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Light transmission through fiber post: The effect on adhesion, elastic modulus and hardness of dual-cure resin cement

Ivana Radovic[a,b,*], *Gabriele Corciolani*[b], *Elisa Magni*[b,c], *Goranka Krstanovic*[a], *Vladimir Pavlovic*[d], *Zoran R. Vulicevic*[a], *Marco Ferrari*[b]

[a] *Clinic for Pediatric and Preventive Dentistry, Faculty of Dentistry, University of Belgrade, Dr. Subotica 11, Beograd 11000, Serbia*
[b] *Department of Dental Materials and Restorative Dentistry, Policlinico "Le Scotte", University of Siena, Viale Bracci, Siena, Italy*
[c] *Department of Restorative Dentistry and Periodontology, Dental School of the Ludwig-Maximilians University, Goethestrasse 70, D-80336 Munich, Germany*
[d] *Department of Physics, Faculty of Agriculture, University of Belgrade, Serbia*

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ABSTRACT

Objectives. The aim of this study was to investigate the effect of fiber post light transmitting ability to the continuity of resin cement-root dentin (C-RD) and resin cement-fiber post (C-FP) interface, elastic modulus and hardness of a dual-cure resin cement.

Methods. Spectrophotometric measurements were applied for the determination of light transmission at coronal, middle and apical level as well as at the apical tip through Tech 21 X-OP (TECH) and DT Light Post (DT). Posts were cemented using dual-cured resin cement (Calibra). Roots were sectioned longitudinally through the post. Epoxy resin replicas were made and used to evaluate C-RD and C-FP interface under SEM. Modulus of elasticity (*E*) and Vicker's hardness (VH) of the cement layer were assessed.

Results. No light transmission was detected through TECH. Light transmission through DT decreased from coronal to apical and rose at the apical tip. TECH presented a significantly lower percentage of continuous C-RD and C-FP interface in comparison to DT. Coronal third of C-RD interface in TECH specimens had a significantly higher percentage of continuity than apical third. No regional differences in continuity of C-RD interface were found in DT specimens. *E* and VH were significantly lower when TECH was used, and decreased from coronal to apical for both posts.

Significance. Cementation of fiber post with no light transmitting ability using a dual-cured resin cement resulted in lower *E* and VH of the cement layer, and lower percentage of continuous C-RD and C-FP interface in comparison to cementation of light transmitting fiber post.

* *Corresponding author at*: Clinic for Pediatric and Preventive Dentistry, Faculty of Dentistry, University of Belgrade, Dr. Subotica 11, Beograd 11000, Serbia. Tel.: +381 112684581; fax: +381 112685361.
E-mail address: ivana.radovic@iritel.com (I. Radovic).

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1. Introduction

The use of fiber post and core systems has been extensively investigated and supported by clinical [1,2] and laboratory studies [1,3]. In order to allow for optimal retention and favorable stress distribution inside the root canal [4], resin-based luting agents are indicated for fiber post cementation [3].

Light curing resins are not recommended for fiber post cementation because of inadequate depth of cure in the apical portions of the root, even if translucent posts are used [5]. Therefore, dual-cured and self-cured resin cements have been advised for fiber post cementation. Dual-cured resin cements have been widely used by the clinicians and were investigated in a number of clinical studies [6–13]. These cements are expected to adequately polymerize in areas which cannot be entirely reached by light as well as in complete absence of light. Nevertheless, it was reported that in the absence of light some dual-cured cements may not reach an adequate degree of conversion [14,15]. Therefore, light curing was recommended for dual-cured resin cements. Having in mind the depth of post space preparations, translucent fiber posts were introduced in order to facilitate light curing. Adequate curing is considered to be especially important in the apical portions of the root canals which have presented impaired adhesion in the vast number of studies that dealt with differences in adhesion along the post space [3].

Recent investigations pointed out that the amount of transmitted light differs between different fiber posts. Limited or no light transmission was recorded through some fiber posts that were claimed to be translucent by the manufacturers [16–18]. A significant reduction of the quantity of transmitted light as the depth increased was also reported [17]. Concern was raised regarding the ability of fiber posts to transmit light in the amount sufficient for polymerization of dual-cured resin cements in the apical portion of the post space.

