Light Conduction Capability of Different Light-Transmitting FRC Posts

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Abstract

Introduction: Application of light transmitting posts to restore greatly damaged endodontically treated teeth has been increased. It is suspected that light intensity decreases as it passes throughout different materials. This can reduce the degree of conversion required for adequate bond strength throughout the length of these posts. The objective of this study was to evaluate the amount of light intensity reduction after passing through different depths of FRC posts. **Methods:** Four groups of five extracted human central incisors were prepared to cement four types of FRC posts with Panavia F 2 resin cement. The apical end of the posts were exposed by sectioning with a diamond disk and then polished. The light intensity measurement was performed using a micro-voltmeter in 8 points or depths with 2mm intervals beginning from the apical depth of 16mm up to a coronal depth of 6mm. Two different output light intensities [HIP (High Intensity Program) and LOP (Low Intensity Program)] were evaluated. **Results:** Statistical analysis showed significant differences in light intensity at various depths between 6 and 16mm in all groups. These reductions were linear in all specimens; however, the rate of reduction was dissimilar among different FRC posts. HIP and LOP light exposure modes had not the same rate of light reduction. **Conclusion:** Light intensity decreased dramatically after passing through different depths of FRC posts. None of the posts had sufficient enough light transmission for satisfactory polymerization at the apical and middle levels.

Key Words: FRC post, light intensity, light transmitting post, thickness.

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Introduction

Restoration of endodontically treated teeth is usually associated with lack of adequate coronal and radicular tooth structure to provide appropriate retention and resistance forms for restoration of the tooth. Whenever more conservative retention and resistance forms are not feasible, application of posts can be helpful. There are different factors that determine the need for placement of a post, such as remaining tooth structure, position, function and occlusion of the tooth (1).

Having decision to place a post, the clinician can choose to place custom-cast post and core or prefabricated posts. During recent years, non-metal prefabricated posts have attracted attention. Fiber reinforced posts are known to have a modulus of elasticity near to that of the resin cement and remaining tooth structure, which results in suitable retention and more consistent force distribution and consequently more resistance to fracture. Additionally they have good color and translucency (2-4). The retention of fiber posts is directly dependent on the adequate polymerization of the resin cements along with the whole length of the post. The use of chemically cured resin cements have limitations because of having a short setting time (5). Light-cure cements have an unlimited working time, but they need sufficient light intensity at various depths which is essential to gain favorable physical properties (6). Dual-cure resin cements have both types of chemical and light activation, but some dual-cure cements seem to be more dependent on light activation (7). In such cases, the depth of light penetration is of great importance, since in absence of adequate light intensity, polymerization will be insufficient (5).

Some of the consequences of insufficient polymerization are low physical properties, solubility, water sorption, microleakage, deboning and increased risk of tooth destruction due to low retention and resistance (8). The use of light-transmitting fiber posts is claimed to promote improved polymerization and subsequently better bond strength through the canal resulting in more reinforcement of the remaining root structure (5). However, little is known about the behavior of internal root reinforcement (9). The minimally acceptable light intensity for curing of light curing dental materials has been reported to be 233 mW/cm^2 (10,11). Moazzami et al. (12,13) showed a significant reduction in light intensity after passing through different thicknesses of dental materials, tooth structures, and light reflecting proximal wedges. As light passes through the light-transmitting posts, light intensity decreases and degree of conversion of the resin cement also reduces as it gets further from the main light source. Subsequently the physical, mechanical and biologic properties of resin cements will be affected (11). The aim of this study was to evaluate the capability of different FRC posts to transmit adequate light at different depths with two light intensities.

Materials and Methods

Twenty extracted maxillary central incisors, free of caries, cracks, fractures and restorations were selected for this study and used within 2 months after extraction. The teeth were stored in 0.2% sodium azide solution until being used.

The prepared teeth were divided into four experimental groups according to the type of light-transmitting fiber posts as shown in Table 1. Step-back preparation technique was followed, Pizoreamers numbers 2, 3, 4 were used to the length of 20 mm to prepare the suitable space for post placement. Its special drill was used according to the manufacturer's Instructions in Match post group. All posts were cemented with Panavia F 2.0 (Kuraray, Japan) following the manufacturer's instructions. The cement was used to simulate clinical conditions and to stabilize the posts in the canals during sample preparation.

