original **ARTICLE**

EFFECT OF TYPES AND THICKNESS OF CERAMICS IN THE ATTENUATION OF LIGHT EMISSION IN DIFFERENT PHOTOACTIVATION MODES

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ABSTRACT

Introduction: Dental ceramics are materials with satisfactory physical and chemical properties, but they can also cause attenuation of the blue light coming from photopolymerizers due to factors such as thickness, opacity, porosity, color and surface glaze, which justify the present study. **Objective:** to evaluate the light intensity through different types of ceramics, with different thicknesses, from two LED light curing units in different activation modes. **Methods:** A portable radiometer (Bluemeter®) was used to measure light intensities (in mW/cm2) from two different light curing units (Valo® in High and Xtra modes, and Bluephase G2® in High mode) through 50 ceramic discs of zirconium dioxide and high opacity lithium disilicate (HO), medium opacity (OM), low opacity (LO) and high translucency (HT), with 0.5-mm and 1.0-mm thickness, positioned between the tip of the light curing unit and the measurement sensor of the radiometer (n=5). **Results:** From the statistical analysis, it was observed that the attenuation of the light emitted by the photopolymerizers varied according to the different compositions of the ceramics, being the thickness a highly relevant factor in determining the results. **Conclusion:** The passage of light through the ceramic discs varied according to the modes of operation of the light-curing device. It was possible to conclude that the two studied factors interfere in the attenuation of the energy emitted by the light-curing units and that care with the type of ceramics and the type of light-curing unit must be observed in the step of choosing the cementing protocol.

KEYWORDS:

Photopolymerization. Ceramics. Opacity. Thickness.

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INTRODUCTION

Dental ceramics are products of the reaction of crystalline substances in a vitreous matrix, with the addition of numerous molecules (metallic oxides or metalloids) with physical, mechanical and chemical properties considered clinically satisfactory.[1,2,3] With advances in technology and research, ceramics are currently employed in indirect single restorations (*inlays* and *onlays*), partial or total prostheses, fixed or removable,[1,2,3] in different thicknesses and degrees of translucency and opacity.

Classification of ceramic materials can be made on the basis of their composition, in feldspathic, feldspathic reinforced with leucite, lithium disilicate, zirconia and alumina; but also in other forms as for the microstructure in amorphous, crystalline glass or crystalline particles in vitreous matrix. As for the translucency, they are classified in opaque, translucent and transparent.

Based on the assumption that ceramics present factors such as thickness, opacity, porosity, color and glaze, which attenuate the photons that come into contact with its surface,[1,2,3] studies on the degree of light absorption, light reflection and light scattering, emitted by curing lights through them, are of upmost importance.[3,4,5,6] It is known that ceramics cause attenuation of the blue light emitted from the light-curing units, and thus, measurement of light intensity delivered through dental ceramics is the object of study of many researchers, who look for factors related to the light transmittance of these materials in relation to the light emitted by curing lights.[7,8,9,10] Some authors have studied the relationship of the degree of conversion of resin cements when light activated and when chemically activated. In conclusion, the photoactivated cements had a higher degree of conversion, while other authors found higher results for chemically activated cements.[5] Some studies[3] tested different light-emitting sources through ceramics of zirconium dioxide and lithium disilicate, showing surprinsingly a greater attenuation of light by the lithium disilicate ceramics.

Thickness was also a determining factor, being directly related to the degree of attenuation of light intensity.[3] Exposure of resin cements through ceramics that block the passage of light may not allow the polymerization of monomers, regardless of the exposure time and light intensities used.[4] Ceramic thickness has been an important factor in light attenuation, and in vitro tests show a direct relationship between these factors,[11,12,13,14] although other studies do not demonstrate the relevance of ceramic thickness in microhardness tests of resin cements.[6]

Based on this problem and in the lack of consensus on the influence of some factors such as thickness and translucency on the amount of light that crosses the ceramics during a photopolymerization process, the objective of this study was to evaluate the attenuation of the light intensity of two curing lights (Valo® and Bluephase G2®), in different modes of photoactivation, through high-opacity (HO), medium opacity (MO), low translucency (LT) and high translucency (HT) ceramic discs of lithium disilicate and zirconia, in different thicknesses.

