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MASKING PROPERTIES OF TWO CERAMIC MATERIALS WITH DIFFERENT THICKNESS AS A MONOLITHIC RESTORATION

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ABSTRACT

Study objective: The purpose of this in vitro study was to determine the translucency of 2 materials used for monolithic restorations by assessing their translucency parameters (TPs) with different thicknesses.

Material and methods: thirty-six specimens were prepared of two materials: lithium disilicate and Resinous hybrid ceramic (Hyramic) (Shenzhen Upcera

Dental Technology Co., Ltd) with three different thicknesses of 0.5, 0.9 and 1.2mm. Then the translucency was evaluated between them through measuring of translucency parameters (TPs) against black and white tiles using spectrophotometer in 2 different areas on each specimen. Data were analyzed using 2-way ANOVA (a=.05).

Results: Mean (TPs) values of Dental lithium disilicate were significantly higher than that of Hyramic for all thicknesses, the highest value was found with 0.5 mm samples, followed by 0.9 mm samples, while the lowest value was found with 1.2 mm samples (P<.001).

Conclusions: since lithium disilicate showed higher translucency in most tested group, so when higher masking effect needed its preferable to use resinous hybrid ceramic than using dental lithium disilicate due to its lower translucency, using thicker ceramic offers higher masking power for both materials as translucency decreases with the increase in thicknesses.

INTRODUCTION

Recently, esthetic restorations became a popular esthetic trend between patients who seeks for better smile by long term esthetic restoration[1], due to Advancement of both monolithic ceramic restoration materials, fabrication techniques like Pressing and CAD-CAM and bonding concept replacing old adhesion concept with recent advancement in bonding to both tooth structure and ceramic materials has led to the widespread of these materials in the market.[2]

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Increasing ceramic restoration thickness provides better masking of dark teeth. If the monolithic restoration thickness is more than 1.0 to 1.5 mm, successful masking can be achieved, as more material is available to mask the discoloration[3]

Studies have shown that the esthetic results of ceramic restorations over various backgrounds are clinically acceptable with 2.0 mm of thickness[4]

However, extensive tooth preparation or over contoured restorations to achieve such a thickness is not accepted biologically[5]

Masking discolored or dark teeth require meticulous selection of monolithic ceramic material for achievement of highly esthetic monolithic restoration. A variety of porcelain materials are available, but when it comes to selection, the ability to mask discolored tooth structures is one of the important factors. [6]

There are many methods to measure the translucency developed upon various basic colorimetric concepts. As the indices for the translucency, total or direct transmission coefficient (TC), translucency parameter (TP), and contrast ratio (CR) have been generally used however, there are currently no guidelines that recommend which method to be used to assess the translucency of dental restorative materials.[7]

TP represents the color difference (ΔE^*) between a material of uniform thickness over a black and a white background, it is based on Commission Internationale de l'Eclairage (CIE) colorimetry and can be calculated by the color difference formula[8]. When a color difference is equal to zero ($\Delta E^*=0$), it defines a non-translucent material with perfect masking properties. [8]

it was concluded the final aesthetic outcomes of an all-ceramic restorations was not affected by substrate color when the thickness was more than 2.0 mm, but if the thickness of a restoration was less than 1.5 mm, the esthetic outcome is a sum of the color of the substrate and the masking power of all ceramic monolithic restoration which is affected directly by material translucency.[8]

Therefore, the purpose of this in vitro study was to determine the translucency of two dental ceramic materials indicated for monolithic restorations fabrication by assessing their TP. The null hypothesis was that no significant differences would be found in masking ability among the tested materials and thicknesses.

MATERIALS & METHODS

Two dental ceramic systems were selected (Table 1) of shade A2 (HT) with three thicknesses of 0.5, 0.9 and 1.2 was selected as they reflect the range of preparations for monolithic all ceramic restorations depending on the need to mask tooth shade.

Power analysis

For determining number of each subgroup power analysis was designed to have adequate power to apply a 2-sided statistical test of the research hypothesis (null hypothesis) that there is no difference between different tested materials and thicknesses. By adopting an alpha (α) level of 0.05 (5%), a beta (β) level of 0.20 (20%) i.e., power=80% and an effect size (f) of (0.858), the predicted sample size (n) was found to be a total of (36) samples i.e. (18) samples for each group and (6) samples for each subgroup.

