Influence of Light Transmission through Fiber Posts: Quantitative Analysis, Microhardness, and on Bond Strength of a Resin Cement

Abstract
Context: Light transmission (LT) into deeper areas of the dentin root is limited. Aim: The aim of this study is to perform a quantitative investigation of the radial transmission of light (LT) through different fiber posts and its influence on the Knoop hardness number (KHN) and bond strength (BS) of a dual-cure self-adhesive resin cement at 3 different depths. Materials and Methods: Four types of fiber posts (2 translucent and 2 conventional) were used. LT and KHN analyses were performed in a specially designed matrix, which allowed measurements at 3 different depths. LT was measured using a volt-ampere meter while KHN tests were performed in a microhardness tester. For BS analysis, endodontically treated bovine roots were divided into 4 groups, each group receiving one type of post. After cementation, cross sections of the root were tested for resistance to displacement using a universal testing machine. Statistical Analysis Used: Statistical analysis was performed by using this ANOVA and Tukey’s test. Results: For LT, translucent posts showed significantly higher values at all depths compared to the conventional ones. For all posts, LT decreased at the deeper depths. The KHN results showed no statistical differences among the different posts, regardless of depth. For BS, a translucent post showed the highest values, and comparative analyses between the different depths of posts also showed statistically significant differences while comparisons among the different depths of the same post showed no differences. Conclusions: LT depended on the type of post and on depth. The type of post did not significantly influence the cement KHN. A translucent post showed higher BS in pooled data.

Keywords: Bond strength, fiberglass post, light transmission, microhardness

Introduction
Endodontically treated teeth often present extensive structure loss. Thus, the use of posts and cores is usually necessary to improve the retention of restorations. However, because prefabricated fiber posts do not present precise fit into root canal preparation, the cementation process is critical to ensure adequate post retention and stability. Resin luting agents are recommended for cementing fiber posts, and they are available in 3 curing systems: self-cured, light-cured, or dual-cured. The use of self-cured materials has provided more reliable cementation of intraradicular posts since there is evidence that light does not properly polymerize the cement into the root, particularly in the deeper areas. However, considering the different techniques of cementation and types of cements, the self-adhesive dual-cure resin cement appears to be less sensitive, with fewer clinical steps, being easier to apply than conventional resin cement associated with an etch and rinse adhesive, and thus being a viable alternative for cementation of intraradicular fiber posts.

Besides the use of self-adhesive resin cements, another factor that may maximize clinical effectiveness of fiber post cementation is utilization of translucent posts. They may increase light transmission (LT) into deeper areas of the dentin root, improving the polymerization of light-or dual-cure resin cements. Manufacturers have recommended the use of light- or dual-cured resin cements in association with translucent fiber posts.

How to cite this article: Alves Morgan LF, Pinotti MB, Ferreira FM, Gomes GM, Silva GC, Albuquerque RD, et al. Influence of light transmission through fiber posts: Quantitative analysis, microhardness, and on bond strength of a resin cement. Indian J Dent Res 2018;29:74-80.
The ability of translucent posts to transmit light has been investigated. Most studies showed that light intensity decreased as root depth increased, resulting in loss of mechanical properties of the cement. Undesirable effects such as incomplete polymerization of resin cements, biological toxicity, and low-bond strength (BS) values have also been described in the literature. On the other hand, the use of translucent posts has already shown positive results in cement polymerization. Thus, the effectiveness of the use of translucent posts in association of dual-cured resin cements is still controversial.

Thus, the aim of this study was to quantitatively investigate LT through fiber posts and the effect of this LT on the Knoop microhardness number (KHN) and the BS of a dual-cure self-adhesive resin cement bonded to root dentin at 3 different depths. The research null hypothesis is that there will be no statistically significant difference on LT, KHN, and BS for the different depths.

**Materials and Methods**

Four different fiber posts of 2 types (translucent and conventional) and one self-adhesive resin cement were used in the study [Table 1].

The translucent (T) types, which had similar compositions but different amounts of chemical components, were (T1) white post-DC (FGM, Joinville, SC, Brazil) and (T2) DT Light Post (Bisco, Inc., Schaumburg, IL, USA). The conventional opaque types (C), presenting different compositions, were (C1)Exacto and (C2) Reforpost (both from Ángelus, Londrina, PR, Brazil). For each group, one post was used for LT, 5 for KHN, and 8 for BS. Before the tests, all the posts were cut on the coronal portion under cooling at the standard height of 16 mm by a precision machine (Isomet 1000, Buehler, Lake Bluff, IL, USA).