The samples were prepared for light intensity measurement at the apical portion of the root by being sectioned with diamond disks (D & Z, Germany) and water spray until the apical tip of the post was exposed. The exposed tip was then polished with SiC paper (600, 800, and 1200 grit) under running water (Fig.1).

Silicon putty impression material was used to stabilize each specimen on the photocell. This maintained their position and prevented leakage of light (Fig. 1). Light exposure was done in two different intensities; 400 mW/cm^2 (LOP: Low power intensity) and 750 mW/cm^2 (HIP: High power intensity) with a Bluephase C8 light cure unit (Ivoclar/Vivadent AG, Liechtenstein) for each sample. After 5 seconds of exposure, the amount of light intensity was measured at the tip of the post with the photocell and micro-voltmeter. The output light intensities were recorded for both modalities. The whole procedure was done in a dark room. Afterwards, specimens were progressively sectioned and polished to record transmitted light through different depths as shown in Fig. 1. The length of D. T. Light post, Endolight post, Match post and H.T.C.O were 20, 19, 21 and 17mm, respectively and in all of them the amount of light intensity was measured at each 2mm from 16mm up to 6mm of length. The length of 16mm was chosen as the standardized length due to availability of experimental post lengths.

The micro-voltmeter could measure the amount of transmitted light through the posts more accurately than the radiometer; however, its scale is different from the known scale used by a radiometer (mW/cm^2). Therefore, the obtained records from micro-voltmeter were calibrated by the use of a simple ratio ($\frac{X+Y}{2}$) in which:

$X=\frac{HIPr}{HIPp}=\frac{832}{555}=1.499=1.5$ r=Radiometer

$Y=\frac{LOPr}{LOPp}=\frac{715}{540}=1.324$ p=Photocell

This ratio resulted in two constants for HIP and LOP, to convert the micro-voltmeter recorded measurements to mW/cm^2 scale. Finally, the data was statistically analyzed by three way ANOVA.

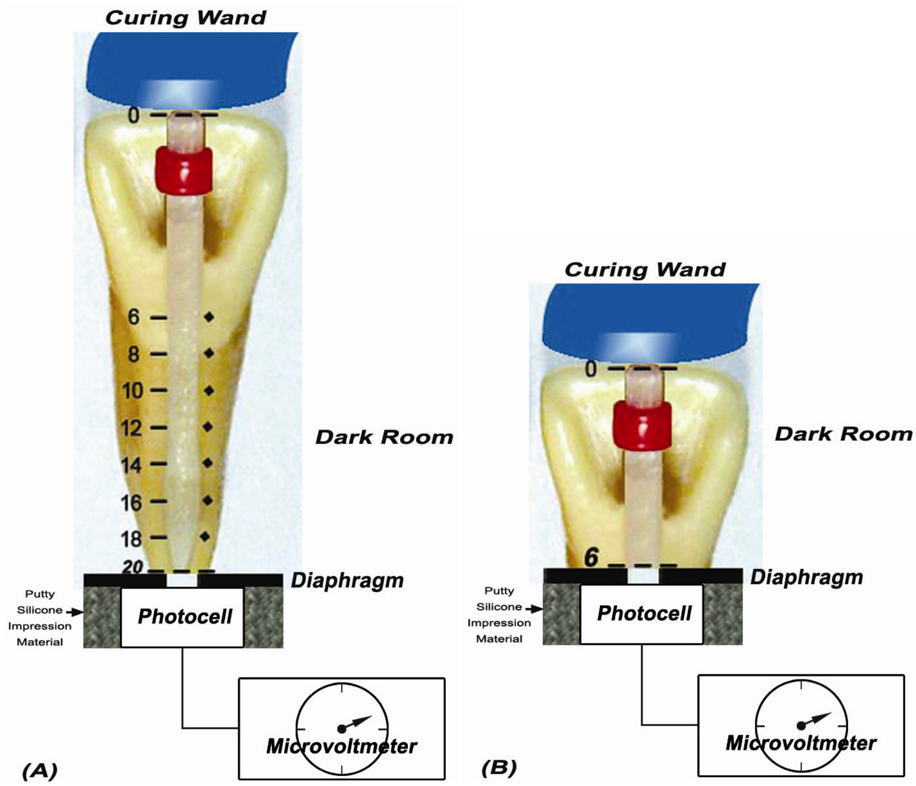

Figure 1. Schematic illustration of light intensity measurement at different depths (A: 16 mm, B: 6 mm)

