Translucency parameters of different CAD/CAM ceramics for monolithic restorations

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Abstract

The translucency of dental ceramics [feldspathic ceramic (FC), lithium disilicate glass-ceramic (LD), zirconia-reinforced lithium silicate glass-ceramic (LS), and translucent zirconia (TZ)], in two thicknesses (1 and 2 mm), using different parameters was assessed. Translucency parameters (TP^*_{ab}, TP_{00}), contrast ratio (CR), light transmittance at 468 nm (T%), and light attenuation were determined. Data were analyzed by ANOVA, Tukey's test, and Pearson correlations (α=0.05). CR ranged from 0.64 (LS-1 mm) to 0.96 (TZ-2 mm). TP^*_{ab} ranged from 3.7 (TZ-2 mm) to 32.2 (LS-1 mm). TP_{00} ranged from 3.0 (TZ-2 mm) to 26.4 (LS-1 mm). T% ranged from 14.9 (TZ-2 mm) to 75.2 (FC-1 mm). Light attenuation varied from 54% (LS-1 mm) to 84% (TZ-2 mm). There were significant strong negative correlations between CR and TP^*_{ab} (R=-0.997), CR and TP_{00} (R=-0.991), TP^*_{ab} and light attenuation (R=-0.888), and TP_{00} and light attenuation (R=-0.867). LS showed the highest translucency, whereas TZ showed the lowest translucency. When thickness increased, CR and light attenuation also increased, while TP and transmittance decreased.
Keywords: dental ceramics, translucency, light attenuation.

INTRODUCTION

Given the large number of ceramic systems available and the pace at which new materials have been introduced, clinicians have a tough decision about the choice of the ceramic restorative material for each clinical situation. The selection of the ceramic material is occasionally made based on a comprehensive understanding of the characteristics of the materials. In general, this choice is often based on criteria such as mechanical resistance, determined by different laboratory tests, translucency, and fabrication techniques [1]. The investigation of several translucency parameters and their correlation to ceramics used for monolithic restorations permits the dentist to make well-informed decisions in rehabilitation cases, which can result in longer-lasting treatments.

Monolithic restorations are those fabricated with a single ceramic material, in contrast to layered restorations, when there is a need for veneering ceramic application over copings. Monolithic ceramics have been used for inlays, onlays, full crowns, and fixed partial dentures; and have been manufactured by different techniques, such as heat-pressing or CAD/CAM [2]. The materials most commonly used for monolithic restorations include lithium disilicate glass-ceramic (IPS e.max CAD, Ivoclar Vivadent), feldspathic ceramic (VitaBloc Mark II, Vita Zahnfabrik), zirconia-reinforced lithium silicate ceramic (Suprinity, Vita Zahnfabrik), nanoceramic resin (Lava Ultimate, 3M), and hybrid ceramic (Enamic, Vita Zahnfabrik) [1]. When compared to ceramics with a high concentration of glass matrix and glass ceramic, zirconia is less translucent [3], and also its optical properties are less sensitive to thickness variations [4]. Translucent zirconias (Prettau Zirconia, Zirkonzahn, and Katana, Kuraray Noritake) have been recently introduced and can be used to fabricate monolithic indirect restorations with good esthetic outcomes [5].

Translucency is described by the amount of light transmitted through the substrate or by the amount of diffuse reflection on the substrate [6]. The translucency of ceramic materials is usually determined by contrast ratio (CR) and translucency parameter (TP). CR can be defined as the amount of light reflected by a specimen when it is placed against a black and a white background. CR is used to measure the reduction in opacity and the increase in translucency of a given material. TP is calculated by the difference in the color parameters (L*, a*, and b*) of a material over black and white backgrounds [7]. Numerous factors may affect the translucency of ceramics, such as hue, saturation, thickness, roughness, volume of porosity, type and volume of crystalline phase, surface texture, and whether it is a monolithic or layered structure [8-11]. Translucency has been reported as one of the major contributing factors associated with the esthetic results of ceramic restorations [12]. Furthermore, it is intimately associated with light transmission and to polymerization, degree of conversion, and mechanical properties of the resin cements [13].