Study design

Thirty-six square shaped specimens of final dimensions (10*10) mm and three thicknesses of 0.5, 0.9 and 1.2 of Lithium Disilicate and resinous hybrid Ceramic (Hyramic) both shade A2 and high translucency (HT), (6) samples for each subgroup.

Sample preperation

All samples were sectioned using diamond wafering blade mounted on a saw (Buehler ISOMET 4000 Linear Precision Saw).

TABLE (1): Tested ceramic systems

Material description	Brand name	manufacturer	Fabrication technique
Lithium Disilicate	Dental Lithium Disilicate	Shenzhen Upcera Dental Technology Co., Ltd	CAD-CAM
Resinous hybrid ceramic	Hyramic	Shenzhen Upcera Dental Technology Co., Ltd	CAD-CAM

Lithium Disilicate specimens undergone crystallization cycle with the Programat EP 3010 (Ivoclar Vivadent AG) according to Upcera manufacture instructions.

All specimens of each subgroup were both sides polished sequentially by using a series of sand paper sheets of decreasing grit size (#220, 400,800 and 1000) fixed to dental surveyor plate (Marathon 103 dental Surveyor) while specimens attached to a low-speed motor (NSK Ultimate 500 Motor) running at 300 RPM and load of 200 gm. for 15 second for each sand paper.

Thickness of specimens was verified after polishing using a digital caliper (RS PRO 200mm Digital Caliper) with accepted accuracy of ±0.02 mm.

All specimens were ultrasonic bath cleaned for 10 minutes using Ultrasonic Cleaner and dried with compressed air.

One surface glazing of lithium disilicate specimens using lithium disilicate glaze and One surface polishing of Hyramic specimens using Upcera polishing kit.

Hydrofluoric acid etching and silnation of non-polished surface of Hyramic and non-glazed surface of lithium disilicate was carried out using 9.5% porcelain etchant (bisco dental) for 30 sec according to manufacturer instructions.

Measurements

The CIE L*a*b* values of each specimen were measured on a black background and on a white background with a spectrophotometer (Cary 5000 Agilent Technologies (USA). The translucency parameter (TP) was obtained by calculating the color difference between the specimen against the white background and against the black background with the following equation

$$TP=\{(L_b-L_w)^2 + (a_b-a_w)^2 +(b_b-b_w)^{2}\}$$

where L* refers to the brightness, a* to redness to greenness, and b* to yellowness to blueness. The subscripts B refers to the color coordinates on the black background and W to those on the white background[9]. A high TP value indicates high translucency and low opacity. Three measurements were made for each specimen on its respective background, and the average value was recorded.

Statistical analysis

The effects of the material and thickness on the TP values of the lithium disilicate and Hyramic were analyzed using Two-way ANOVA test. Comparison of main and simple effects were done utilizing pairwise t-the two different materials in different groups and translucency parameter. The significance level was set at $p \leq 0.05$ within all tests. Statistical analysis was performed with IBM*® SPSS**® Statistics Version 26 for Windows tests with Bonferroni correction. Spearman rank order correlation coefficient was used to study the correlation between.

* ® IBM Corporation, NY, USA.

** ®SPSS, Inc., an IBM Company.

RESULTS

1. Descriptive statistics

TABLE (2): Descriptive statistics for translucency parameter (TP) for different groups

Ceramic aterial	Thickness	Mean	Std. Deviation	Median	Min.	Max.
Lithium disilicate	0.5 mm	25.69	0.25	25.65	25.40	26.08
	0.9 mm	18.28	0.20	18.29	18.07	18.57
	1.2 mm	14.35	0.16	14.35	14.17	14.59
Resinous hybrid ceramic	0.5 mm	20.32	0.17	20.37	20.07	20.52
	0.9 mm	15.48	0.20	15.47	15.28	15.79
	1.2 mm	12.33	0.16	12.36	12.15	12.55