No attempt was made in the literature so far to investigate the effect of fiber post light transmitting ability to the adhesive potential of dual-cured resin cements used for post cementation. One study investigated the influence of fiber post translucency on the degree of conversion of dual-cured resin cement [19]. The use of non-light transmitting carbon fiber post resulted in lower degree of conversion at medium depth of the post space in comparison to translucent fiber post [19]. It may be assumed that the amount of light transmitted through the post affects dual-cured resin cement's coupling to root dentin and fiber post, as well as micromechanical properties of the cement itself. Therefore, the aim of this study was: (1) to determine the light transmission at different post levels and at the apical tip through two fiber posts that differ in light-conducting aspect by taking spectrophotometric measurements; (2) to investigate whether the type of fiber post influences the continuity of resin cement-root dentin (C-RD) and resin cement-fiber post (C-FP) interface, keeping all other variables constant. (3) To investigate whether the type of fiber post influences the elastic modulus and hardness of the cement layer. The null hypothesis was that there are no statistically significant differences in the continuity of C-RD/C-FP interface and in elastic modulus/hardness of the cement layer following the cementation of two fiber posts with different light transmitting properties.

2. Materials and methods

2.1. *Measurements of light transmission through the posts*

A pilot investigation was firstly conducted in order to select two fiber posts that differ in light transmission. Several fiber posts that are claimed by the manufacturers to transmit light were used. Each post was placed perpendicular through a black cardboard taken from the Q-14 color separation scale (Kodak Co, Rochester, USA). The distance between the card and the apical tip of each post was set at 10 mm and light curing unit (L.E.Demetron 1, Kerr, Danbury, CT, USA) was placed on the opposite end of the post. Two fiber posts that appeared to differ the most in the amount of light that could be visually observed below the black cardboard were then selected for further investigation.

Two groups were formed according to the fiber post investigated. Ten posts were used in each group.

Group 1: Tech 21 X-OP fiber post #12 (Isasan, Rovello Poro, Italy) which consists of silica–zirconia fibers (55%), diphenilpropane and methyloxirane (45%). Its coronal diameter is 1.2 mm and its apical diameter is 0.8 mm.
Group 2: DT Light Post #2 (RTD, St Egreve, France) which consists of epoxy resin (40%), and quartz fibers (60%). Its coronal diameter is 1.8 mm and its apical diameter is 1 mm.

Each post was placed through a black cardboard in the same manner as in pilot investigations. The system light curing unit/post was positioned on a stand. A 50-μm fiber optic (P50-2-UV-VIS, Ocean Optics, FL, USA) connected to a spectrophotometer (PSD1000, Ocean Optics, FL, USA) was oriented perpendicular to the post and stabilized. The fiber was placed at three different levels along the post—2 mm, 5 mm and 8 mm from the apical tip (Fig. 1A), and at the tip of the post (Fig. 1B). These distances were always verified by an electronic digital caliper with a 10-μm resolution (1651 DGT, Beta, Milan, Italy).

The spectrophotometer was connected to a computer running spectrum analyzer software (OOIBase 32, Ocean Optics, FL, USA). The software was set in "Scope" mode, in order to evaluate the light counts that correlated to the amount of photons received from the Charge Coupled Device detector of the spectrophotometer. At 470 nm, for each count 30 photons were received from the detector of the instrument.

Counts were recorded at each level. In both groups a radiometer was used prior to measurements (Optilux Radiometer, sds/Kerr, Orange, CA, USA) in order to check that the output of the light tip (Light Guide Curved 11 mm 1020898, Kerr, Danbury, CT, USA) remained over 700 mW/cm^2.