In different clinical settings, ceramic restorations with varying thicknesses are necessary, depending on a number of factors, such as color, amount of remaining tooth structure, and interocclusal space available for the restorations, so that they can naturally reproduce the optical properties of enamel

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and dentin. Therefore, understanding the relationship between translucency and thickness of ceramic materials, whether for monolithic or layered restorations, is crucial for ensuring a satisfactory esthetic outcome, mimicking the tooth structure, and allowing proper polymerization of the luting material [4]. Therefore, the aim of this study was to assess the translucency of different CAD/CAM-milled ceramic materials used in monolithic restorations (feldspathic ceramic, lithium disilicate glass-ceramic, zirconia-reinforced lithium silicate glass ceramic, and translucent zirconia), in two thicknesses, using different parameters (CR, TP^{*}_{ab}, TP_{00}, direct transmittance of light, light source irradiance through interposing ceramics and percentage of light attenuation). The correlations between the studied parameters were also evaluated. The hypotheses were: i) there would be no difference in the translucency of the assessed ceramic materials, and ii) translucency parameters would not be influenced by different thicknesses.

MATERIALS AND METHODS

Four ceramic materials for monolithic CAD/CAM-milled restorations were used (Table I). The ceramic blocks were cut into slices of 1.1 and 2.1 mm (n=10) using a low-speed diamond saw (Isomet 1000, Buehler, Lake Bluff, USA), for translucent zirconia (TZ) the dimension was 20% larger than the final size. The slices were then sintered or crystallized according to the manufacturers' recommendations. After, the specimens were polished on both sides using wet 120- to 1200-grit silicon carbide on a polishing machine (MetaServ 250, Buehler, Lake Bluff, USA). During the procedure, the specimens were repeatedly measured with a digital caliper (799, Starrett, Athol, USA) to guarantee a final thickness of 1 or 2 mm. Before the color readings, all specimens were ultrasonically cleaned in distilled water for 10 min and air-dried.

The color parameters were determined with a spectrophotometer (SpectroShade Micro, MHT, Verona, Italy). Readings were obtained in triplicates. The device was calibrated before the measurements and was placed at a 90° angle to the surface. The CIEL*a*b* parameters were determined, where L* represents the luminosity axis (L*=0 is black and L*=100 is white), a* indicates the greenness (-a*) and redness (+a*) axis, and b* indicates the blueness (-b*) and yellowness (+b*) axis [14]. The contrast ratio (CR) was determined through light reflection against a standardized black background (L*=24.58, a*=0.27, b*=2.58) and white background (L*=92.95, a*=-0.78, b*=3.57), and it was estimated by [15, 16]:

$$CR=Y_B/Y_W \tag{A}$$

where the L* values were used to calculate the spectral reflectance Y, luminance from tristimulus color space (XYZ), against black and white backgrounds (Y_B and Y_W, respectively). CR values can vary from 0 (transparent) to 1 (opaque). The translucency parameters (TP^{*}_{ab} and TP_{00}), also determined against black and white backgrounds, were calculated based on CIEL*a*b* [16, 17] and CIEDE2000 [17] formulas:

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

where L*, a*, and b* are CIEL*a*b* parameters, and subscripts B and W are the measurements made against black and white backgrounds, respectively;

$$TP_{00}=\left[\left(\frac{L'_B-L'_W}{k_LS_L}\right)^2+\left(\frac{C'_B-C'_W}{k_CS_C}\right)^2+\left(\frac{H'_B-H'_W}{k_HS_H}\right)^2+RT\left(\frac{C'_B-C'_W}{k_CS_C}\right)\left(\frac{\Delta H'_B-H'_W}{k_HS_H}\right)\right]^{1/2} \tag{C}$$

where lightness (L'), chroma (C'), and hue (H') of the specimens were determined over the black and white backgrounds (subscripts B and W, respectively). R_T represents a rotation function related to the interaction between variances of hue and chroma in the blue region. The weighting functions S_L, S_C, and S_H adjust the total color difference for variation in the location of the color difference pair at the L*, a*, and b* coordinates, and the parametric factors k_L, k_C, and k_H are correction terms for experimental conditions. In the present

Table I - Classification and composition of the ceramic materials investigated.

