https://doi.org/10.54589/aol.36/2/106

The luminous transmittance of the quartz-glass fiber posts is superior to glass fiber posts

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ABSTRACT

Fiber-reinforced prefabricated intraarticular posts have gained popularity due to several favorable characteristics for clinical use compared to metallic intraradicular posts. ***Aim:*** *To evaluate the light transmission capacity of two types of fiber posts, using two different methods.* ***Materials and Method:*** *The posts were divided into two groups: experimental group - quartz-glass fiber posts (n=10) and control group – glass fiber posts (n=10). The light transmittance of the samples was compared by means of light intensity test by photographs and ultraviolet-visible spectrophotometer. This test was analyzed by thirds: coronal, middle, and apical. The spectophotometer tested the luminous transmittance along the length of the post. The statistical analysis was conducted with a significance level of 0.05.* ***Results:*** *Light transmission was 97% on the coronal third, 68% in the middle third, and 27.66% in the apical third in the posts of the experimental group. In the posts of the control group, the light transmission was 95.33% in the coronal third, 80.66% in the middle third, and 41.33% in the apical third. Light transmission was significantly higher in the middle third of the posts of the experimental group when compared to the control group (p<0.05). The luminous transmittance of the posts of the experimental group was 97.4% with wavelengths of 400 nm, 97% at 450 and 500 nm, and 96.9% at 550 nm. In the posts of the control group, the luminous transmittance was 72.3% with wavelengths of 400 nm, 68.6% at 450 nm; 64.6% at 500 nm and 61.5% at 550 nm. The posts of the experimental group demonstrated significantly higher light transmittance than the control group (p<0.001).* ***Conclusion:*** *the luminous transmittance of quartz-glass fiber posts is higher than glass fiber posts.*

Keywords: *dental pins - photoelectron spectroscopy - light.*

To cite:
Pasmadjian ACP, Diógenes AN, Perin CP, Pierdoná J, Rezende LVML, Madalena IR, Baratto-Filho F, da Cunha LF. The luminous transmittance of the quartz-glass fiber posts is superior to glass fiber posts. Acta Odontol Latinoam. 2023 Aug 30;36(2):105-111. https://doi.org/10.54589/aol.36/2/106

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Received: January 2023.
Accepted: July 2023.

Superioridade da transmitância luminosa dos pinos de fibra de quartzo

RESUMO

Os pinos intra-articulares pré-fabricados reforçados com fibras têm ganhado popularidade devido a várias características favoráveis ao uso clínico em comparação com os pinos intra-radiculares metálicos). ***Objetivo:*** *Avaliar a capacidade de transmissão de luz de dois tipos de pinos de fibra, usando dois métodos diferentes.* ***Materiais e Método:*** *Os pinos foram divididos em dois grupos: grupo experimental - pinos de fibra de vidro de quartzo e grupo controle - pinos de fibra de vidro. A transmitância de luz das amostras foi comparada por meio de teste de intensidade de luz por fotografias e espectrofotômetro ultravioleta-visível. Este teste foi analisado por terços: coronal, médio e apical. O espectrofotômetro testou a transmitância luminosa ao longo do comprimento do pino. A análise estatística foi realizada com nível de significância de 0,05.* ***Resultados:*** *A transmissão luminosa foi de 97% no terço coronal, 68% no terço médio e 27,66% no terço apical nos pinos do grupo experimental. Nos pinos do grupo controle, a transmissão de luz foi de 95,33% no terço coronal, 80,66% no terço médio e 41,33% no terço apical. A transmissão luminosa foi significativamente maior no terço médio dos pinos do grupo experimental quando comparado ao grupo controle (p<0,05). A transmitância luminosa dos pinos do grupo experimental foi de 97,4% com comprimento de onda de 400 nm, 97% em 450 e 500 nm e 96,9% em 550 nm. Nos postes do grupo controle, a transmitância luminosa foi de 72,3% com comprimento de onda de 400 nm, 68,6% em 450 nm; 64,6% a 500 nm e 61,5% a 550 nm. Os pinos do grupo experimental demonstraram transmitância de luz significativamente maior do que o grupo controle (p<0,001).* ***Conclusão:*** *a transmitância luminosa dos pinos de fibra de vidro de quartzo é maior do que pinos de fibra de vidro.*