2.2. *Specimen preparation for interface observations*

Twenty intact single-rooted human premolars, extracted due to orthodontic reasons, were selected for the study. The teeth were stored in 1% chloramine T at 4 °C for not more than six

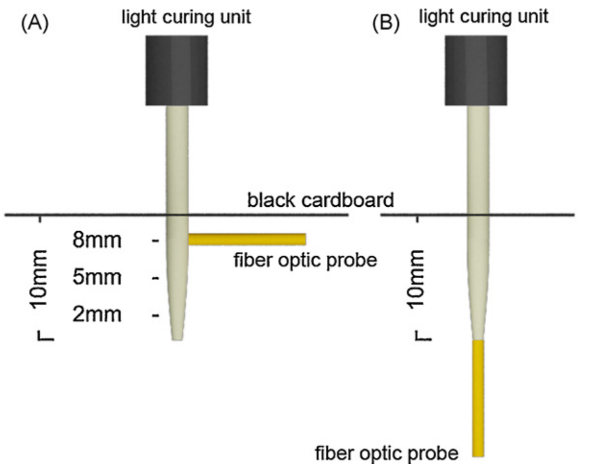

Fig. 1 – Schematic drawing of the test setup for the measurements of light transmission through the posts. Each post was placed through a black cardboard. The distance between the card and the apical tip of each post was set at 10 mm and light curing unit was placed on the opposite end of the post. A 50-μm fiber optic connected to a spectrophotometer was oriented perpendicular to the post and stabilized. The fiber was placed at three different levels along the post—2 mm, 5 mm and 8 mm from the apical tip (A), and at the tip of the post (B).

months until use. The crown of each tooth was removed at 1 mm above the cement-enamel junction, using a slow speed diamond saw (Isomet, Buehler, Lake Bluff, IL, USA) under water-cooling.

A crown-down preparation technique was followed, using stainless steel K-files (Union Broach, New York, NY) combined with 2.5% sodium hypochlorite irrigation. The canals were filled with gutta-percha and a sealer (Acroseal, Septodont, Saint Maur Des Fosses, France; batch R1 077, R1 081) following the lateral condensation technique. The filled roots were coronally sealed with glass ionomer cement (Fuji IX, GC Corporation, Tokyo, Japan; batch 0711071) and stored in water for 48 h to allow the sealer to set. The roots were then divided into two experimental groups ($n = 10$) according to the fiber post used.

Group 1: Tech 21 X-OP fiber post #12.
Group 2: DT Light Post #2.

After removing the temporary coronal seal, 8 mm post space was prepared in each root with drills provided by post manufacturers. In both groups, XPBond Dual Cure adhesive system was used (XPBond and Self-Cure Activator; Dentsply Caulk, Milford, DE, USA; batch 0604001288) in combination with the dual-cure resin cement Calibra (Dentsply Caulk; batch base 060112, batch catalyst 060605). Caulk 34% Tooth Conditioner Gel (34% phosphoric acid; Dentsply Caulk) was applied to the post space through a needle, and after 15 s it was completely rinsed off with water carried into the canal with an endodontic syringe. Excess water was removed from the post space with a gentle air blast. Paper points were used to remove residual moisture. XPBond was mixed with Self-Cure Activator following the manufacturer's instructions. The adhesive/activator mixture was applied to post preparation with a microbrush, maintaining the contact of adhesive/activator with tooth structure for 20 s. The adhesive/activator solution in excess was absorbed from the post space by a paper point and light-cured for 40 s (L.E.Demetron 1). Resin cement components were mixed and introduced into the post preparation with a lentulo spiral. The post was seated immediately and the excess was removed. Light curing was performed through the post for 40 s. The exposed dentin along the coronal part of the root was covered with flowable composite (Tetric Flow, Ivoclar Vivadent, Schaan, Liechtenstein; batch G08479). All the post-cemented roots were placed in water at room temperature.

Table 1 – Light transmission through Tech 21 X-OP and DT Light Post.

	Level	Mean (counts)	Standard deviation (counts)
Tech 21 X-OP	Coronal	0	0
	Middle	0	0
	Apical	0	0
	Tip	0	0
DT Light Post	Coronal	900	14.9
	Middle	820	15.6
	Apical	620	12.3
	Tip	4096	0.0

After 7 days each root was longitudinally cut through the post using a low speed diamond saw (Isomet). Only one section per root was randomly selected and used for interface evaluation, in order to allow that the sections can be treated as independent statistical units. Sections were polished with silicon carbide papers (600, 800, 1000, 1200) under running water and gently decalcified for 15 s with silica-free phosphoric acid gel (Uni-Etch, Bisco, Schaumburg). After rinsing with water and air drying, polyvinyl siloxane (Elite HD+, Zhermack, Badia Polesine, Italy; batch 47233) impressions of the surfaces to be observed were taken. Positive replicas were then obtained using epoxy resin (i-pox plus, AuDent AG, Triesenberg, Liechtenstein).