Ceramic material	Brand and manufacturer	Composition	Shade
Feldspathic ceramic (FC)	VitaBloc Mark II, Vita Zahnfabrik, Bad Sackingen, Germany	20-23% Al_2O_3, 56-64% SiO_2, 6-9% Na_2O, 6-8% K_2O, 0.3-0.6% CaO, 0.0-0.1% TiO_2	A1C
Zirconia-reinforced lithium silicate glass-ceramic (LS)	Vita Suprinity, Vita Zahnfabrik, Bad Sackingen, Germany	8-12% ZrO_2, 56-64% SiO_2, 15-21% Li_2O, 0.1% La_2O_3, pigments <10%, others >10%	HT-A1
Lithium disilicate glass-ceramic (LD)	IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein	Li_2O, K_2O, MgO, Al_2O_3, P_2O_5, other oxides	HT-A1
Translucent zirconia (TZ)	Prettau Zirconia, Zirkonzahn, Gais, Italy	Zr_2O, 4-6% Y_2O_3, <1% Al_2O_3, ≤0.02% SiO_2, ≤0.01% Fe_2O_3, ≤0.04% Na_2O	Non-colored*

**: without addition of dye.*

study, k_L, k_C, and k_H were set to 1. For measuring the direct transmittance of light, in percentage (T%), an ultraviolet-visible (UV/vis) spectrophotometer (UV-1601, Shimadzu, Kyoto, Japan) was used. The calibration parameters of the spectrophotometer in scan mode were as follows: slit of 0.5 nm, 10 nm smooth, and scan speed of 240 nm/min. Measurements were made between 400-780 nm with an interval of 5 nm. The mean T% values at the wavelength of 468 nm were used to compare the different ceramic materials and the thicknesses of 1 and 2 mm.

The quantitative analysis of irradiance for the light source and the percentage of light attenuation was performed using the images obtained for the ceramic specimens placed in front of a known light-emitting source (Poly Wireless, Kavo, Joinville, Brazil), using a camera (70D, Canon) with an aperture of f/32, speed of 3000, ISO 100, equipped with a 100 mm macro lens, providing images with 5472x3648 pixels in RAW format. These parameters were used to prevent the saturation of the charge-coupled device (CCD) of the camera in the image obtained from the reference light source. The images were acquired with a standalone light source (for control and estimation of the absolute value) and with ceramic veneers placed in front of the light source. The LED (light-emitting diode) light source had an irradiance of 870 mW/cm^2, measured with a radiometer (RD7, Ecel, Ribeirão Preto, Brazil). To quantify the light source irradiance, the value of the blue spectrum (given that an LED curing unit was used as a light source) was acquired on a central line on each image using a program devised in matrix processing software (GNU Octave). This central line was chosen for each image according to the largest visible diameter of the light source, with a total length of 1000 pixels and a resolution of 8×10^{-3} mm/pixel. For each image, after the interposition of the ceramic veneers, the data were collected, the histograms were plotted, and the mean irradiance values were checked against the reference standard for the light source irradiation and the light attenuation was estimated.

Data were statistically analyzed using two-way ANOVA (ceramic material and thickness) and Tukey's test. The correlation between CR, TP^*_{ab}, TP_{00}, T%, and light source attenuation was determined by Pearson's correlation coefficient. The significance level was set at 5% for all analyses. All analyses were performed using SigmaPlot software, version 11.0 (Systat Software, San Jose, USA).

RESULTS

The means and standard deviations for contrast ratio (CR), translucency parameters (TP^*_{ab} and TP_{00}), direct transmittance of light (T%), light source irradiation through ceramic interposition, and the percentage of light source attenuation of the different ceramics and thicknesses are shown in Tables II and III. CR, TP^*_{ab} , TP_{00}, and T% showed significant differences for ceramic materials ($p<0.001$), thickness ($p<0.001$), and double interaction ($p<0.001$). Feldspathic ceramic (FC) and zirconia-reinforced lithium silicate glass-ceramic (LS) showed statistically greater translucency at a thickness of 1 mm compared to 2 mm.

Table II - Means ± standard deviations for contrast ratio (CR), translucency parameters (TP^*_{ab} and TP_{00}), and direct transmittance of light (T%).

