees such as medium or high opacity.

Our findings were consistent with those of Durães et al. [19] demonstrating medium opacity (MO) is capable of masking the abutment color, particularly when thicknesses exceed 1 mm. Durães' study did not include other opacities such as HO, while our study did not compare thicknesses greater than 1 m.

Ayata's study [17] demonstrated that the effect of porcelain thickness has a greater role than the degree of transparency in masking the color of the abutment which was not shown in our study. This may be due to the fact that Ayata's study did not take into consideration the

degrees of medium or high opacity, and focused solely on the HT and LT transparencies and compared only the thicknesses of 0.3 and 0.5 mm.

One of the limitations of the research is the relatively small sample size, due to the large number of existing translucency groups that must be studied. In addition to the multiple possibilities related to the thickness of the ceramic material according to what the clinical condition requires. Our research also relied on homogeneous ceramic discs thickness but clinically, the laminate veneers usually have

gradual thickness according to the prepared area of the natural tooth.

Conclusion

Within the limitations of this research, we can conclude:

- The transparency and thickness of the porcelain play a significant role in determining the final color.
- MO, HO transparencies have the ability to give the desired final color value and masking the abutment or base color.
- HT, LT transparencies have

a slight ability to modify the abutment hue without significantly changing its value.

- Increasing the thickness of the porcelain has a significant role in increasing the ability to modify the color.
- HT, LT transparencies with small thicknesses tend to modify the color towards the blue and green components with low value, while MO, HO transparencies with larger thicknesses tend to modify the color towards the yellow and red components with higher value.

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