2.3. *SEM interface observations*

Each replica was mounted on a metallic stub, sputtered with gold (BAL-TEC SC-RD 005, BAL-TEC AG, Balzers, Liechtenstein), and observed under a scanning electron microscope (JSM-6390 LV, JEOL, Tokyo, Japan) at different magnifications. Measurements were made using the JEOL's image analysis software directly on the sections in the microscope. Firstly the exact length of the entire cement-dentin and cement-post bonding interface was measured. The bonding interface on each side of the post was further divided into coronal, middle and apical third. In each third gaps and discontinuities at the C-RD and C-FP interface were measured. The integrity of the interface in each third was then expressed as the percentage of the continuous (gap-free) interface. The percentage of the continuous interface along the entire C-RD and C-FP interface was also calculated.

Table 2 – Percentage of the continuous C-RD and C-FP interface. Numbers are means; values in brackets are standard deviations. Groups marked with the same superscript letters/symbols are not statistically significantly different. Upper case letters indicate statistically significant differences at the C-RD interface between two fiber posts for each root third and for the entire cement–dentin interface (Mann–Whitney *U*-test, $p < 0.05$). Symbols indicate statistically significant differences at the C-FP interface between two fiber posts for each root third and for the entire cement-fiber post interface (Mann–Whitney *U*-test, $p < 0.05$). Lower case letters indicate statistically significant differences within the column, i.e. between the post space thirds for each fiber post, at C-RD and C-FP interface (Wilcoxon signed ranks test, $p < 0.05$).

	C-RD interface (%)		C-FP interface (%)	
	Tech 21 X-OP	DT Light Post	Tech 21 X-OP	DT Light Post
Coronal third	87.56 (24.01)^{Aa}	94.47 (4.73)^{Aa}	93.69 (13.85)$^{\blacksquare a}$	100.00 (0.00)$^{\blacksquare a}$
Middle third	68.96 (19.10)^{Aab}	81.61 (25.65)^{Aa}	92.97 (11.69)$^{\blacksquare a}$	100.00 (0.00)$^{\blacksquare a}$
Apical third	58.47 (29.02)^{Ab}	94.97 (8.52)^{Ba}	75.97 (31.58)$^{\blacksquare a}$	100.00 (0.00)$^{\blacktriangleright a}$
Entire interface	71.66 (22.60)^{A}	90.35 (11.02)^{B}	87.54 (12.50)$^{\blacksquare}$	100.00 (0.00)$^{\blacktriangleright}$

2.4. *Elastic modulus and hardness measurements*

Three sections were randomly selected per group for the analysis of the micromechanical properties of the cement layer in each third of the post space. The specimens were fixed to glass slabs with methacrylate resin (Technovit 4004, Heraeus Kulzer, Wehrheim, Germany), with the flat surface to be tested parallel to the slab. Prior to testing, the surfaces were polished with 1 μm-polycrystalline diamonds (DP-Spray, P; Struers) under water-cooling. Modulus of elasticity (*E*) and Vicker's hardness (VH) of the cement layer were assessed. The measurements were performed by means of a microhardness indenter (Fischerscope H100C; Fischer, Sindelfingen, Germany). A constant distance of 200 μm was maintained between the measurement points, which were located from the most coronal to the most apical limits of the post space. The test procedure was carried out force controlled. The test load increased and decreased at a constant speed between 0.4 mN and 500 mN. The force application time can be non-standardly varied. The force increased from 0.4 mN to 500 mN in 20 s, the maximal force of 500 mN was kept constant for 5 s, then the force decreased from 500 mN to 0.4 mN in 20 s and the minimal force of 0.4 mN was kept constant for 5 s. The load and the penetration depth of the indenter (Vicker's pyramid: diamond right pyramid with an angle $\alpha = 136^\circ$ between the opposite faces at the vertex) were continuously measured during the load–unload-hysteresis.

The Universal Hardness is defined as the test force divided by the apparent area of the indentation at maximal force. From a multiplicity of measurements stored in a database supplied by the manufacturer, a conversion factor between Universal Hardness and Vicker's hardness (VH) was calculated and implemented into the software, so that the measurements were expressed in Vicker's hardness units.