**Light transmission**

LT was evaluated using a volt-ampere meter (Nova, Ophir, Hicksville, NY, USA) at 3 depths (thirds): cervical third (CT) at 4.1–8 mm depth; middle third (MT) at 8.1–12 mm depth; and apical third (AT) at 12.1–16 mm depth.

To assess the 3 postdepths, a metal matrix device was designed and manufactured to support the posts, the digital power meter, and the tip of the curing light unit. It also obstructed the influence of external sources of light. It had two parts: a nonreflective internal frame, which contained the posts and the volt-ampere meter, and an external cylinder, which enveloped the first part and guided the curing light tip at its top. Metal blocks assisted in determining the position of the volt-ampere meter sensor for each third of the evaluated post [Figure 1, patent pending]. Furthermore, the metal matrix allowed that the curing light unit touches the top of the post.

The postspace frame was manufactured with the exact dimensions of each post by means of electroerosion machining (EDM Global, Mason, OH, USA). Since the tested posts had different shapes, one frame was manufactured for each type of post. Aiming at standardizing the quantitative radial reading, the frame had a 120-degree lateral opening for each third of the posts.

The measures of each depth were taken separately. For an accurate separate assessment of each third, strategically positioned 4 mm-thick metallic blocks determined the internal position of the volt-ampere meter in relationship to the posts.

---

**Table 1: Composition, type, and batch number of the materials used (posts and resin cement)**

| Group | Manufacturer/batch number | Type             | Chemical composition                                                                 |
|-------|---------------------------|------------------|--------------------------------------------------------------------------------------|
| T1    | FGM Produtos Odontológicos (Brazil)/140410 | Translucent      | Fiberglass (80%±5), epoxy resin (20%±5), silica, silane and polymerizing promoters  |
| T2    | Bisco, INC (EUA)/0800007811 | Translucent      | Glass fibers (55%), epoxy (45%)                                                      |
| C1    | Angelus (Brazil)/14818    | Conventional     | Fiberglass (87%), epoxy resin (13%)                                                  |
| C2    | Angelus (Brazil)/14874    | Conventional     | Carbon fibers (79%), epoxy resin (21%)                                               |
| Resin cement | 3M ESPE (USA)/372990 | Self-etch/ dual-cure | Powder: Glass particles, initiators, silica, substituted pyrimidine, calcium hydroxide, peroxide composite and pigment; liquid: Metacrylate phosphoric acid ester, dimethacrylate, acetate, stabilizer, and initiator |

---

Figure 1: (a) frame; (b) external cylinder; (c) volt-ampere meter; (d) post; (e) metallic blocks; (f) light curing tip; (g) set of apparatus
A 60-s light exposure was used (Curing Light 2500, 3M ESPE, St. Paul, MN, USA), and the luminous intensity was recorded by the volt-ampere meter at 2 and 59 s to establish the mean. The curing unit was preheated with five 60-s cycles before the first measure, and between each measurement, the light source was left at rest for 1 min and 30 s, which was the time necessary for the cooling fan to turn off.

Equations 1 and 2 were used to calculate the luminous intensity per unit of area at each depth. Equation 1 provided the area of exposure from a trunk of cone to the volt-ampere meter scanner (considering a 120° side opening). In this equation, “A” was the area (mm²), “g” (m) was the generatrix, “R” (m) was the large base radius, “r” (m) was the small base radius, and “h” (m) was the height of the truncated cone.

\[
A = \frac{1}{3} \pi g (R + r)
\]

which further developed to: \[A = \frac{1}{3} \pi g (R + r)\] (1)

Equation 2 represented the luminous flux per unit of area, \(I_g\) (W. m⁻²). In this equation, \(A\) (mm²) derived from Equation 1, and “I” (W) was the total luminous flux from a given section of a post of height “h” (m), the measurement particularly targeting one-third of the surface area of this section (120° side opening).

\[I_g = I/A\]

(2)

**Knoop hardness number measurements**

KHN of the cement was measured at 3 depths of posts: CT at 4.1–6.8 mm depth; MT at 8.8–11.5 mm depth; and AT at 13.5–16 mm depth.

