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Evaluation of translucency of two types of glass ceramics with different thickness: An *in vitro* study

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ABSTRACT

Background: Veneered all-ceramic restorations are associated with a high incidence of chipping and veneer delamination from the inner core. Monolithic all-ceramic crowns facilitate the fabrication process and minimize residual stresses between core and veneer. A new material, zirconia-reinforced lithium silicate (ZRL), Celtra Duo was recently introduced for the fabrication of monolithic anterior crowns to overcome the aesthetic drawbacks of traditional zirconia and also to improve the strength of the lithium disilicate.

Aim: This study aimed to evaluate and compare the translucency of CAD/CAM zirconia reinforced lithium disilicate ceramic and Lithium silicate glass-ceramic at a different thickness .

Materials and methods: A CAD/CAM Lithium Silicate glass-ceramic (e.max CAD) and CAD/CAM ZLS Celtra Duo ceramic materials were used in the study. A total of forty Disc-shaped ceramic specimens (n=40), which comprises 20 from each ceramic material (n=20) were fabricated. The twenty specimens from each material group were divided into four subgroups with five specimens each (n=5) with a thickness of 1.0 mm, 1.2 mm, 1.5 mm and 2.0 mm, respectively. All the specimens were thermo-cycled to simulate one-year clinical service followed by analyzing the degree of translucency using spectrophotometer. The obtained data were subjected to statistical analysis using the student t-test and post-hoc pair-wise comparisons .

Results: A decrease in translucency with an increase in the thickness of the ceramic specimens was observed. Significant differences were observed between the ceramic materials except at 1.5 mm thickness (p=0.621) .

Conclusion: Both the ceramic materials displayed decreased in their translucency with the increase in the thickness. The glazed Celtra Duo has demonstrated relatively more translucency than e.max CAD ceramic at all thicknesses.

1. Introduction

The Patients' demand for natural-looking restorations, such as laminates, inlays, onlays and full coverage crowns, that mimic tooth structure has led to the development of new all-ceramic systems. Esthetically pleasing restoration should be an exact replica of shape, size, translucency and surface texture of the natural tooth. Despite the clinical success that was offered by porcelain fused to metal

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restoration, unpleasant esthetic light reflection from the opaque metal substructure can compromise the natural appearance and affect the overall esthetic result of the restoration [1]. All-ceramic restorations play one of the most critical roles in today's dentistry. Literature indicates the effectiveness of all-ceramic restorations for numerous clinical applications [2,3].

The interest of dentists, dental technicians and patients in all-ceramic materials is rapidly increasing as stronger and tougher materials are being developed and commercialized along with novel processing technologies [4-6]. The optical properties of the restorative materials, the hard tissues, and the interaction between them influence the aesthetics of the restorations and the natural tooth. Therefore, the translucency of a material is an essential factor for the clinical selection of restorative materials. From the aesthetic aspect, it is crucial to select a material that closely matches the natural translucency and grey -scale of the tooth. Therefore, clinicians must have adequate knowledge about the translucency of various restorative materials in order to match the esthetics of the artificial restorations with the natural teeth in individual clinical situations [2,4].

Recently, the progress in the development of CAD-CAM technology and the materials science led to the development of promising materials such as Zirconia reinforced-lithium Silicate (ZLS). This material claimed to have enhanced translucency as its' glassy matrix contains a homogeneous crystalline structure made of lithium silicate crystals, is reinforced with about 10% of tetragonal zirconia fillers. These fillers provide enhanced strength than the Lithium di Silicate ceramics [7]. ZLS possesses higher translucency, along with adequate biaxial flexural strength. These characteristics make this material a better choice for minimally invasive, single tooth esthetic restorations [7-9]. Numerous studies reported that the thickness of the ceramic materials influences the translucency parameter [10]. Studies also considered the ceramic thickness of 1.5-2.0 mm is adequate to achieve appropriate chromatic masking [10]. However, limited research is available regarding the effect of thickness on the translucency of ZLS ceramics. Hence, this study was designed to evaluate the effect of the thickness on the translucency of ZLS ceramic materials. Also, this study compared the translucency of ZLS ceramics with Lithium di Silicate ceramics at different thicknesses.