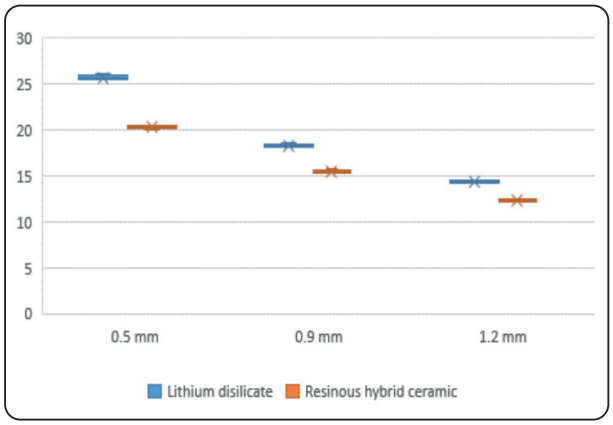

Fig. (1) Box plot showing translucency parameter (TP) values for different groups

2. Effect of different variables and their interaction

Effect of different variables and their interaction on translucency parameter (TP) were presented in table (3)

There was a significant interaction between type of ceramic material and thickness (p<0.001).

3. Interactions

Mean and standard deviation (SD) values of translucency parameter (TP) for different ceramic materials and thicknesses were presented in table (4) and figures (2, 3)

TABLE (4): Mean ± standard deviation (SD) of translucency parameter (TP) for different ceramic materials and thicknesses

Thickness	Translucency parameter (TP) (mean±SD)		p-value
	Lithium [disilicate	Resinous hybrid ceramic	
0.5 mm	25.69±0.25[a]	20.32±0.17[a]	<0.001*
0.9 mm	18.28±0.20[b]	15.48±0.20[b]	<0.001*
1.2 mm	14.35±0.16[c]	12.33±0.16[c]	<0.001*
p-value	<0.001*	<0.001*	

Different superscript letters indicate a statistically significant difference within the same vertical column *; significant (p ≤ 0.05) ns; non-significant (p>0.05)

TABLE (3): Effect of different variables and their interactions on translucency parameter (TP)

Source	Sum of squares	df	Mean square	f-value	p-value
Ceramic material	86.53	1	86.53	2341.28	<0.001*
Thickness	478.44	2	239.22	6472.73	<0.001*
Material * Thickness	15.36	2	7.68	207.84	<0.001*

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

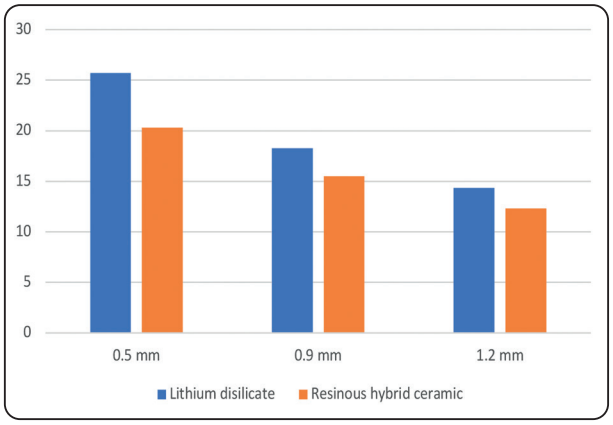

Fig. (2): Bar showing average translucency parameter (TP) for different ceramic chart materials and thicknesses (A)

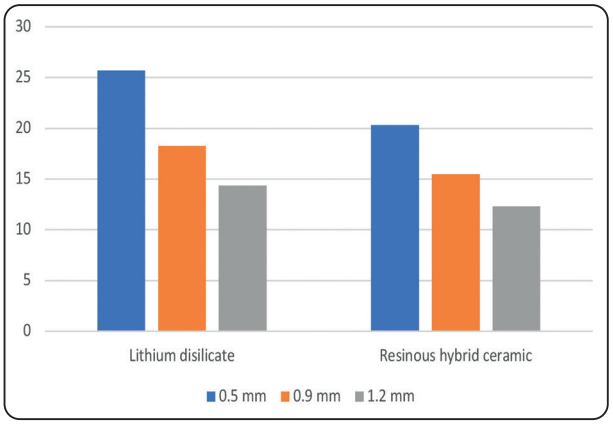

Fig. (3): Bar chart showing average translucency parameter (TP) for different ceramic materials and thicknesses (B)

DISCUSSION

One of the most challenging factors for treatment with ceramic restorations is to mask discolored tooth. studies showed that esthetic results over various background are clinically acceptable within 2 mm thickness of dental glass ceramics. But the goal is to achieve maximum aesthetics with limited tooth preparation for tooth preservation, so masking power of different materials and different thicknesses was investigated.[10]

Among all ceramic systems Lithium Disilicate was considered the gold standard for aesthetic monolithic restorations recently resinous hybrid ceramics was introduced and gained attention due to its mechanical properties that mimic tooth dentine structure, however limited data about optical properties of this ceramic systems and its masking ability in different thicknesses are available[7].