Table 1. FRC posts tested in this study

Groups	Post	Manufacturer	Shape/Length(mm)	Chemical composition
1	D.T. Light	RTD (France)	Double taper/20	Quartz fiber (60%) Epoxy resin (40%)
2	Endo Light	RTD (France)	Continuous taper (0.02)/19	Quartz fiber (60%) Epoxy resin (40%)
3	Match post	RTD (France)	Taper ¼ apically/21	Glass fiber (60%) Epoxy resin (40%)
4	H. T. Co	H. T. Co (Iran)	Double taper/17	Glass fiber (60%) Epoxy resin (40%)

Results

The mean values of light intensity at different depths for each type of post and two initial intensities are shown in Table 2 (both gray cells show insufficient value of light intensities). Statistical analysis by Hotelling Trace shows significant differences in light intensity in various depths from 6 to 16mm ($P<0.0001$). These dramatic reductions in all posts were linear regardless of post type and mode of exposure. It was also shown that there is a significant interaction between type of post and depth of light transmission ($P<0.0001$). This means that the rate of reduction was dissimilar among posts. The mean intensity was significantly higher with the HIP mode in all depths regardless of the type of post ($P<0.0001$). There was a significant interaction between type of post and curing light intensities ($P<0.0001$). This means HIP and LOP intensities had dissimilar trends. The rate of reduction of intensity is dependent on the exposure mode, however, there is no interaction between different depths and exposure modes (P=0.288). This shows that the trend of reduction does not have a significant difference at various depths for the two types of exposure modes (Table 2 and Fig. 2). Generally speaking, there is a significant difference in light transmission capability between the posts regardless of depths and curing light intensities (P<0.0001).