2. Materials and methods

2.1 Materials

Two all-ceramic materials such as Lithium disilicate (IPS e.max CAD, Ivoclar Vivadent, USA), and Lithium disilicate reinforced by zirconia (Celtra Duo, Dentsply Sirona, GmbH) were used in the study.

2.2 Methods

A total of 40 disc-shaped ceramic specimens with different thickness were milled using CAD/CAM technology. The forty specimens comprise 20 from each ceramic material. The thickness of the specimens was 1.0mm, 1.2 mm, 1.5 mm, and 2.0 mm, and a diameter of 10 mm. Five samples were allocated for each thickness from each ceramic material.

2.3 Preparation of specimen

Lithium Disilicate glass-ceramic (IPS e.max CAD) blocks were milled, and the specimens were crystallized and glazed at 840ºC (1544°F) in a ceramic furnace (Programat® CS, Ivoclar Vivadent) following the manufacturer's instructions.

Lithium disilicate reinforced by zirconia (Celtra Duo) ceramics were milled, polished and glazed the specimens at after 820°C as per the manufacturers' recommendations.

2.4 Evaluation of translucency [11]

All the specimens were ultrasonically cleaned in distilled water for 10 minutes and dried with compressed air before subjecting them to the translucency evaluation. The translucency of the ceramic samples was evaluated with translucency parameter (TP), using a clinical spectrophotometer (UV-3101 PC).

Specimens were placed over white (L^* = 96.3, a^* = 0.1, b^* = 1.9) and black (L^* = 8.9, a^*=-0.7, b^*= 1.2) tiles and "tooth single" mode were selected.

Measurements for each specimen were repeated two times on each background, and the mean CIE $L^*a^*b^*$ values were recorded for both backgrounds. TPs were obtained by calculating the colour difference between the value while the specimen over the white background and that over the black background using the following formula:

$$TP = [(L^*B - L^*W)^2 + (a^*B - a^*W)^2 + (b^*B - b^*W)^2]^{1/2}$$

Where, B corresponds to the colour coordinates over the black background, and W corresponds to those over the white background.

If the material is opaque, the TP value was assigned as zero; and if the material is transparent, the TP value was considered as 100. The greater the TP value, the higher the translucency of the material.

2.5 Statistical analysis

The obtained data were analyzed using Statistical Package for Social Sciences, version 20.0. (SPSS, IBM Corp., NY). The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using mean and standard deviation. The unpaired t-test was used to compare mean translucency scores between two groups at a different thickness. The p-value <0.05 was considered statistically significant for all the comparisons.

3.Results

The obtained mean and standard deviations of translucency of the ceramic materials with different thickness are given in table 1. Among the ceramic materials tested, both the Celtra Duo and the e.max CAD materials showed more translucency at 1.0 mm thickness (Table 1). Celtra Duo ceramic materials exhibited more translucency at all the thickness compared to e.max CAD except at 1.5 mm thickness. However, no statistical significance (p=0.6221) was observed between the ceramic samples at 1.5 mm thickness. The decrease in translucency was observed as the thickness of the ceramic specimens was increased. At 2.0 mm thickness, both the ceramic materials demonstrated the least translucency. Among both the ceramic materials, e.max displayed the least translucency at 2.0 mm thickness (Table 1). Significant differences were observed between the ceramic materials at all the thickness except at 1.5 thickness (p=0.621).

4. Discussion

Spectrophotometry is a method used to measure colour and translucency in dentistry [12,13] quantitatively. Different parameters are used to describe the translucency, such as the translucency parameter, making it difficult for clinicians to compare studies. Moreover, these parameters are not applicable to the direct measurement of translucency and cannot be used below 50% transmission [14,15]. Therefore, in the present study, the absolute translucency was determined to obtain meaningful and comparable values. Ceramic was one of the primary materials used as an esthetic restorative material. Due to optical properties and colour, which looks like natural teeth, with good resistance against wear and more stable in colour. The manufactures lately claim that newly Introduced all ceramics in dentistry have translucency properties comparable to feldspathic porcelains along with improved mechanical resistance. Therefore, a correct selection, esthetics and longevity have to be considered from the main parameters.