The indentation modulus was calculated from the slope of the tangent of the indentation depth-curve at maximal force and is comparable with the modulus of elasticity of the material (*E*).

2.5. *Statistical analysis of the interface continuity data*

Since the interface continuity data were not normally distributed (Kolmogorov–Smirnov test, $p < 0.05$), non-parametric statistical tests were selected to assess significant differences. Mann–Whitney *U*-test was applied to compare DT Light Post to Tech 21 X-OP in the percentage of continuous C-RD and C-FP interface in each third as well as in the percentage of continuity along the entire two interfaces. Wilcoxon signed ranks test was used to compare the percentage of continuous inter-

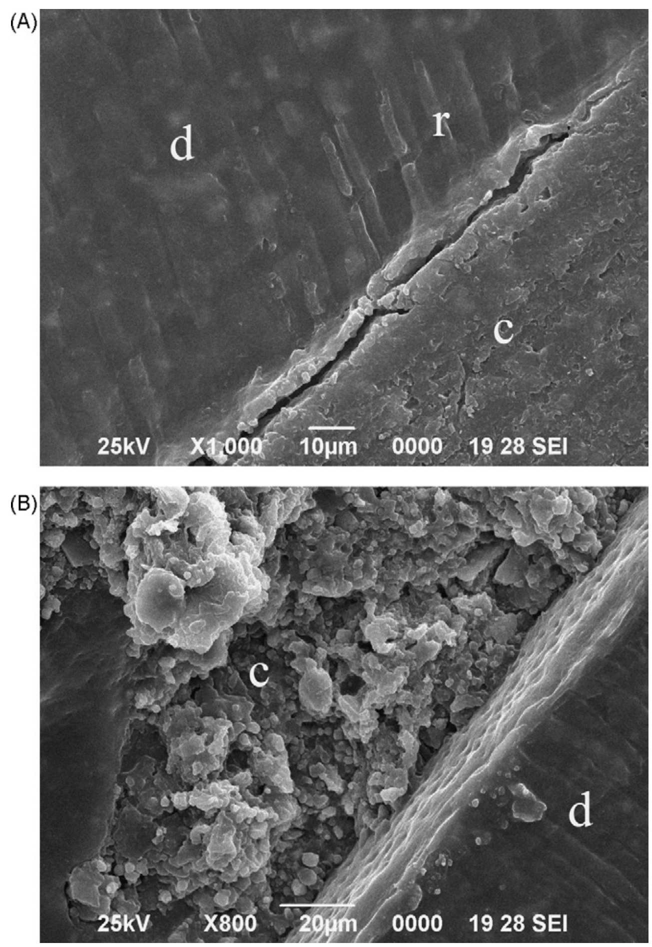

Fig. 2 – SEM micrographs of Tech 21 X-OP specimens. (A) The gaps at the C-RD interface were most often located between the adhesive and the cement while resin tags could be seen in dentinal tubules. (B) In some Tech 21 X-OP specimens areas of poorly polymerized adhesive and cement could be seen, especially in the apical third. c: resin cement; d: dentin; r: resin tag.

Table 3 – Percentage of the continuous C-RD and C-FP interface. Numbers are means; values in brackets are standard deviations. Groups marked with the same superscript letters are not statistically significantly different. Letters indicate statistically significant differences within the row, i.e. between C-RD and C-FP interface in each root third and at the entire interface for each of the two fiber posts (Wilcoxon signed ranks test, $p < 0.05$).

		C-RD interface (%)	C-FP interface (%)
Tech 21 X-OP	Apical third	58.47 (29.02)^{A}	75.97 (31.58)^{A}
	Middle third	68.96 (19.10)^{A}	92.97 (11.69)^{B}
	Coronal third	87.56 (24.01)^{A}	93.69 (13.85)^{B}
	Entire interface	71.66 (22.60)^{A}	87.54 (12.50)^{B}
DT Light Post	Apical third	94.97 (8.52)^{A}	100.00 (0.00)^{A}
	Middle third	81.61 (25.65)^{A}	100.00 (0.00)^{A}
	Coronal third	94.47 (4.73)^{A}	100.00 (0.00)^{B}
	Entire interface	90.35 (11.02)^{A}	100.00 (0.00)^{B}

face among the thirds for each fiber post separately. Wilcoxon signed ranks test was also used to compare C-RD to C-FP interface in each third and along the entire interface for each of the two posts separately.