Ceramic	CR		TP^*_{ab}		TP_{00}		T%	
	1 mm	2 mm	1 mm	2 mm	1 mm	2 mm	1 mm	2 mm
FC	0.76±0.00^{Bb}	0.85±0.01^{Ab}	21.6±1.2^{Ab}	14.3±0.5^{Bb}	15.5±1.0^{Ab}	10.1±0.5^{Bb}	75.2±1.4^{Aa}	50.4±3.8^{Ba}
LS	0.64±0.02^{Bc}	0.77±0.01^{Ab}	32.2±1.6^{Aa}	22.6±0.7^{Ba}	26.4±1.6^{Aa}	17.7±0.8^{Ba}	42.3±7.8^{Ab}	27.1±2.1^{Bc}
LD	0.77±0.01^{Ab}	0.85±0.01^{Ab}	20.7±0.9^{Ab}	13.1±1.2^{Bb}	15.0±0.8^{Ab}	9.6±1.0^{Bb}	45.3±0.7^{Ab}	41.8±3.1^{Ab}
TZ	0.93±0.02^{Ba}	0.96±0.00^{Aa}	6.6±1.3^{Ac}	3.7±0.2^{Bc}	4.0±0.8^{Ac}	3.0±0.1^{Bc}	17.6±0.3^{Ac}	14.9±0.7^{Ad}

For each parameter, in the lines, values followed by the same capital letters are statistically similar (p>0.05). For each parameter, in the columns, values followed by the same lowercase letters are statistically similar (p>0.05).

Table III - Means ± standard deviations of the interposition of the ceramic's veneers for the light source irradiance and percentage of light attenuation.

Interposing ceramic	Light source irradiance (mW/cm^2)			Light attenuation (%)		
	1 mm	2 mm	Total	1 mm	2 mm	Total
FC	339±91	197±83	268±107^a	61±10	77±10	69±12^a
LS	404±107	261±56	333±106^a	54±12	70±6	62±12^a
LD	378±60	235±63	307±91^a	57±7	73±7	65±10^a
TZ	233±92	139±43	176±75^b	76±11	84±5	80±9^b
Total	334±110^A	208±73^B		62±13^A	76±8^B	

For each parameter, in the lines, values followed by the same capital letters are statistically similar (p>0.05). For each parameter, in the columns, values followed by the same lowercase letters are statistically similar (p>0.05).

Lithium disilicate glass-ceramic (LD) also showed greater translucency in 1 mm for TP^*_{ab} and TP_{00}. For translucent zirconia (TZ), 2 mm specimens were less translucent than 1 mm specimens for all parameters, except for T%. LS, 1 mm-thick specimens, showed greater translucency, for TP^*_{ab}, TP_{00}, and CR, followed by LD and FC, which showed similar values. TZ was the less translucent ceramic for all parameters. For T%, in 1 mm-thick specimens, the ceramics varied in the following order: FC>LD=LS>TZ. At 2 mm, T% was different for all ceramics. For the light source irradiation through ceramic interposition and the light attenuation (in %), there were statistically significant differences among the ceramic materials ($p<0.001$) and thickness ($p<0.001$). The double interaction was not statistically significant ($p=0.625$ for light source irradiation and $p=0.618$ for light source attenuation). LS, LD, and FC showed the higher means for light source irradiation and the lower ones for the percentage of light attenuation, whereas TZ had the lowest mean for light source irradiation and the highest one for light attenuation. Regarding thickness, 1 mm exhibited significantly higher light source irradiation and lower light source attenuation when compared to 2 mm.

Table IV shows the correlations between the translucency parameters evaluated. There were significant strong negative correlations between CR and TP^*_{ab} ($R=-0.997$), between CR and TP_{00} ($R=-0.991$), between TP^*_{ab} and light attenuation ($R=-0.888$), and between TP_{00} and light attenuation ($R=-0.867$). Significant strong positive correlations were found between CR and light attenuation ($R=0.909$), and between TP^*_{ab} and TP_{00} ($R=0.994$). Non-significant moderate negative correlations were identified between CR and T% ($R=-0.543$) and between T% and light attenuation ($R=-0.570$); whereas there were non-significant moderate positive correlations between TP^*_{ab} and T% ($R=0.522$), and between TP_{00} and T% ($R=0.441$).

Table IV - Correlations between the evaluated translucency parameters.