The metallic device for KHN tests consisted of four parts, including a new part designed to support the resin cement [Figure 2b and c]. Its internal structure provided the separation of each third, which allowed the resin to polymerize in blocks, separately [Figure 2c]. The other parts, (a) a frame, the main structure which contained the posts, (d) post, (e) light curing tip, and (f) an external cylinder which holds the other part while also incorporating the tip of curing light unit.

Figure 2: Metallic matrix: (a) a frame, the main structure which contained the posts, (b) a support to standardize the position and volume of resin cement, (c) a support to standardize the length of each third deep postregions, (d) post, (e) light curing tip, and (f) an external cylinder which holds the other part while also incorporating the tip of curing light unit.

The surface to be analyzed was sequentially polished with #320 to #1200-grit SiC papers and filled with diamond polish paste (Buehler, IL, USA). The control group used the same post as the T1 group and the same method but did not include the photopolymerization step.

KHN measurements were performed by a hardness tester (Micromet 5104, Buehler, Tokyo, Japan) using a static load of 50 g for 10 s. Three indentations were performed for each third of each group. The values were obtained from the average reading of the 3 indentations oriented along the axis of the post on each third.

**Bond strength measurements**

The crowns of 32 permanent bovine incisor teeth with mature roots were removed with a precision machine (Isomet), leaving a 19 mm-long root (approved by Ethics Committee of Animal Experiments #19-2010) and resulting in 8 roots allocated to each of the 4 groups. The preparation of root canals was standardized using ISO size 110 Gates-Glidden drills (Dentsply Maillefer SA, Baillagues, Switzerland). The root canals were obturated using cold lateral compaction of gutta-percha with the sealer 26 (Dentsply, Tulsa, OK, USA). After 7 days, 14 mm deep postspaces were prepared with drills (Dentsply Maillefer SA) ISO size 30, 70, and 110, except for Group T1, in which root canals were prepared using drills provided by the manufacturer’s kit. After preparation, root canals were dried with endo paper points (Dentsply, Tulsa, OK, USA). Roots were then filled with cement (RelayX Unicem Aplicap) from bottom to top (Elongation tips). Then, previously cleaned (70% alcohol) posts were placed into the root canals. Finally, sets were photoactivated (Curing...
Light 2500) for 40 s with light curing unit tip point down the axis of the tooth root. The teeth were in storage in wet conditions. One week after cementation, the roots were embedded in acrylic resin (Duralay, Reliance, Worth, IL, USA), confined into tubes of polyvinyl chloride, and each one was sectioned transversely by diamond disk (Isomet) to produce discs of one millimeter: 2 discs of the coronal third (CT) at 2.5 and 4.0 mm; 2 of the MT at 6.5 and 8.0 mm; and 2 of the AT at 10.5 and 12 mm. Thus, 16 specimens were made for each posttype for each of the 3 root thirds (coronal, middle, and apical). The specimens were stored in sterile distilled water at room temperature for 1 week.

The dimensions of the discs were calculated to obtain the bonding area in mm² by applying the formula: \( \Pi (R + r) [(h^2 + (R - r)^2) / 2] \), where \( \Pi = 3.14 \), “\( R \)” represented the coronal radius (mm), “\( r \)” was the apical radius (mm) and “\( h \)” was the disc thickness (mm).

The specimens were subjected to compressive loads on the post in the apical-coronal direction of its longitudinal axis by a universal testing machine (AG-I, Shimadzu Autograph, São Paulo, SP, Brazil) at a crosshead speed of 0.5 mm/min until the moment of displacement.

**Data treatment**

For LT, ANOVA, and Tukey’s statistical tests were applied to the results (\( P < 0.05 \)) to compare the thirds and the groups.

The KHN and BS results were pooled from the three root sections and were used to assess differences among groups. Data gathered from each section of the root were used to verify differences within the sections (one-way ANOVA). Later, the results were analyzed for each post according to the different thirds to evaluate the presence of interaction effects (two-way ANOVA and Tukey’s test; \( P < 0.05 \)).

**Results**

Table 2 shows within-group means, standard deviations, and statistical analyses of the amount of radially LT through the fiber posts at the different depths. For AT, the cross-group analysis indicated a higher luminous energy in T2, followed by T1. Groups C1 and C2 showed significantly lower values and had no significant differences between them. For MT, the analysis revealed significantly higher values for groups T1 and T2, with significant differences between them. Groups C1 and C2 presented statistically lower values. For CT, Group T2 showed higher luminous energy than T1 while groups C1 and C2 once again presented significantly lower values. Finally, within-group analyses of the different thirds showed significant reductions in the luminous intensity as a result of increased depths.