2.6. *Statistical analysis of the elastic modulus and Vicker's hardness data*

Since the elastic modulus (*E*) and Vicker's hardness (VH) data were normally distributed (Kolmogorov–Smirnov test, $p > 0.05$), parametric statistical tests were selected. Repeated measures analysis of variance (ANOVA) was used to compare *E* and VH measurements between the post space thirds for each fiber post. Independent samples *t*-tests were used to compare *E* and VH measurements between DT Light Post and Tech 21 X-OP in each post space third. In all the statistical tests, the level of significance was set at $p < 0.05$ and calculations were handled by the SPSS 15.0 software (SPSS Inc.; Chicago, IL, USA).

3. Results

3.1. *Light transmission*

No light transmission was detected through Tech 21 X-OP. For DT Light Post light intensity decreased from the coronal to apical portion and peaked at the apical tip (Table 1).

3.2. *Interface continuity*

3.2.1. *C-RD interface*

When two fiber posts were compared, Tech 21 X-OP specimens presented significantly lower percentage of the continuous interface in the apical third and along the entire interface (Table 2). The comparisons between the post space thirds revealed that in Tech 21 X-OP apical third exhibited lower percentage of continuous interface than coronal third. In DT Light Post group no differences were found among the interface thirds. In both groups the gaps at the C-RD interface were mostly located between the adhesive and the cement (Fig. 2A). In some Tech 21 X-OP specimens conglomerates of poorly polymerized adhesive and resin cement could be seen, particularly in the apical third (Fig. 2B).

3.2.2. *C-FP interface*

When two fiber posts were compared, Tech 21 X-OP specimens presented significantly lower percentage of the continuous interface in the apical third and along the entire interface (Table 2). DT Light Post specimens presented no gaps at the C-FP interface (Tables 2 and 3, Fig. 3). The comparisons between the post space thirds revealed no significant differences for neither of the posts.

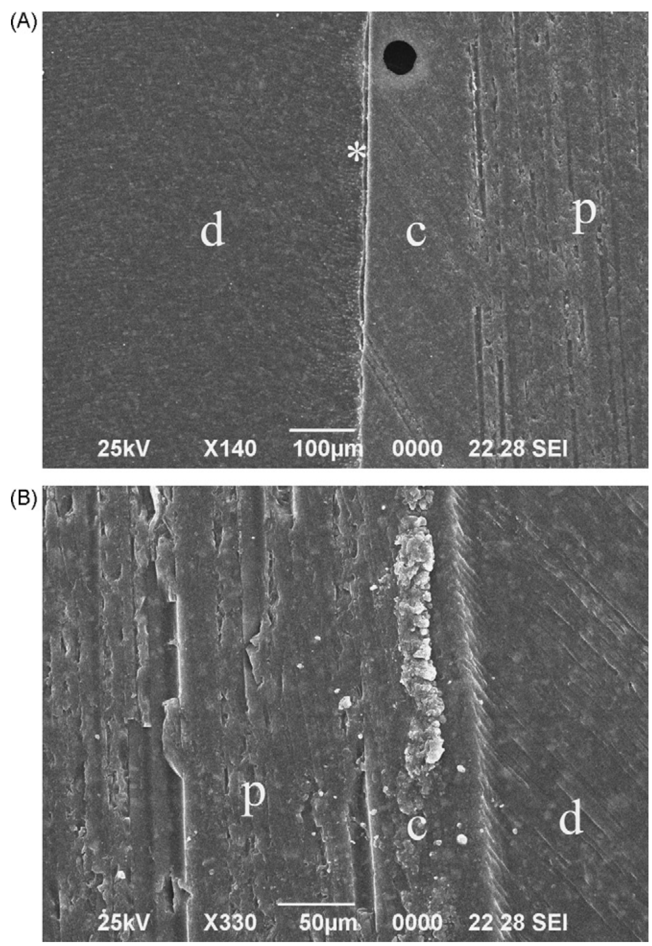

Fig. 3 – SEM micrographs of DT Light Post specimens. (A) In DT Light Post specimens all the gaps were located at the C-RD interface (asterisk) whereas C-FP interface was 100% continuous. c: resin cement; d: dentin; p: fiber post.