Parameter	TP^*_{ab}	TP_{00}	T%	Light attenuation
CR	R=-0.997 p<0.001	R=-0.991 p<0.001	R=-0.543 p=0.164	R=0.909 p=0.002
TP^*_{ab}		R=0.994 p<0.001	R=0.522 p=0.1 84	R=-0.888 p=0.003
TP_{00}			R=0.441 p=0.274	R=-0.867 p=0.005
T%				R=-0.570 p=0.140

DISCUSSION

The first hypothesis of this study was rejected because translucent zirconia (TZ) showed the lowest translucency in all parameters. On the contrary, LS glass-ceramic exhibited the highest translucency. These outcomes are in accordance with previous studies, which reported that lithium disilicate glass-ceramics are significantly more translucent (higher TP) than zirconia [4, 18, 19]. The higher opacity of zirconia can be attributed to the high crystal content and the lack of crystal symmetry, which could lead to different refractive indices, reducing translucency [4, 12, 20]. Conversely, the higher translucency of lithium silicate glass-ceramic can be explained by its composition and microstructure. This zirconia-reinforced lithium silicate glass-ceramic (approximately 10% in weight) was created to incorporate the improved properties of a lithium disilicate glass-ceramic and of zirconia. The inclusion of zirconia particles reinforces the material, reducing cracks [21]. Awad et al. [22] compared the absolute translucency of several CAD/CAM restorative materials and showed that zirconia-reinforced lithium silicate glass-ceramic had a significantly higher translucency than lithium disilicate glass-ceramic. The difference in translucency was attributed to grain size and to variations in crystal structure. After crystallization, zirconia-reinforced lithium silicate glass-ceramic crystals have a mean grain size of 500 to 700 nm, 4 to 8 times smaller than the grain size of lithium disilicate crystals. Moreover, because the lithium silicate crystals dispersed in the matrix are smaller, the glass content is larger, providing higher translucency when compared with lithium disilicate glass-ceramics. The results of the present study also are corroborated by a previous work [23] that evaluated the TP^*_{ab} of five CAD/CAM-milled materials for monolithic restorations (Lava Ultimate, Vita Enamic, Vitablocs Mark II, Vita Suprinity, and IPS e.max CAD), indicating higher translucency for zirconia-reinforced lithium silicate glass-ceramic than for feldspathic ceramic and lithium disilicate glass-ceramic.

The translucency of the ceramic materials can be influenced by their different compositions and crystal contents [9, 10]. The findings of the present study also corroborated that variations in the translucency of the assessed ceramics are related to the type of ceramic, type of crystal, and crystalline content. In general, ceramics with a high glass content, such as glass-ceramics and feldspathic ceramics, are more translucent than zirconia [24]. The TP^*_{ab} of 1 mm human dentin was estimated at 16.4 and that of human enamel was 18.1 [25] The values were relatively close to those of feldspathic ceramic, FC (1 and 2 mm), lithium disilicate glass-ceramic, LD (1 and 2 mm), and zirconia-reinforced lithium silicate glass-ceramic, LS 1 mm (TP^*_{ab} between 13.1 and 22.6). 2 mm-thick LS had a much higher TP^*_{ab} (32.2). As for zirconia, TP^*_{ab} for 1 and 2 mm ranged from 3.7 to 6.6, i.e., lower than TP^*_{ab} of both human enamel and dentin. These data also confirmed the capacity of ceramics with a high glass matrix content to be almost as translucent as natural teeth [26].

The second hypothesis, that parameters for the assessment of translucency would not be influenced by different thicknesses of the materials, was rejected since specimens with 1 mm in thickness were more translucent in all parameters than those with 2 mm for all the evaluated ceramics. These findings are corroborated by previous studies. Antonson and Anusavice [8] assessed the translucency of ceramics for core and veneer application as a function of thickness. They showed a positive correlation between thickness and contrast ratio (CR). It has been demonstrated that, for different ceramic materials used for monolithic and layered restorations, the increase in thickness led to higher opacity [9, 10, 27]. In general, an increase in thickness is believed to reduce translucency, since the absorption of incident light is larger in thicker materials [28]. According to Lambert's law, a smaller thickness of the material provides higher light transmission because of lower absorption [27]. Thus, both the microstructure (type of crystal and crystalline content) and the thickness seem to play an important role in the translucency of dental ceramics. In the case of dental porcelains, the literature reports that thickness is the major factor affecting light transmission, rather than opacity [29]. Barizon et al. [11] assessed the effect of shade and thickness on the translucency (TP^*_{ab}) of different ceramic materials used for laminate veneers, and also concluded that, among the analyzed factors (material, shade, and thickness), thickness showed the most significant effect.