KNH showed no statistical difference in the cross-group analysis and in the within-group analysis of the different thirds (one-way ANOVA). The results for each post, depending on the different thirds and the presence of interaction effects, showed no significant differences (two-way ANOVA). The Tukey posttest showed no individual differences [Table 3].

In BS analysis, there was a significant difference within each post type, with groups T1 and C1 showing the highest values. Comparative analyses among the same third of each post type revealed significant differences (one-way ANOVA). The analysis of the results for each post, depending on the different thirds and the presence of interaction between the effects, did not differ significantly (two-way ANOVA) \( (P < 0.05) \) [Table 4].

**Discussion**

Although studies have revealed unfavorable results concerning the amount of luminous energy transmitted through translucent posts, \([10,15,17,23,29,30]\) some of the manufacturers promise a sufficient transmission of light.

**Table 2: Within-group means, standard deviations, statistical tests of the light transmission in mW/cm²**

| Position     | AT (12 mm depth) | MT (8 mm depth) | CT (4 mm depth) |
|--------------|------------------|-----------------|-----------------|
| Type of post |                  |                 |                 |
| T1           | 5.76±0.046        | 6.515±0.145     | 14.156±0.093    |
| T2           | 6.164±0.125       | 1.433±0.100     | 14.319±0.216    |
| C1           | 0.003±0.000       | 0.002±0.000     | 0.030±0.000     |
| C2           | 0.001±0.000       | 0.001±0.000     | 0.035±0.000     |

Matrix of respective posts:

| T1           | 0.484±0.011       |
| T2           | 0.226±0.009       |
| C1           | 0.1160±0.017      |
| C2           | 0.142±0.013       |

ANOVA and Tukey tests. Different capital-letters stand for statistically significant cross-group differences within each column/third \( (P<0.05) \). Different lower-case letters stand for statistically significant differences across the depths (thirds) within each line \( (P<0.05) \). AT=Apical third, MT=Middle third, CT=Cervical third

**Table 3: Means and standard deviations of experimental and control groups of the different thirds and posts for Knoop hardness number**

| Post  | Means±SD | Pooled |
|-------|----------|--------|
|       | CT       | MT     | AT     |
| Control | 58.1±4.3 | 58.0±4.3 | 58.4±3.1 |
| T1     | 57.1±4.3 | 57.5±4.3 | 54.2±3.3 |
| T2     | 57.3±4.3 | 57.4±4.3 | 56.2±4.7 |
| C1     | 56.7±4.3 | 57.0±4.3 | 56.7±4.7 |
| C2     | 50.8±4.3 | 50.7±4.3 | 49.7±3.3 |

Different letters indicate significant differences \( (P<0.05) \). Lower case letters compare values per row and capital letters compares values per column. SD=Standard deviation, AT=Apical third, MT=Middle third, CT=Cervical third
for the polymerization of both light- and dual-cured resin cements. The LT and characteristics of the root dentin\cite{24,31,32} are closely related to the cementation quality and the stability of the adhesives interfaces when light- or dual-cured cements are used.\cite{133‑36} Consequently, studies are still necessary to validate this clinical recommendation.

Special attention was given to developing a valid methodology. The designed metal matrix used for LT and KHN tests prevented the introduction of any light wavelengths along the optical path of the post that had not been axially introduced through the upper end of the post. Furthermore, the matrix provided a fixed distance between the top of the post and curing light tip, guaranteeing the same amount of light energy reaching the posts. The electroerosion machining of the internal frames that supported the posts resulted in a standardized fit for all different posts, minimizing the effect of the adaptation, and cement thickness layer on the results. Another adopted care was related to the calculus. The investigated posts were different in diameters and in shapes. Assuming that the amount of light transmitted through the post is directly related to its diameter,\cite{23} the data calculation for each post was based on the standardized area that was exposed (120°) to the volt-ampere meter for LT, or on the standardized area that was in contact with the resin cement for KHN, as explained through Equation 1. In addition, the choice of an self-adhesive dual-cure cement was based on the fact that it did not use adhesive systems, eliminating this variable. Moreover, it is a type of cement recommended for post cementation due to its simple use and its partially chemical cure. However, the mechanism of chemical reaction of the cement, besides being dependent on the light energy, is also related to the presence of dentin.\cite{24,35} The evaluations of the KHN of the present samples were made without the presence of dentin, therefore enabling the evaluation of the effect of LT alone.