MATERIALS AND METHODS

In order to perform this study, fifty ceramic discs were made, five per group, according to the specifications in Table 1. Ceramic discs were

Figure 1:
Measurement of different ceramic materials.

Table 1:
Ceramic materials used in the experiment.

Ceramic code	Ceramic (manufacturer)	Composition	Thickness	Processing route
Z	Zirkonzahn (Zirkonzahn, EUA)	$ZrO_2{\cdot}K_2O{\cdot}Al_2O_3$	0,5 mm	Slip casting
Z1	Zirkonzahn	$ZrO_2{\cdot}K_2O{\cdot}Al_2O_3$	1,0 mm	Slip casting
HO (high opacity), MO (médium opacity), LT (low translucency) and HT (high translucency)	E-Max (Ivoclar Vivadent, Liechtenstein)	$LiO_2{\cdot}2SiO_2$	0,5 mm	Slip casting
HO1, MO1, LT1 e HT1	E-Max	$LiO_2{\cdot}2SiO_2$	1,0 mm	Slip casting

made by the same laboratory, being ten disks for each type of ceramic, five of them with a 0.5mm thickness and five with 1mm, measured with a digital caliper (Fig 1).

Valo® (V) (Ultradent, Utah, USA) and Bluephase G2® (B) (Ivoclar Vivadent, Schaan, Liechtenstein) were used for the tests. Measurement of the light intensity (mW/cm2) of curing light units was done by a calibrated radiometer (Bluemeter, Ivoclar Vivadent, Schaan, Liechtenstein) that also worked as a support for the disks positioned immediately above the sensor. The photoactivation modes of the units were selected according to the highest light intensity they presented in the initial calibration (Table 2). In the Valo®, the "High" and "Xtra" modes were chosen, being 10 seconds for the "High" and 3 seconds for the Xtra ", as determined by the manufacturer. Bluephase G2® was used in its "High" mode for 10 seconds.

Light intensity measurements (n = 5) were analyzed through the ceramic discs, with the highest and lowest value being discarded, and the remaining 3 values were used for statistical analysis. A total of 750 activations were done considering all groups. Data was statistically performed by ANOVA and Tukey's test ($\alpha = 0.05$) with the Minilab software.

Table 2:
Light intensity of light curing units and photoactivation modes.

Photopolimerizers	Light intensity (mW/cm²)
Valo — High (VHI) — 10s	1.486
Bluephase G2 — High (BHI) — 10s	1.675
Valo — Xtra (VXT) — 3s	2.663

RESULTS

Mean values of light intensity for the different groups are described in Table 3. Statistical analysis showed attenuation of light intensity emitted by the curing lights. There were significant differences in light intensity, from the main factors and their studied levels ($p < 0.01$), but the greatest differences detected were for thickness ($p < 0.001$).

The highest values of light intensity occurred in the "Xtra" mode of the Valo® device (VXTZ, VXTZ1, VXHO1, VXHO1, VXMO1, VXL1, VXHT, VXHT1) on all types of ceramic discs ($p < 0.001$ (VXHO1, VXMO1). This curing light unit and mode were the only one to reach the radiometer sensor when 1.0mm thick discs of medium opacity (MO) and high opacity (HO) were used.

Valo® and Bluephase G2® units in "High" operating modes did not present significant differences of light intensities in all ceramic discs ($p > 0.05$). The highest light intensity was presented when high translucency ceramics were used, 0.5 mm thick (VXTHT), while the low translucency (LT) ceramics of 1.0 mm did not allow sufficient light to pass through the radiometer, in all situations of photoactivation ($p > 0.05$).

Light intensities of Valo® and Bluephase G2® in High operating mode were not sufficient to cross the 1.0mm thick high opacity (HO) and medium opacity (MO) ceramic discs (VHHO1, BHHO1, VHMO1, BHMO1). The 1.0mm thick discs presented lower results of light intensity than the 0.5mm discs in all modes of photoactivation ($p < 0.01$) (Graph 1).