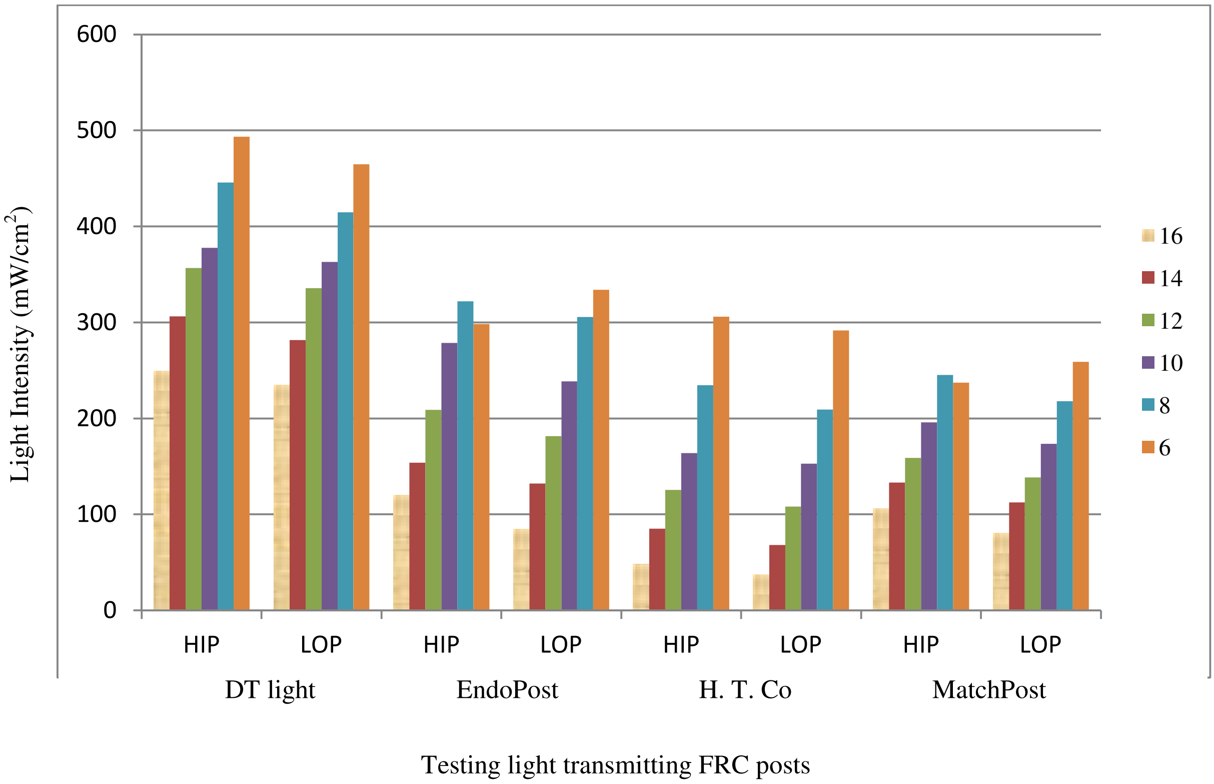

Figure 2. Light intensity (mW/cm²) in different thicknesses of testing light transmitting FRC posts

Table 2. Mean values of light intensity (mW/cm^2) recorded at different depths (mm) for each FRC post with two initial intensities (HIP & LOP)

Post type	Light exposure mode	Different depths (mm)*					
		16	14	12	10	8	6
DT Light	HIP	**249.924**	306.404	356.671	377.559	445.627	493.352
	LOP	**234.674**	**281.552**	335.491	363.168	414.845	464.619
EndoPost	HIP	**120.302**	**153.908**	**209.011**	**278.456**	321.936	**298.184**
	LOP	**85.002**	**132.162**	**181.583**	**238.628**	305.556	333.971
H. T. Co	HIP	**48.290**	**85.284**	**125.385**	**163.796**	**234.674**	306.121
	LOP	**37.841**	**68.037**	**108.158**	**152.828**	**209.258**	**291.719**
MatchPost	HIP	**106.500**	**133.292**	**158.708**	**195.876**	**245.236**	**237.247**
	LOP	**80.766**	**112.395**	**138.658**	**173.676**	**218.010**	**259.048**

*Values in the dark gray are less than 233 mW/cm^2 as referenced by Rueggeberg et al. (11), and values in bold font are less than 300 mW/cm^2 as referenced by Leonard et al. (18)

Discussion

The aim of this study was to evaluate the amount of light transmission attenuation by different translucent fiber reinforced posts at various depths of prepared post spaces with two different initial intensities (HIP, LOP). Light transmitting posts were introduced to increase the light transmission and degree of polymerization of luting cements. Consequently this results in greater bond strength to the canal walls and resultant reinforcement of weak tooth structure (5). Patyk and Gottingen (2) reported that glass fibers are able to transmit light. Teixeira et al. (3) showed that fiber reinforced posts have limited light transmission capability. Gorraci et al. (14) found that light intensity decreased from coronal to apical portion of the FRC posts. It is essential to improve FRC posts transmission properties in order to achieve adequate physical and mechanical qualities of resin cement throughout the post space because it has been shown that they have limited light transmission capability (3). There are different factors that influence the degree of polymerization of resin cement such as adequate light intensity, suitable wavelength of visible light, adequate exposure time, the distance from light guide tip, environmental temperature, color/opacity of resin material, post-exposure time, filler composition, shape and size (15). In this study, the type of posts, depth of measurement and initial light intensity (HIP, LOP) were the variables. While exposure time, environmental temperature, type of luting cement and visible light wavelength were constant.

