Comparison of light transmittance in different thicknesses of zirconia under various light curing units

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PURPOSE. The objective of this study was to compare the light transmittance of zirconia in different thicknesses using various light curing units. **MATERIALS AND METHODS.** A total of 21 disc-shaped zirconia specimens (5 mm in diameter) in different thicknesses (0.3, 0.5 and 0.8 mm) were prepared. The light transmittance of the specimens under three different light-curing units (quartz tungsten halogen, light-emitting diodes and plasma arc) was compared by using a hand-held radiometer. Statistical significance was determined using two-way ANOVA (α=.05). **RESULTS.** ANOVA revealed that thickness of zirconia and light curing unit had significant effects on light transmittance (P<.001). **CONCLUSION.** Greater thickness of zirconia results in lower light transmittance. Light-emitting diodes light-curing units might be considered as effective as Plasma arc light-curing units or more effective than Quartz-tungsten-halogen light-curing units for polymerization of the resin-based materials. **[J Adv Prosthodont 2012;4:93-6]**

KEY WORDS: Zirconia; Light curing unit; Light transmittance

INTRODUCTION

Patients' and clinicians' esthetic demands have led to the development of high-technology processes such as glass infiltrated spinell and alumina, fused alumina or zirconia materials that are becoming increasingly advanced in their optical properties.[1-3] These restorations allow diffuse transmission as well as specular reflectance of light, reproducing a depth of translucency and color mimicking that of natural teeth.[4] Among a variety of core materials, zirconia has been proved to possess better mechanical properties. However, it has poor translucency and therefore, it is difficult to satisfy the esthetic requirements. Furthermore, the optical property of core materials plays an important role in matching the affected shade of the artificial restorations with the natural appearance of teeth. In addition, the optical properties of the material depend on the amount of crystals within the core matrix, their chemical nature, and the size of the particles.[5,6]

Although the characteristics of coping is important for the clinical success, the variables that contribute to a durable and predictable restoration includes the luting material, its polymerization behavior and mechanism, the nature and thickness of the restoration itself and the light polymerizing unit.[3]

The rapid advancement in esthetic dental restorative techniques has dramatically increased the use of light curing units (LCUs) to cure resin based materials. Nowadays, boosted versions of high intensity quartz-tungsten-halogen (QTH), plasma arc (PAC) and light emitting diode (LED) LCUs that possess higher light intensity than conventional LCUs have been developed.[7,8] However, doubts about the effectiveness of these LCUs still in doubt.

Since, the zirconia restorations permit the use of both resin luting agents and conventional cements (such as zinc phosphate or resin-modified glass ionomer cements) for cementation, the polymerization of resin-based luting agents is important for long-term stability of the restoration. In most clinical cases, dual-curing resin cement is used when bonding ceramic to enamel and dentin.[9] Dual polymerization, the combination of light and chemical polymerization, provides a better conversion of monomers. This is important because inadequate polymerization is usually associated with poor mechanical and biological properties of the resin cements.[10] Moreover, adequate polymerization of resin cements depends not only on resin cement but also on the LCU intensity, wavelength of the visible light and polymerization time. Therefore, it is important to evaluate the effect of different light curing units or different thicknesses of zirconia

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on light transmittance of the zirconia restoration.

Based on these considerations, the tested null hypothesis was twofold. (1) No differences exist among the transmittance measurements of the various LCUs. (2) The thickness of zirconia would not affect the light transmittance of zirconia.

MATERIALS AND METHODS

Zirconia disc-shaped specimens (5 mm in diameter) (n = 21) (in A1 shade) were manufactured from pre-sintered Y-TZP disc shaped blocks (Copran Zr®, WhitePeaks Dental GmbH & Co. KG, Essen, Germany); composition according to the manufacturer in wt%, ZrO_2, 88.0 - 96.0%; Y_2O_3, 4.0 - 6.0%; and Al_2O_3, less than 0.4%) with Yenadent D40 unit (Yena CNC Milling Systems, Yena Makina San. Tic. Ltd. Sti, Istanbul, Turkey) and then sintered to full density in a high-temperature furnace (Protherm, B&D Dental Origin Milling, UT, USA); 1450℃ for 2 hours) according to the manufacturer's instructions. Three different thicknesses (0.3, 0.5 and 0.8 mm) (n = 7/group) of zirconia were evaluated. Before measurement of translucency, the zirconia discs were ultrasonically cleaned in distilled water for 10 minutes and then dried with compressed air. The thickness of the discs was measured using a digital micrometer (Mitutoyo Manufacturing Company Ltd, Kawasaki, Japan). The accuracy of the micrometer was ± 10 ㎛.

Light curing units used in the present study were given in Table 1. The power outputs from a QTH LCU (Blue Swan Digital, Dentanet, Ankara, Turkey), LED LCU (Elipar Freelight 2, 3M Espe, St. Paul, MN, USA) and PAC LCU (PlasmaStar, SP-2000, Monitex, Taiwan) were approved by a hand-held radiometer (Demetron, Kerr, Orange, CA, USA). The irradiation was performed top through the zirconia specimens. Then, the light transmission value of each thickness was measured by placing the disc on the aperture of the radiometer and recording the average of resultant light readings through the disc. Then transmittance percentage was calculated for each thickness.

Two-way analysis of variance (ANOVA) and Tukey's post-hoc tests were performed to determine the effects of different zirconia thicknesses and LCUs on light transmittance (α =.05).

RESULTS

The mean transmittance values and standard deviations for specimens are shown in Fig. 1. Statistical analysis demonstrated that different zirconia thickness and light curing unit had significant effects on light transmission percentage values (P<.001). Furthermore, no significant two factor interaction between zirconia thickness and LCUs was observed (P<.177).