Some parameters used in this study (CR and TP^*_{ab}) are widely reported for determining the translucency of ceramic materials. However, the different parameters to evaluate the translucency of restorative materials may hinder the comparison of data across studies. While several studies report CR or TP^*_{ab} to assess the translucency of different restorative materials, few of them demonstrated that these two parameters are correlated with each other. Previous studies with dental ceramics have shown a strong negative correlation between CR and TP^*_{ab}. Barizon et al. [7] evaluated six different ceramic systems and found a Pearson's correlation coefficient of -0.99 between their CR and TP^*_{ab}. Della Bona et al. [30] and Nogueira and Della Bona [31] used Pearson's correlation coefficient and the coefficient of determination (Pearson's coefficient squared, R^2) and demonstrated that CR and TP^*_{ab} had a strong negative correlation (R^2=-0.97 and R=-0.99) for all restorative materials analyzed in their studies. Our results confirmed a strong negative correlation between CR and TP^*_{ab} (R=-0.99). Since this correlation is quite strong, as determined by the correlation equation and by knowing one of the parameters, it is possible to predict the behavior and determine the other parameter. While CR and TP^*_{ab} are widely used, TP_{00} is not frequently reported for dental ceramics [32-34], and its correlations with other translucency parameters are poorly known for these indirect restorative materials. However, as TP^*_{ab} and TP_{00} present a strong positive correlation, it is expected that the correlations with TP_{00} will follow the same trend as for TP^*_{ab}. With respect to T%, for different CAD/CAM ceramic materials, a strong positive correlation was demonstrated between CR and T% at 525 nm (R^2=0.85) [31]. In the present study, T% at 468 nm showed a moderate non-significant correlation with all the other parameters evaluated. This wavelength was chosen because ceramic restorations are adhesively cemented with light-cured and dual-cured resin cements. In these materials, the most used photoinitiator system is a camphorquinone and a tertiary amine. The camphoroquinone absorbs light with wavelengths ranging from 360 to 510 nm, with a maximum absorption peak at 468 nm [35].

The light source irradiance through the interposing ceramics and the light attenuation analysis presented herein is a quick and easy method, with relatively low cost and no need for specific equipment. By using standardized photographs from a light source (LED curing unit with known irradiance) with and without the interposition of ceramic veneers, it was possible to determine the light attenuation of each material in the two thicknesses assessed. As shown in Table III, the amount of light (in %) that passed through the ceramic veneers and that would effectively reach the resin cement layer ranged from 15.9% (TZ, 2 mm) to 46.5% (LS, 1 mm). Even under favorable conditions, almost 50% of the light was attenuated at 1 mm for a glass-ceramic with a high translucency level. Under the most critical condition, where 2 mm of TZ was interposed, nearly 75% of the light was attenuated, which could indicate a significant decrease in the physicochemical properties of resin cements, compromising the clinical longevity of the restorative treatment. It is also noteworthy that, when thickness increased, light attenuation increased significantly for all assessed materials. Translucency was 42% smaller for FC, 35% smaller for LS, 38% smaller for LD, and 35% smaller for TZ. The present study showed a strong negative correlation between TP^*_{ab} and light attenuation (R=-0.89), and a strong positive correlation between CR and light attenuation (R=0.91). This allows the validation of the light source irradiance through the ceramics and the percentage of light attenuation values obtained, as they strongly correlate with CR, TP^*_{ab}, and TP_{00}.

Therefore, the findings of the present study should be taken into consideration when selecting ceramic material in different clinical situations. In each case, the need for higher translucency of the ceramic restorative material or masking ability in the presence of darker substrates should be identified and well-investigated concerning the optical characteristics of the remaining tooth structure. With the advent of new ceramic materials, dentists should get acquainted with the translucency of different dental ceramics, mainly for the restoration of anterior teeth, to guarantee the appropriate selection of the restorative material and better esthetic outcomes.

CONCLUSIONS

The ceramic materials and their thicknesses influenced the translucency parameters assessed. Zirconia-reinforced lithium silicate glass-ceramic exhibited the highest translucency, whereas translucent zirconia was the less translucent ceramic. For the same material, the increase in thickness resulted in higher contrast ratio (CR), higher light attenuation, lower transmittance of light, and lower translucency parameter (TP). There were strong negative correlations between CR and TP, and between TP and light attenuation. A strong positive correlation was found between CR and light attenuation.

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