Palavras-chave: *pinos dentários - espectroscopia fotoeletrônica - luz.*

INTRODUCTION

Fiber-reinforced prefabricated intraarticular posts have gained popularity due to several favorable characteristics for clinical use compared to metallic intraradicular posts.[1,2] Notable qualities of the material include dentin-like mechanical properties, the ability to adhere to the root structure, and good esthetics[2,3]. Scientific evidence demonstrates that prefabricated fiber-reinforced posts have an elastic modulus around 20 Gpa[4-6], which is very similar to dentin (18 GPa)[7]. The convergence of properties standardizes the stress distribution and reduces the risk of fracture[8-10]. Another relevant aspect of fiber-reinforced prefabricated intraradicular posts is their ability to transmit light, enhanced by the association of carbon, glass, quartz, and zirconia fibers[11]. Translucent posts can allow lighter to pass through, improving the depth and quality of polymarization of the material chosen for cementation[12-14].

Carbon fibers represent one of the first prefabricated posts available on the market. They are composed of unidirectional carbon fibers inserted in an epoxy resin matrix. They no longer represent routine use in clinical practice, mainly due to their dark color, which impairs the aesthetics of the restoration[15]. Glass fiber posts can be made of two types: S-glass and E-glass. They have different properties, but generally, are amorphous, and they are formed of a three-dimensional network of silica, with oxygen and other atoms arranged randomly[16]. Furthermore, Glass fiber posts can be associated with quartz fibers, which are pure silica in their crystallized form. Posts reinforced with glass and quartz fiber lead to better stress distribution when compared to rigid metal posts or zirconium oxide ceramic posts[14]. Fiber-reinforced posts also have advantageous optical properties over metallic post systems, reinforced by carbon fibers or metal oxide post systems[16].

Glass fibers posts have a refractive index like resin; therefore, they allow efficient light transmission[16,17]. Consequently, the addition of glass fibers to the dental composite will improve its mechanical properties without affecting the degree of conversion of the resin matrix, unlike opaque-colored fibers, as carbon, or zirconia[12,16]. The clinician must realize that there are recognizably substantial differences in the mechanical load capacity of different fiber-reinforced posts and must be aware of such differences to select an appropriate post system to use[18]. Therefore, the aim of this study was to evaluate the luminous transmittance of quartz-glass fiber posts and conventional fiberglass posts.

MATERIAL AND METHOD

Experimental design

Quartz-glass fiber posts and glass fiber posts were evaluated for light transmittance using photo light intensity test and ultraviolet visible and infrared spectrophotometer. The posts were divided into two groups: the experimental group - quartz-glass fiber posts (n=10) and the control group – glass fiber posts (n=10). The posts in the experimental group are made by optical fiber, epoxy resin and glass fiber. The exact proportion is not revealed by factory. The composition of the glass fiber posts (Exacto®, Angelus Londrina, PR, Brazil) is 80% fibers glass and 20% epoxy resin. Both have a length of 18 mm, conical with the same maximum and minimum diameters of, respectively, 1.8 and 1.0 mm.

Analysis of the light transmittance using photo light intensity test

The light intensity was made with a LED dental curing-light Radii Expert SDI and a camera Canon 70D with lens macro 100mm and exposure settings in ISO 100, aperture F18 and shutter speed 125, therefore resulting in images of 5,612x3,440 pixels in RAW format. The spectrophotometer was connected to a computer running the spectrum analyzer software (OOIBase32, Ocean Optics). The software was set in a mode to evaluate the light counts correlating with the number of photons received from the spectrometer's CCD detector. At the test of 470 nm, to each count, 30 photons were received on the equipment's detector.

The counts were registered in total light-darkness for ten posts from each group. The posts were vertically positioned over a bench with the curing light Radii Expert SDI leaning at the cervical region. Furthermore, the photos of the posts irradiated by the light-curing device were taken in complete darkness (Canon 70D with lens Macro 100mm). The photos were divided in thirds: coronal, middle and apical.