Lithium disilicate ceramic material which has durability and superior esthetics is considered one of the important ceramic material available nowadays. The light diffusion and translucency of IPS e.max ceramics were reached to replicate natural tooth appearance and structure [16]. New additions to the category to the glass-ceramics are zirconia reinforced lithium

Table 1: Comparison of translucency of ceramic materials at different thicknesses.

Thickness	Materials	N	Mean±SD$	t-Value	Significance (p - value)
1.0 mm	e.max CAD	5	12.40±0.55	3.464	0.009*
	Celtra Duo	5	13.60±0.55		
1.2 mm	e.max CAD	5	10.40±0.55	2.558	0.034*
	Celtra Duo	5	11.60±0.89		
1.5 mm	e.max CAD	5	9.20±0.84	0.535	0.621
	Celtra Duo	5	9.00±0.00		
2.0 mm	e.max CAD	5	6.00±0.00	4.00	0.016*
	Celtra Duo	5	6.80±0.45		

* Significant differences were observed. $Standard Deviation.

disilicate in vitro testing of the ZLS showed a favourable combination of the material characteristics of zirconia and glass-ceramics. This study aimed to assess the effect of zirconia addition to lithium disilicate ceramic on translucency.

Celtra Duo is a new class of ceramic, which is called zirconia-reinforced lithium silicate. In these ceramics, 10% of zirconia is dissolved into the lithium silicate glass matrix that results in approximately four times smaller silicate crystals with a high glass content. These smaller crystals with a high glass content exhibit higher translucency compared to conventional lithium disilicate ceramics (Celtra Duo; DeguDent GmbH). Celtra Duo presents higher T% values than IPS e.max CAD.

The present study reported the highest translucency parameter (TP) with the zirconia-reinforced lithium silicate glass-ceramic compared to Lithium disilicate glass-ceramic. The results of this study are in accordance with the previous studies [17-20]. Zirconia-reinforced lithium silicate glass-ceramic demonstrated a higher mean of translucency than Lithium disilicate glass-ceramic. This increase in the translucency can be attributed to the addition of zirconia and the ensuing nucleation process, resulting in more homogenous crystalline structure and finer crystal size (0.5 μm) compared to the needle-shaped coarser crystalline structure (1.5 μm) of Lithium disilicate glass-ceramic [21]. Also, the thickness influenced the final colour of the ceramic, partially due to the translucency, as the thicker ceramic disks were less translucent [20].

The results of this study were in accordance with the study by Heffernan *et al.* (2002) [22,23], who stated that the amount of light absorbed, reflected and transmitted is dependent on several factors including the particles size compared to the incident light's wavelength. They also stated that the porcelain translucency depends on the composition of ceramic and an increase in particle size is inversely proportional to the translucency. The other factors include irregularities in the distribution of the phases and optical anisotropy of the grains.

Similarly, Bachhav VC *et al.* (2011) [20] also reported that the translucency of ceramics decreased with an increase in the thickness. Therefore, thickness of the ceramic restorations must be considered as one of the factors during shade selection and fabrication.

Giordano RA [24], and Denry IL [25] reviewed various ceramic materials and reported that the amount of glass content also influences the translucency. The decrease in glass content in ceramics results in greater opacity.

The limitations of this study include the *in vitro* use of a spectrophotometer to evaluate the translucency of all ceramic materials. In addition, the samples used in this study were disc shaped rather than crown shaped. Further studies may be required to evaluate the clinical implications of the color and translucency of all ceramic restorations with different layers including core and veneer ceramics. Also, the effect of repeated firings and the influence of the type of luting cements may be studied.

5. Conclusion

From this study, it can be concluded that the translucency of the ceramic material is inversely proportion to the thickness. Compared to e.max CAD, Celtra Duo ceramic materials exhibited more translucency at all thicknesses except at 1.5 mm.

Conflicts of interest: Authors declared no conflicts of interest.

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