In the present study, the values obtained for LT revealed higher results for translucent posts, which was expected since translucent posts may present luminescent agents and have less opacifiers than conventional posts, resulting in better LT.\cite{27} Low luminous intensity was also shown across all investigated depths, which is in accordance with the previous studies.\cite{29,35} The reduced luminosity, as a result of the increased depth, was expected and can be explained by the principles of transmittance, reflectance, and absorbance. During its path along the post, light loses energy. The T2 results for the MT depth were unexpected. The MT showed less LT than the AT. At MT region, this post is remarkably conic, and the longitudinal orientation of the fibers appears to be the most likely feature to explain this phenomenon, i.e., the MT region of this post has fewer translucent fiber endings, which act as waveguides, so it is acceptable that smaller amounts of light were recorded. The null hypothesis was rejected since translucent posts revealed higher LT, and statistically lower values of LT were found on deeper areas.

The KHN test is a common method to evaluate changes that can be attributed to the amount of polymerization of the resin-base materials.\cite{7} It is frequently used to evaluate the physical properties of these materials.\cite{17,37,38} In the present study, for KHN, the null hypothesis tested was accepted since there was no difference in the microhardness of the tested resin cement between the different posts and control at different depths. A previous study\cite{24} also found similar and uniform values for the same cement in combination with a translucent fiber post. Since the translucent posts presented higher LT than the conventional ones, it seems that the amount of energy effectively transmitted was unable to result in a better cement monomer conversion compared to that found in the conventional opaque posts.

For the evaluation of the BS of fiber posts to root dentin, a pushout test is a reliable method. The perpendicular sectioning of root-post sets into 1-mm-thick sections in this study allowed a uniform force application, with less interference of tensile forces.\cite{24,39,40} The results for BS showed statistical differences among the posts, for the pool of the three thirds, and among the different thirds of the posts. A translucent post, T1, revealed better-pooled BS values, as observed in another study.\cite{27} However, these differences may be due to the postadaptation and not only to the LT according to Pirani et al., 2005.\cite{81} Group T1, which showed the highest values of BS, was the only root canal preparation made with the drill provided by the manufacturer × s kit, which allowed a more precise fit of the post into the root canal. Regarding the results of the comparative analysis between the different postthirds, the highest values obtained by CT and MT for C2 can also be explained by the adaptation of this post, which has a cylindrical geometry similar to the drill used to format the root space. This hypothesis is supported by the data obtained for KHN test, in which there was no difference in the results between the control group and the others. This may show that clinical success in the cementation of fiber posts may also be related to the frictional retention achieved by a precise fit.\cite{6,24} The null hypothesis was rejected since the differences were found in BS analysis.

---

**Table 4: Means and standard deviations of experimental groups of different thirds and posts for bond strength (MPa)**

| Post | Mean±SD | CT | MT | AT | Pooled |
|------|---------|----|----|----|--------|
| T1   | 14.7±3.2| 12.6±3.1 | 14.1±3.4 | 13.8±3.4 |
| T2   | 9.6±3.3  | 10.0±3.2 | 12.1±5.0 | 10.4±3.4 |
| C1   | 9.6±2.7  | 8.2±1.9  | 13.3±3.7 | 10.2±3.4 |
| C2   | 13.4±3.8 | 12.4±2.5 | 6.9±2.6  | 10.9±4.2 |

Different letters indicate significant differences (P<0.05). Lowercase letters compare values per row, and capital letters compare values per column. SD=Standard deviation, AT=Apical third, MT=Middle third, CT=Cervical third.
Despite the low rates for LT, the present results proved that the posts do in fact transmit light radially, but in most cases, not enough to improve KHN and BS values. The fit of the post into root canal may play an important role in BS. Future tests may consider the behavior of BS for self-adhesive cements after aging.