The thickness of a material has a reducing effect for the light passing through it and is an effective factor on curing efficiency. Moazzami et al. (12,13) showed a marked reduction in light intensity after passing through different thicknesses of dental materials, tooth structures, and light reflecting proximal wedges. Some authors advocate that light posts greatly increase the transmission of light to the apical third of the post space (1). However, some research agrees with the present study that the light posts cannot induce enough polymerization of resin cements in the apical region of root canals (3,14,16,17). Santos et al. (16) used resin blocks instead of natural teeth that were used in this study. They concluded that the amount of transmitted light depends on the type of post and there was a reduction in light intensity in correlation with depth of measurement. They reported that even without a post the apical regions of the canals did not receive adequate light transmission. Their findings completely agree with the results of this study.

The minimal light intensity necessary for complete polymerization in light-curing dental materials has been measured in many studies (11,18). If we assume that the minimal needed intensity at any location within the root canal is 300 mW/cm^2 as Leonard et al. (18) have reported, then based on the results of this study with the HIP as the initial light curing source, DT Light Post, Endolight Post and Match Post provided acceptable intensity for polymerization only up to 14, 8, and 6mm, respectively. When considering LOP as the initial intensity mode, minimally acceptable light intensity (300 mW/cm^2) penetrated up to a depth of 12 and 8 mm in DT Light post and Endo light post. However, Match post provided less than 300 mW/cm^2 light intensity even at the depth of 6mm. It can be concluded that in the apical and middle portions of the root space, resin cement remained under-polymerized with all posts used in this study. Consequently, this results in reduced physical, mechanical, and reinforcing qualities of the cement. This is in agreement with some studies that showed a significant light attenuation after passing through the depths of FRC posts (16,19). In addition, under-polymerized resin cement can have an adverse effect on biocompatibility since there is a possibility for uncured monomers to leak through the dentinal tubules and accessory canals (20).

In the current study, two types of quartz fiber posts (DT Light post and Endo Light post) and two types of glass fiber posts (Match post and H.T.C.O) were used Table 1. According to the results, quartz fiber posts performed better than glass fiber posts. There is a significant difference in light transmission capability between the posts. The descending order of posts regarding the degree of light transmission efficiency is D.T Light Post, EndoLight Post, H.T.C.O and MatchPost.

It has been reported that there is a reverse correlation between the output light intensity and the adequacy of light curing unit which can lessen the depth of cure (21,22). However, Blue phase LED curing system used in this study, have been claimed by the manufacturers to have less age-related problems (23).

The diameter of light guide tip was elicited to have an effect on the intensity of output light (24-26). Leonard et al. (18) concluded that the diameter of 12mm can reduce the intensity by 39% compared to diameter of 8mm. The diameter of light guide tip in this study was 9mm. It would be of interest to assess the optimum initial light intensity to provide adequate light transmission at different thicknesses (depths) of different posts as well as the effect of different light guide tip diameters in combination with light transmitting posts in future studies.

Conclusion

According to the parameters of this study, the following conclusions were submitted:

1. With increasing post length, the amount of transmitted light, particularly at the middle and apical end of the post decreased significantly and linearly in all specimens.

2. The light transmission reduction trend varies among different posts.

3. The trend of light transmission attenuation is not identical in both HIP and LOP curing modes in different FRC posts.

4. The apical regions of all posts and even middle part in some posts do not receive the minimum of 233 mW/cm^2 or even 300 mW/cm^2, so the amount of light transmission, at least in the apical portion is not enough for adequate polymerization in all types of FRC posts.

5. The degree of light transmission efficiency in descending order is D.T Light Post, EndoLight Post, H.T.C.O, and Match Post.

Therefore, the light transmission adequacy of light posts and/or the output light intensity of light curing units should be increased or adjusted up to appropriate levels to provide adequate light transmission the full length of posts, which requires further investigations.