Analysis of the light transmittance using ultraviolet-visible spectophotometer

The same posts were sanitized with 70% alcohol, stored in Eppendorf flasks and always handled with procedure gloves. After distribution and sample identification, they were submitted to an ultraviolet visible and near infrared spectrophotometer (Cary 5000 UV-Vis-NIR Spectrophotometer®, Agilent Technologies, Santa Clara, Califórnia, EUA). The mean exposure time was set at 10s, and the application distance was set at 10mm. The analyzed wavelengths were 400 nm, 450 nm, 500 nm and 550 nm. Light transmission was measured using an optical transmission microscope coupled to spectrometer. The upward referenced light source was transmitted through the edge of the cut and measured the percentage of light intensity (compared to the 100% reference) for each post. Values were given as the percentage of incident light measured at the opposite length of the post.

Statistical analysis

The analyzed all groups of specimens for means and standard deviations. The statistical analysis was performed by testing data normality using the Shapiro–Wilk test followed by Welch's t-test, with a significance level of 0.05.

RESULTS

In the transmission of light in the posts of the experimental group was 97% on the coronal third, 68% in the middle third, and 27.66% in the apical third. In the posts of the control group, the light transmission was 95.33% in the coronal third, 80.66% in the middle third, and 41.33% in the apical third (Fig. 1). Figure 2 represents the difference in light transmittance in relation to the experimental and control fiber posts, respectively. Light transmission was significantly higher in the middle third of the posts of the experimental group when compared to the control group (p=0.0155) (Table 1).

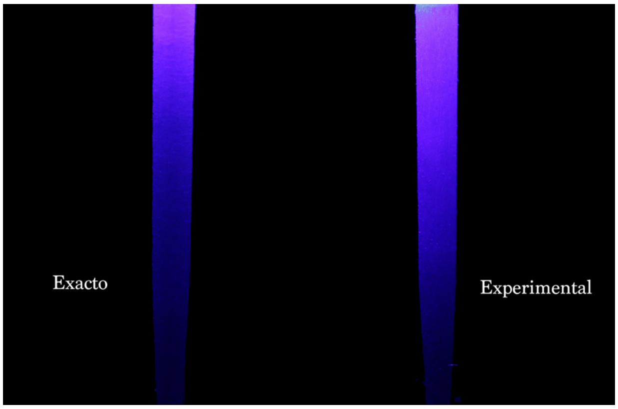

Fig. 1: Luminous transmittance between the thirds of the posts of the experimental and control groups.

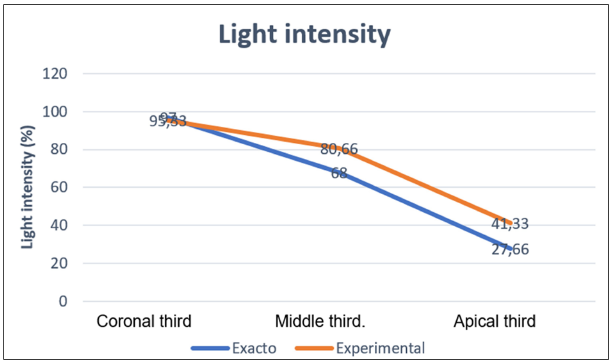

Fig. 2: Illustrated photo of the luminous transmittance between the thirds of the posts of the experimental and control groups, respectively.

Table 1. Means (standard deviations) of groups as a function of third.

Group	Coronal	Mean	Apical
Exacto	97.00 (1.00)[a]	68.00 (4.35)[c]	27.66 (1.52)[d]
Experimental	95.33 (0.57)[a]	80.66 (4.61)[b]	41.33 (9.45)[d]

*Values followed by the same letter are statistically similar (p > 0.05).

The luminous transmittance of the posts of the experimental group was 97.4% with om wavelengths of 400 nm, 97% at 450 and 500 nm, and 96.9% at 550 nm. In the posts of the control group, the luminous transmittance was 72.3% with wavelengths of 400 nm, 68.6% at 450nm; 64.6% at 500nm and 61.5% at 550 nm (Fig. 1). The values of light transmittance measured by spectrometer (mean and standard deviations) and the differences in the groups are shown in Table 2. The post of the experimental group demonstrated significantly higher light transmittance than the control group (p<0.001).