Table 4 – Elastic modulus and Vicker's hardness. Numbers are means; values in brackets are standard deviations. Groups marked with the same superscript letters are not statistically significantly different. Letters indicate statistically significant differences within the column, i.e. between the post space thirds for each fiber post (repeated measures ANOVA, $p < 0.05$).

Tech 21 X-OP		DT Light Post	
Elastic modulus (GPa)	Vicker's hardness (N/mm^2)	Elastic modulus (GPa)	Vicker's hardness (N/mm^2)
9.60 (1.53)^A	59.23 (15.32)^A	10.75 (1.51)^A	63.12 (13.79)^A
8.70 (2.40)^B	42.27 (11.36)^B	10.91 (1.18)^A	61.57 (12.58)^A
5.88 (1.60)^C	37.62 (11.57)^B	9.69 (1.18)^B	49.09 (11.80)^B

Table 5 – Elastic modulus and Vicker's hardness. Numbers are means; values in brackets are standard deviations. Groups marked with the same superscript letters are not statistically significantly different. Letters indicate statistically significant differences within the row, i.e. between Tech 1 X-OP and DT Light Post in each post space third (independent samples *t*-test, $p < 0.05$).

	Post space third	Tech 21 X-OP	DT Light Post
Elastic modulus (GPa)	Coronal	9.60 (1.53)^A	10.75 (1.51)^B
	Middle	8.70 (2.40)^A	10.91 (1.18)^B
	Apical	5.88 (1.60)^A	9.69 (1.18)^B
Vicker's hardness (N/mm^2)	Coronal	59.23 (15.32)^A	63.12 (13.79)^A
	Middle	42.27 (11.36)^A	61.57 (12.58)^B
	Apical	37.62 (11.57)^A	49.09 (11.80)^B

3.2.3. *Comparisons between C-RD and C-FP interface for each fiber post*

For Tech 21 X-OP, C-FP interface had a significantly higher percentage of continuity than C-RD interface in middle and coronal third (Table 3). In DT Light Post specimens, percentage of continuous C-FP interface along the entire interface and in coronal third was significantly higher than the percentage of the continuous C-RD interface.

3.3. *Elastic modulus and Vicker's hardness*

E and VH decreased from coronal to apical for both fiber posts. Significant differences in *E* and VH were found between the post space thirds (Table 4). In Tech 21 X-OP specimens *E* and VH in middle and apical third were significantly lower than in coronal third. For DT Light Post, no differences were found between coronal and middle third in *E* and VH measurements, whereas significantly lower *E* and VH were found in apical third. When two fiber posts were compared, *E* was significantly lower in Tech 21 X-OP specimens in all post space thirds. VH in coronal third did not significantly differ between two fiber posts, while it was significantly lower in middle and apical third in Tech 21 X-OP specimens (Table 5).

4. Discussion

SEM method used in this study has been widely used for investigation of adhesion in root canals following cementation of fiber posts [20–22]. In order to avoid possible influence of shrinkage under vacuum in the SEM chamber on the presence of gaps along the investigated interfaces, epoxy resin replicas were made. Significant differences were found in the percentage of the continuous C-RD and C-FP interface between the experimental groups. Likewise, elastic modulus and microhardness of the cement layer were significantly influenced by the fiber post used. Therefore, the null hypothesis had to be rejected.

Both investigated fiber posts are claimed to transmit light by the manufacturers. Nevertheless, no light transmission was detected through Tech 21 X-OP. It is possible that the presence of silica–zirconia fibers in Tech 21 X-OP fiber post adversely influenced its light transmitting properties. In the previous investigation of fiber post light transmission that used the same spectrophotometric method as the present study, somewhat lower readings were recorded for DT Light Post [18]. Nevertheless, the same trend of reduction in light transmission from coronal to apical, followed by the increase at the tip of the posts was found. Previous study investigated DT Light Post size 1, whereas size 2 was used in the present study. The difference in sizes as well as variations in composition of posts originating from two different batches may clarify the difference in spectrophotometric counts that were recorded.