Conclusions

- The amount of radial transmission of luminous energy depended on the type of post
- There was a decrease in the amount of radial transmission at deeper depths
- The amount of light transmitted through the post did not significantly influence the cement’s microhardness or the BS of the different posts and thirds evaluated, except for one translucent post (T1) in BS tests.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. de Castro Albuquerque R, Polletto LT, Fontana RH, Cimini CA. Stress analysis of an upper central incisor restored with different posts. J Oral Rehabil 2003;30:936-43.
2. Jacobi R, Shillingburg HT Jr, Pirs, and other retentive devices in posterior teeth. Dent Clin North Am 1993;37:367-90.
3. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999;27:275-8.
4. Akgungor G, Akkayan B. Influence of dentin bonding agents and polymerization modes on the bond strength between translucent fiber posts and three dentin regions within a post space. J Prosthodont Dent 2006;95:368-78.
5. D’Arcangelo C, D’Amario M, Vadini M, Zazzeroni S, De Angelis F, Caputi S, et al. An evaluation of luting agent application technique effect on fibre post retention. J Dent 2008;36:235-40.
6. Goracci C, Fabianelli A, Sadek FT, Papacchini F, Tay FR, Ferrari M, et al. The contribution of friction to the dislocation resistance of bonded fiber posts. J Endod 2005;31:608-12.
7. Ceballos L, Garrido MA, Fuentes V, Rodriguez J. Mechanical characterization of resin cements used for luting fiber posts by nanoindentation. Dent Mater 2007;23:100-5.
8. Lui JL. Depth of composite polymerization within simulated root canals using light-transmitting posts. Oper Dent 1994;19:165-8.
9. Naumann M, Sterzenbach G, Rosentritt M, Buser F, Frankenberger R. Is adhesive cementation of endodontic posts necessary? J Endod 2008;34:1006-10.
10. Giachetti L, Grandini S, Calamai P, Fantini G, Scaminaci Russo D. Translucent fiber post cementation using light- and dual-curing adhesive techniques and a self-adhesive material: Push-out test. J Dent 2009;37:638-42.
11. Ebrahimi SF, Shadman N, Nasery EB, Sadeghian F. Effect of polymerization mode of two adhesive systems on push-out bond strength of fiber post to different regions of root canal dentin. Dent Res J (Isfahan) 2014;11:32-8.
12. Bahari M, Savoie OS, Kimyay S, Mohammadi N, Saati Khosrosheahi E. Effect of light intensity on the degree of conversion of dual-cured resin cement at different depths with the use of translucent fiber posts. J Dent (Tehran) 2014;11:249-55.
13. Dogar A, Altintas SC, Kavak S, Guner A. Determining the influence of fibre post light transmission on polymerization depth and viscoelastic behaviour of dual-cured resin cement. Int Endod J 2012;45:1135-40.
14. Giachetti L, Scaminaci Russo D, Baldini M, Bertini F, Steier L, Ferrari M, et al. Push-out strength of translucent fibre posts cemented using a dual-curing technique or a light-curing self-adhering material. Int Endod J 2012;45:249-56.
15. Khabeer A, Whitworth J, Rolland S. Polymerization kinetics of resin cements after light activation through fibre posts: An *in vitro* study. Int Endod J 2015;48:261-7.
16. Navarra CO, Goracci C, Breschi L, Vichi A, Corciolani G, Cadano M, et al. Influence of post type of degree of conversion of a resin-based luting agent. Am J Dent 2012;25:17-20.
17. Radovic I, Corciolani G, Magni E, Krstanovic G, Pavlovic V, Vulcicovic ZR, et al. Light transmission through fiber post: The effect on adhesion, elastic modulus and hardness of dual-cure resin cement. Dent Mater 2009;25:837-44.
18. Faria e Silva AL, Arias VG, Soares LE, Martin AA, Martins LR. Influence of fiber-post translucency on the degree of conversion of a dual-cured resin cement. J Endod 2007;33:303-5.
19. Janke V, von Neuhoff N, Schlegelberger B, Leyhausen G, Geurtse W. TEGDMA causes apoptosis in primary human gingival fibroblasts. J Dent Res 2005;82:814-8.
20. Kong N, Jiang T, Zhou Z, Fu J. Cytotoxicity of polymerized resin cements on human dental pulp cells *in vitro*. Dent Mater 2009;25:1371-5.
21. Koulouzidou EA, Papazisis KT, Yiannaki E, Palaghias G, Helvatjoglu-Antoniades M. Effects of dentin bonding agents on the cell cycle of fibroblasts. J Endod 2009;35:275-9.
22. Morgan LF, Teixeira KI, Vascconcellos WA, Albuquerque RC, Cortes ME. Correlation between the cytotoxicity of self-etching resin cements and the degree of conversion. Indian J Dent Res 2015;26:284-8.
23. Galliano GA, de Melo RM, Barbosa SH, Zamboni SC, Bottino MA, Scotti R, et al. Evaluation of light transmission through translucent and opaque posts. Oper Dent 2008;33:321-4.
24. Pedreira AP, Pegoraro LF, de Góes MF, Pegoraro TA, Carvalho RM. Microhardness of resin cements in the intraradicular environment: Effects of water storage and softening treatment. Dent Mater 2009;25:868-76.
25. Zamboni Quitero MF, Garone-Netto N, de Freitas PM, de Cerqueira Luz MA. Effect of post translucency on bond strength of different resin luting agents to root dentin. J Prosthodont Dent 2014;111:35-41.
26. Wang VJ, Chen YM, Yip KH, Smales RJ, Meng QF, Chen L, et al. Effect of two fiber post types and two luting cement systems on regional post retention using the push-out test. Dent Mater 2008;24:372-7.
27. Reginato CF, Oliveira AS, Kaizer MR, Jardim PS, Moraes RR. Polymerization efficiency through translucent and opaque fiber posts and bonding to root dentin. J Prosthodont Res 2013;57:20-3.
28. Baena E, Fuentes MV, Garrido MA, Rodriguez J, Ceballos L. Influence of post-cure time on the microhardness of self-adhesive resin cements inside the root canal. Oper Dent 2012;37:548-56.
29. dos Santos Alves Morgan LF, Peixoto RT, de Castro Albuquerque R, Santos Corrêa MF, de Abreu Poletto LT, Pinotti MB, et al. Light transmission through a translucent fiber...
30. Roberts HW, Leonard DL, Vandewalle KS, Cohen ME, Charlton DG. The effect of a translucent post on resin composite depth of cure. Dent Mater 2004;20:617-22.