Table 2. Means (standard deviations) transmittance of the groups.

Group	Transmittance
Exacto	0.66 (0.32)[b]
Experimental	0.97 (0.02)[a]

Figure 3 is related to the linear representation of the data obtained, in which the experimental group showed greater homogeneity and stability in light transmission throughout the analyzed spectrum (close to 0.97). The control group showed the greatest change throughout the analysis, and at the wavelength of 550 nm, there was the lowest mean transmittance (0.615); while the highest transmittance occurred at 400 nm, (0.723).

Fig. 3: Values of linear representation of the data obtained from the light transmittance of the groups as a function of the wavelength.

DISCUSSION

In this study, the luminous transmittance through glass fiber posts and quartz-glass fiber posts was investigated. According to the results of this *in vitro* study, quartz-glass fiber posts showed significantly better luminous transmittance compared to glass fiber posts. The null hypothesis tested in this study that the luminous transmittance of different glass fiber posts would not differ was therefore rejected. From a clinical point of view, this may indicate better polymerization of the cementing agent used in the root canal[18].

Resin-based cement is widely used today for the cementation of various indirect dental restorations that have received intraradical support[19]. Dual-curing resin-based types of cement are clinically preferred over purely light-curing types of cement because the former can better tolerate light exposure in locations that do not allow optimal access to curing light due to indirect-direction morphology[19,20]. Compared to photopolymerizable resin-based materials, free radical-mediated polymerization of dual-polymerized materials is more complex, as two initiation reactions occur simultaneously and interact with each other[21]. Recognition of this complexity led to numerous studies on dual-polymerization resin types of cement[20] and, among other specificities, also the availability of the intraradical retainer in relation to luminous transmittance[11-14].

Scientific evidence shows that there is no difficulty for light to reach a more superficial region of the intraradicular post[14,22-25]. In this study, the evaluate of luminous transmittance was performed in thirds; the depth was defined in millimeters at six pre-established points[22]. Our results showed significantly higher luminous transmittance in the middle third of the quartz-glass fiber post when compared to the glass fiber post. This fact becomes important since favorable degrees of cure of the cementing agent have been described in depths above 8mm[23,26]. Silva et al. studied the degree of conversion after the cementation of two types of posts at three levels of depth and demonstrated statistically favorable results between the middle thirds of the two types of posts also related to translucency[23].

The luminous transmittance of glass fiber posts and zirconia, quartz, and silica have already been previously tested[27]. However, methodological differences were found in the digital camera, in the variety of posts designs such as, non-standard diameter and lengths, and a more robust sample. Thus, replication of this study is suggested, considering the results of the apical third. In the apical third, the *p-value* was very close to the significance level. The null hypothesis could be rejected if the sample was larger.

Regarding luminous transmittance analyzed by the UV/Vis spectrophotometer, better luminous transmittance was also demonstrated by the quartz-glass fiber posts, which may be related to the type and arrangement of the fibers, thus increasing the luminous transmission values. The result of this method can be considered extremely efficient in the present study, as the posts have the same design both in length and thickness. When irradiation occurs, the light beams are distributed along the posts by total internal reflection. The critical angle is the product of the difference in refractive indices between the core and surface material. Rays that exceed the surface boundary of the material at an angle greater than the critical angles are reflected[27]. Thus, differences in optical properties are explained by variability in fiber diameter, orientation pattern and variable matrix composition. All these factors contribute to refraction divergences and make it difficult to compare posts from different commercial brands[8,11-14,27,28].

The two luminous transmittance methods used in this study should be carefully used to estímate clinical performance. However, they can be correlated with the bond strength tests of the posts to the resin cement in the root canal, thus explaining possible favorable results for the quartz-glass fiber posts due to the greater luminous transmittance.

CONCLUSION

Quartz-glass fiber posts show significantly better light transmittance compared to glass fiber posts.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

FUNDING

This study was supported by a Grant from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES-Brasil) - PDPG-POSDOC/Bolsa-CAPES [nº 88887.755620/2022-00] (I.R.M.)

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