The occurrence of gaps in general may be related to the high C-factor in bonded root canals [23]. The lower percentage of continuous C-RD and C-FP interface in Tech 21 X-OP specimens may be the consequence of the lack of light transmission through this fiber post. The absence of light may have impaired complete polymerization of the cement (Fig. 2B), particularly in the apical third, and may have adversely affected its coupling with root dentin and post surface. Resin cement polymerization in the apical third relied solely on chemical catalysts. This may clarify the significantly lower percentage of continuous C-RD interface in Tech 21 X-OP specimens in comparison to coronal third that was accessible to light (Table 2).

On the other side, no regional differences were found along the C-RD interface in DT Light Post specimens. Spectrophotometric measurements revealed a reduction in light transmission from coronal to apical third of this fiber post. Nevertheless, a considerably high peak in counts was measured at the tips of the posts. This may be explained by the unidirectional longitudinal orientation of the reinforcing quartz fibers that could facilitate the transmission of light up to the tip of the post. Therefore, light could participate in resin cement polymerization in the apical third in a manner similar to coronal third. The presence of light in the apical third may thus clarify the lack of regional differences along the C-RD interface in DT Light Post specimens.

The absence of gaps at C-FP interface in DT Light Post specimens indicates more predictable adhesion at the post-cement in comparison to cement-dentin level. In Tech 21 X-OP specimens no difference in continuity of the entire interface was found between C-RD and C-FP interface. Apart from differences in post surface properties between the two posts that may have affected adhesion to resin cement, it may be speculated that light transmission contributed to favorable post-cement coupling in DT Light Post specimens.

Markedly lower percentage of continuous resin cement-root dentin interface was reported in the study that investigated cementation of Fibrekor fiber post (Jeneric Pentron Incorporated, Wallingford, CT, USA) with a self-cured, dual-cured and light-cured resin cement, using a similar method as in the present study [24]. The authors of the present study believe that this difference in case of dual-cured and light-cured cement may be partly attributed to the lack of light transmitting ability of Fibrekor fiber post [16]. However, it remains unclear why cementation of Fibrekor post with a self-cured cement did not result in a higher percentage of the continuous C-RD interface [24]. A reduction in interface continuity from coronal to apical third was also reported [24], which is in accordance with the present study.

Universal occurrence of interfacial gaps was also reported when carbon fiber posts Tech 2000 (Isasan) and Endopost (RTD) were cemented using dual-cured resin cements [25]. The percentage of continuous interface was not reported in this study [25] which precludes direct comparisons with the present study. Nevertheless, it may be speculated that the lack of light transmission through carbon fiber posts contributed to the high incidence of gaps.

E and VH decreased from coronal to apical for both fiber posts. This finding correlates with previous study that evaluated hardness of dual-cured resin cement used for the cementation of DT Light Post [26]. However, in Tech 21 X-OP specimens, significant differences in comparison to coronal third were found in middle third of the post space already. On the other side, coronal and middle third in DT Light Post specimens were comparable, whereas only measurements in the apical third were significantly lower. Moreover, *E* and VH were significantly higher when DT Light Post was used. Superior micromechanical properties of resin cement in DT Light Post specimens may be attributed to the enhanced cement polymerization in the presence of light. It was previously reported that composite resin micromechanical properties may serve as an indicator for the extent of monomer conversion [27–29]. Therefore, the results of hardness measurements performed in this study indirectly indicate that higher degree of conversion of dual-cured resin cement may be attained by the use of light transmitting fiber post.

The authors are aware that the specific choice of dual-cured resin cement might have influenced the results of the present study. It is possible that adhesion of different resin cement to root dentin in terms of the percentage of continuous C-RD and/or C-FP interface would not be influenced by the type of fiber post and its light transmitting ability.

5. Conclusion

In conclusion, cementation of fiber post with no light transmitting ability using dual-cured resin cement resulted in lower percentage of continuous C-RD and C-FP interface in comparison to cementation of light transmitting fiber post. Elastic modulus and Vicker's hardness of the cement layer significantly decreased from coronal to apical third of the post space regardless of the fiber post used. However, cementation of light transmitting fiber post resulted in higher elastic modulus and Vicker's hardness of the cement layer in comparison to cementation of fiber post with no light transmitting ability.

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