31. Ferrari M, Mannucci F, Vichi A, Cagidiaco MC, Mjör IA. Bonding to root canal: Structural characteristics of the substrate. Am J Dent 2000;13:255-60.

32. Marques de Melo R, Bottino MA, Galvão RK, Soboyejo WO. Bond strengths, degree of conversion of the cement and molecular structure of the adhesive-dentine joint in fibre post restorations. J Dent 2012;40:286-94.

33. Amaral CM, Diniz AM, Arantes EB, Dos Santos GB, Noronha-Filho JD, da Silva EM, et al. Resin-dentin bond stability of experimental 4-META-based etch-and-rinse adhesives solvated by ethanol or acetone. J Adhes Dent 2016;18:513-20.

34. Vichi A, Grandini S, Ferrari M. Comparison between two clinical procedures for bonding fiber posts into a root canal: A microscopic investigation. J Endod 2002;28:355-60.

35. Ramos MB, Pegoraro TA, Pegoraro LF, Carvalho RM. Effects of curing protocol and storage time on the micro-hardness of resin cements used to lute fiber-reinforced resin posts. J Appl Oral Sci 2012;20:556-62.

36. Ho YC, LaiYL, Chou IC, Yang SF, Lee SY. Effects of light attenuation by fibre posts on polymerization of a dual-cured resin cement and microleakage of post-restored teeth. J Dent 2011;39:309-15.

37. DeWald JP, Ferracane JL. A comparison of four modes of evaluating depth of cure of light-activated composites. J Dent Res 1987;66:727-30.

38. Yoldas O, Alaçam T. Microhardness of composites in simulated root canals cured with light transmitting posts and glass-fiber reinforced composite posts. J Endod 2005;31:104-6.

39. Mallmann A, Jacques LB, Valandro LF, Muench A. Microtensile bond strength of photoactivated and autopolymerized adhesive systems to root dentin using translucent and opaque fiber-reinforced composite posts. J Prosthet Dent 2007;97:165-72.

40. Teixeira CS, Silva-Sousa YT, Sousa-Neto MD. Bond strength of fiber posts to weakened roots after resin restoration with different light-curing times. J Endod 2009;35:1034-9.

41. Pirani C, Chersoni S, Foschi F, Piana G, Loushine RJ, Tay FR, et al. Does hybridization of intraradicular dentin really improve fiber post retention in endodontically treated teeth? J Endod 2005;31:891-4.