References

1. Summit JB, Robbins WJ, Hilton TJ, Schwartz RS, Santos JD. Restoration of endodontically treated tooth fundamentals of operative dentistry. A contemporary approach. Chicago: Quintessence, 2006.
2. Patyk A, Gottingen G. Translucency of glass-fiber reinforced root canal posts. International Poster. J Dent Oral Med 2005; 7: Poster 294.
3. Teixeira EC, Teixeira FB, Piasickand JR, Thompson JY. An in vitro assessment of prefabricated fiber post systems. J Am Dent Assoc 2006; 137: 1006-12.
4. Stantos GC, EL-Mowafy O, Rubo JH. Diametric tensile strength of a resin composite core with non metallic prefabricated posts: an in vitro study. J Prosth Dent 2004; 91: 335-41.
5. Lui JL. Composite resin reinforcement of flared canals using light-transmitting plastic posts. Quintessence Int 1994; 25: 313-9.
6. Bayne SC, Heymann HO, Swift EJ Jr. Update on dental composite restorations. J Am Dent Assoc 1994; 125: 687-701.
7. Kumbuloglu O, Lassila LV, User A, Vallittu PK. A study of the physical and chemical properties of four resin composites luting cements. Int J Prosth 2004; 17: 357-63.
8. Ferracane JL. Resin composite–state of art. Dent Mater 2011; 27: 29-38.
9. Goncalves LA, Vansan LP, Paulino SM, Sousa Neto MP, Vansan LP, Sousa MD. Fracture resistance of weakened roots restored with a transilluminating post and adhesive restorative materials. J Prosth Dent 2006; 96: 339-44.
10. Mills RW, Jandt KD, Ashworth SH. Dental composite depth of cure with halogen and blue light emitting diode technology. Br Dent J 1999; 186: 338-41.
11. Reuggerberg FA, Caughman WF, Curits JW. Effect of light intensity and exposure duration on cure of resin composite. J Oper Dent 1994; 19: 26-32.
12. Moazzami SM, Attaran N. The effect of different thicknesses of some restorative materials, tooth structures and air on light intensity reduction: A laboratory evaluation. J Mashhad Dent Sch 2006; 28: 251-62.
13. Moazzami SM, Norollahian S. A new improved design of interdental transparent wedges. J Mashhad Dent Sch 2007; 31: 29-34.
14. Goracci C, Corciolani G, Vichi A, Ferrari M. Light-transmitting ability of marketed fiber posts. J Dent Res 2008; 87: 1122-6.
15. Anusavice KJ. Phillip's science of dental material. Missouri: Saunders; 2003.
16. Santos LF, Cunha Peixoto RT, Albuquerque RC, Santos MF, Abreu LT, Pinotti MB. Light transmission through a translucent fiber post. J Endod 2008; 34: 299-302.
17. Faria Silva AL, Arias VG, Silva Soares LE, Martin AA, Marcondes LR. Influence of fiber-post

translucency on the degree of conversion of dual-cured resin cement. J Endod 2007; 33: 303-5.
18. Leonard DL, Charlton DG, Hilton TJ. Effect of curing tip diameter on the accuracy of dental radiometers. J Oper Dent 1999; 24: 31-7.
19. Rueggeberg FA, Caughman WF, Curtis JW Jr, Davis HC. Factors affecting cure at depths within light-activated resin composites. Am J Dent 1993; 6: 91-5.
20. Faria Silva AL, Casselli DSM, Ambrosano GM, Marcondes LR. Effect of the adhesive application mode and fiber post translucency on the push-out bond strength to dentin. J Endod 2007; 33: 1078-81.
21. Martin FE. A survey of the efficiency of visible light curing units. J Dent 1998; 26: 239-43.
22. Pilo R, Oeligiesser D, Cardish HS. A survey of output intensity and potential for depth of cure among light-curing units in clinical use. J Dent 1999; 27: 235-41.
23. Mills RW, Uhl A, Jandet KD. Optical power outputs, spectra and dental composite depths of cure, obtained with blue light emitting diode (LED) and halogen light curing units (LCUs). Br Dent J 2002; 193: 459-63.
24. Price RB, Derand T, Sedarous M, Andreou P, Loney RW. Effect of distance on the power density from two light guides. J Esthet Dent 2000; 12: 320-7.
25. Nomoto R, Hirano S, McCabe JF. Effect of aperture size on irradiance of LED Curing units. Dent Mater 2004; 20: 687-92.
26. Nitta K. Effect of light guide tip diameter of LED-light curing unit on polymerization of light–cured composites. Dent Mater 2005; 21: 217-23.

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