Table 3:
Descriptive analysis — Mean and standart deviation (Mean±sd)

Group	Mean (mw/cm²)	Standart deviation (±mW/cm²)
VHIZ	462.4	58.5
VXTZ	839.0	51.9
BHIZ	456.4	13.5
VHIZ1	341.0	22.5
VXTZ1	477.2	92.2
BHIZ1	320.4	18.3
VHIHO	639.8	85.4
VXTHO	925.6	148.3
BHIHO	505.8	41.4
VHIHO1	0	0
VXTHO1	562.4	29.6
BHIHO1	0	0
VHIMO	525.8	34.7
VXTMO	802.4	48.5
BHIMO	459.8	23.7
VHIMO1	0	0
VXTMO1	347.6	29.2
BHIMO1	0	0
VHILT	397.0	22.1
VXTLT	690.4	33.0
BHILT	377.0	20.2
VHILT1	0	0
VXTLT1	0	0
BHILT1	0	0
VHIHT	599.8	28.6
VXTHT	930.0	94.1
BHIHT	546.4	35.5
VHIHT1	332.8	28.0
VXTHT1	531.8	24.2
BHIHT1	307.8	9.3

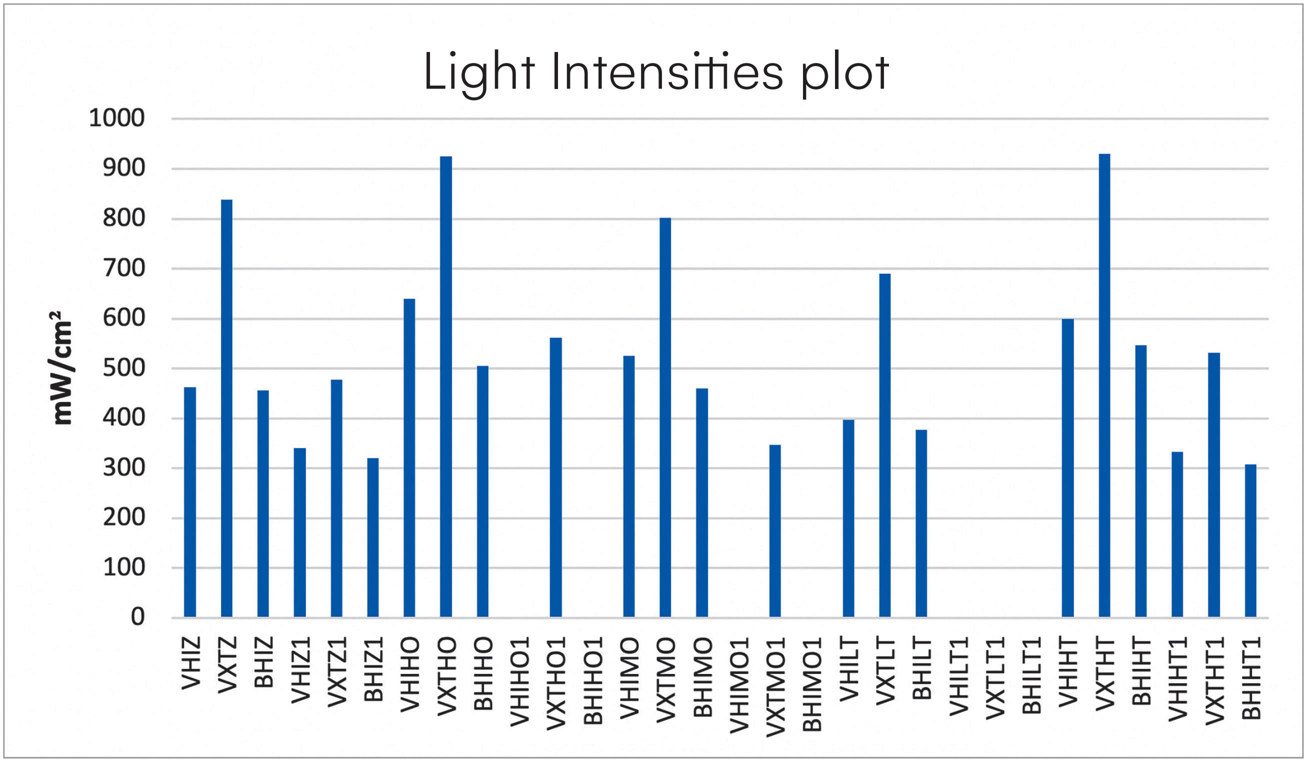

Figure 2:
Light Intensities plot (mW/cm^2).

DISCUSSION

In the present study, significant differences were observed in light attenuation of the current ceramic systems, either because of their compositional structure or because of material thickness. It was also observed that curing devices and their different modes of photoactivation, pre-programmed by the manufacturers, were attenuated by the intensity of light emitted when it passed through the ceramic structure. Some studies have already explained this same attenuation phenomenon in different ways, such as Valentino et al.[8] who stated that the chemical compounds present in the ceramics are responsible for light attenuation. Giannini et al.[3] demonstrated different attenuations of light between different ceramic types and their relation with the emitted light sources. The analysis of this experiment converge with the conclusions of the authors mentioned above. A divergence in the results occurs, since Giannini et al.[3] concluded that zirconia-based ceramics in their composition allowed for greater light passages when compared to those of lithium disilicate. In the results of the present work, the degree of opacity of lithium disilicate discs was highly related to their transmittance, since the high translucency lithium disilicate ceramic discs (HT and HT1), demonstrated highest values of light transmitted. The same result was obtained by Pereira et al.[9]. Low-translucency lithium disilicate ceramics with 1.0mm thick (LT1), although was not the most opaque, it showed the lowest transmittance results, which reinforces the statements of Anusavice,[1] which suggests other factors, such as porosity and color as determinants of light attenuation.