Tukey's post-hoc test revealed that there were significant differences between LCUs (P<.001). Additionally, the transmitted light with respect to LCU can be ranked as follows: LED > PAC > QTH. According to the zirconia thickness, the percentage of light transmittance was ranked as follows: 0.3 mm > 0.5 mm > 0.8 mm (P<.001). As a result, percentage of light transmittance was decreased with the increase in thickness of zirconia disc.

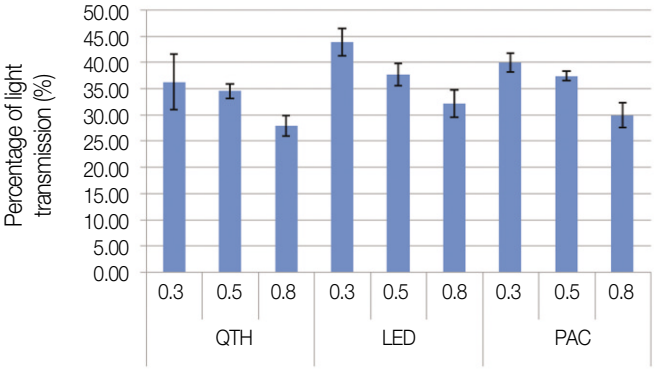

Fig. 1. Mean light transmittance (%) of the zirconia specimens in different thicknesses with different light curing units.

Table 1. Light curing units used in the present study

Light curing unit	Type of light source and diameter of tip	Profiles	Output* (mW/cm²)	Manufacturer
QTH	8 mm	The curing cycle of boost automatically from soft- start to high output	1000	Blue Swan Digital, Dentanet, Turkey
LED	8 mm	Provides light increasing to full intensity over the course of 5 se	1200	Elipar Freelight 2, 3M ESPE, St. Paul, MN, USA
PAC	8 mm	Light exposure time 6 se total, intensity as follows: start 2 se at 50%, 2 se at 50%, 2 se at 100%	2250 ± 50	PlasmaStar, SP-2000, Monitex Industrial Co. Ltd., Taiwan

*According to the manufacturer's information.

DISCUSSION

The first null hypothesis was rejected as statistical analysis revealed differences in light transmittance percentage values after light curing with different LCUs. It is known that inadequate polymerization of resin cements might be a problem especially under ceramic restorations.[9] Therefore, to reach maximum physical properties of resin cements; the conversion rate should be as high as possible.[11] In the present study, to simulate clinical conditions, the LCUs were used at the top of the zirconia discs, where the end of the light guide was in contact with the discs.

Previous studies reported mechanical properties of LED LCU polymerized resin composites are as well or better than some QTH LCUs.[8,12] Similarly, in the present study, light transmittance values obtained with LED LCU were higher than that of QTH LCUs. Furthermore, PAC LCUs are often discussed as an alternative to high-power LED and QTH LCUs.[13] A previous study by Rasetto *et al*. indicated that, PAC polymerization units had comparable light transmission values when compared with QTH LCUs.[3] In accordance with these previous studies, the present study indicated comparable light transmittance values of PAC LCUs with LED LCUs which are higher than that of QTH LCUs. The special spectrum of the PAC, which has very high light intensities (2250 $\pm$ 50 mW/cm^2) at certain wavelengths, might have caused this better outcome.

A previous study by Price *et al*. investigated the effects of different LCUs on resin polymerization and the results were explained by a formula that indicated the total energy that reached the resin composite.[14] With reference to that formula, when the PAC LCU delivered 2200 mW/cm^2 and was used for 10 s, the resin-based material under the restoration should have received 22 J/cm^2, after light transmission. Moreover, when both the QTH LCU which delivered 1000 mW/cm^2 and the LED LCU which delivered 1200 mW/cm^2 were used for 20 s, the resin-based material under the restoration might have received 20 J/cm^2 and 24 J/cm^2, respectively (assuming that the same wavelengths are delivered). This could provide an explanation about the rank of LCUs for the present study (LED > PAC > QTH).

The second null hypothesis that the light transmittance of zirconia decreases when the thickness is increased should be rejected, as the different thicknesses of zirconia had a significant effect on light transmittance values of the tested zirconia specimens. This finding corroborates with the results of a previous pilot study by Rasetto *et al*., suggesting the decrease in light transmittance with the increase in thickness of the ceramic.[3] In addition, a previous study by O'Keefe *et al*. indicated that the thickness of the porcelain veneer was the primary factor affecting the light transmission of the restoration.[15]

Traditional luting agents might provide adequate retention for cementation of zirconium oxide restorations. However, a previous study indicated that cementation with dual-cured luting agents is necessary for ensuring better retention and marginal adaptation.[16] With the increase in zirconia thickness, the decreased light transmittance might have an effect on the mechanical properties of the cements.

In the current study, uniform thicknesses of zirconia specimens have been used. However, in a clinical condition, the zirconia restoration thickness may vary at different regions of tooth. Therefore, although the tip of the LCU seems to be in direct contact with the restoration surface, the distance between the tip and the surface of the luting material can vary markedly over the entire restoration. Accordingly, the differences in restoration translucency might have an effect on the light transmission. Consequently, the optical behavior of zirconia restorations with respect to thickness should also be taken into consideration when the resin-based material is selected for luting of these restorations.

CONCLUSION

Within the limitations of this *in vitro* study, the following conclusions could be drawn:

1. Percentage of transmitted light was dependent on LCU. Moreover, light transmission through even thin zirconia copings appears to be achievable with LED LCUs when compared with PAC and QTH LCUs.
2. Light transmission through the zirconia copings was reduced with increased coping thicknesses for all three LCUs.

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