On concentrating on the translucency effect on the masking ability, it was concluded the final aesthetic outcomes of an all-ceramic restorations was not affected by substrate color when the thickness was more than 2.0 mm, but if the thickness of a restoration was less than 1.5 mm, the esthetic outcome is a sum of the color of the substrate and the masking power of all ceramic monolithic restoration which is affected directly by material translucency, so translucency of various ceramic restorative materials was tested and conclusions indicated that some materials could not reproduce the target color satisfactorily when the abutment color was darker than the target color.[9]

Two methods are available for measurement of translucency of dental ceramics. The absolute translucency by direct transmittance of light and relative translucency by using either contrast ratio (CR) or translucency parameter (TP)[10] , Either CR or TP can be used to evaluate the relative translucency of ceramic systems as concluded by **Barizon** et al[11], Both TP and CR values calculated by calculating color difference between same specimen under black and white backgrounds.[12]

Regarding the effect of ceramic material:

Results of the present study confirmed presence of difference in translucency between two ceramic materials. Generally, the obtained results of TP confirmed that Lithium disilicate showed a significantly higher translucency than Resinous hybrid ceramic. Lithium disilicate (Dental Lithium Disilicate®) Showed TP values ranged from 14.35 to 25.69 which is higher than Resinous hybrid ceramic (Hyramic®) that showed TP values ranged from 12.33 to 20.32.

So, these findings can be regarded for different chemical composition between the two materials regarding the crystal size, the density of crystals, and the interaction between the crystalline phase and the matrix phase with different refractive index for each phase, leading to different refractive indices between the two materials according to **GW Ho** et al[13]

It can be explained that lithium disilicate showed higher translucency because the glassy matrix and the crystalline phase reduce internal light scattering because both glassy matrix phase and crystalline phase showed closeness in the refractive index, While polymeric matrix in resinous hybrid ceramic added to enhance its mechanical properties may cause higher level of light scattering or absorption within the material and less light reflection due to higher difference in refractive index between the two phases of the material. these results were in agreement with **Heffernan** et al[14] who concluded that the range the range of translucency in ceramics at clinically relevant thicknesses results from different chemical compositions. A study by **Chu** et al[15] had regarded the higher translucency of lithium disilicate in comparison to other ceramic types to its relatively low volume of lithium disilicate and its lower refractive index.

Regarding the effect of ceramic material thickness

The results of the present study showed that ceramic material thickness has a significant effect on TP values, results of TP showed that translucency increases with decrease in ceramic thickness for both materials lithium disilicate and resinous hybrid ceramic. The highest TP value was found with 0.5 mm samples while the lowest value was found with 1.2 mm samples for both materials.

These results can be explained by increased light scattering, absorption within the ceramic material and decreased light transmission on increasing ceramic thickness, lithium disilicate showed higher rate of TP values decrease in comparison to resinous hybrid ceramic and this could be regarded to opalescence effect that increases with increasing thickness and cause more light scattering through specimen.

These results were in agreement with **Wang** et al[11] who concluded that the translucency of dental ceramics was significantly influenced by both material and thickness. The translucency of all ceramic materials increased exponentially as the thickness decreased according to **Basso** et al [16] and those conclusion matches **Baegum** et al[17] who concluded that The color masking ability of ceramics used for laminate veneers is significantly affected by the thickness of the ceramic and the shade of the luting agent used.

CONCLUSIONS

1- When higher masking effect needed its preferable to use resinous hybrid ceramic than using lithium disilicate (dental lithium disilicate) due to its higher opacity, lower translucency especially for minimal thickness monolithic restorations.

2- Using thicker ceramic offers higher masking power as translucency decreases with increasing the thickness

3- More studies are needed to confirm the validity of the present research results to ensure difference in optical proprieties between the two tested materials.

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