Archegas et al.[10] correlated a direct proportion between the translucency of the ceramics and the degree of conversion of the resin cements. This way, clinicians should use critical sense when photoactivating each ceramic type, in order to provide enough energy for the polymerization of the composites. Ayres et al.[2] have shown that in addition to the type of ceramic used and the thickness of the material, conditions and photoactivation time have a great influence on the degree of conversion of resin cements, in accordance to other authors[3] who concluded that the type of curing unit influenced the irradiance through different restorative materials.

Other authors[13] also found influence of different ceramic systems in the degree of conversion of resin cements, besides a relation in time of irradiation and an increase of microhardness. However, light attenuation for resin cements due to the presence of ceramic restorations was not compensated for by overexposure to light with time of 120s.[4] Ilie et al.[6] evaluated the relationship between translucency of different ceramics and the hardness of the resin cement, showing that at a thickness of 1mm, lithium disilicate ceramics reduced the hardness of the resin cement, coinciding with other studies[9]. This work also demonstrated that the effects on cement hardness were mainly due to activation time, followed by material translucency and thickness, in accordance to other studies.[2,3,12,13] Kilinc et al.[14] suggested thickness of the ceramics had greater relevance for the degree of attenuation. Zhang & Wang[15] evaluated only the thickness variable, using lithium disilicate. The results were similar to the previous studies, in which the authors suggest longer photoactivation time in order to compensate for material thickness attenuation.

CONCLUSIONS

Based on the results of the experiment, the interaction of photoactivation mode and different thicknesses of ceramics influenced the amount of light attenuation.

With regard to the photoactivation mode, there was no significant difference in light intensity between Valo® and Bluephase G2® devices, in their respective "High" operating modes. The "Xtra" mode of the Valo® device demonstrated the best results for all situations.

Considering the type of ceramics, high translucency lithium disilicate presented greater light transmitance while low translucency showed lower transmittance, although they were not the most opaque disks.

As for ceramic thickness, 1.0mm discs showed the greatest attenuation of light intensity in all ceramic materials and modes of photoactivation.

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