Analysis of Bond Strength by Pull Out Test on Fiber Glass Posts Cemented in Different Lengths

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Introduction

Endodontically treated teeth, unlike vital teeth often need a docking intraradical to be restored.¹ ³ Teeth in which more than 50% loss of the coronary need intraradical posts to retain restorations mainly on previous elements, providing extra strength to the restoration, either directly or indirectly.⁴ Intraradical retainers are increasingly used in dentistry for direct and indirect restorations, and the fiberglass posts are an excellent choice at the expense on metal posts due to advantages such as corrosion resistance, good cosmetic results, ease of removal in cases of endodontic retreatment, cementing and restore in a single session.⁵ ⁶ The remaining root, their size, and shape, determine the selection of post. Holmes demonstrated, in 1996 that the major length of the post results in greater retention and stress distribution. When the remaining root is short and curved, the use of a greater length for these posts is impeded.⁷ In vitro studies have demonstrated that reducing the length can be compensated using cements reinforced with resin.⁸ The technique of using fiberglass post associated with adhesive restorative materials can promote a long clinical success for endodontically treated teeth.⁹

Many published studies have evaluated intraradical bond strength associated with resin cements and adhesive systems.¹⁰ ¹⁸ Few studies made an attempt to evaluate the technique of this procedure. So far, the standard removal procedure flue is 2/3 of root length, however, some teeth are contraindicated because of their anatomy and root diameter.¹⁹ ²¹

The aim of this study was to evaluate by pull-out test, the bond strength of fiberglass posts cemented with different lengths in endodontically treated teeth.

Materials and Methods

A total of 60 bovine incisors with similar lengths and diameters were selected. Using diamond disc (K Sorensen, Barueri, Brazil) in the straight hand piece, the teeth were sectioned at cementoenamel junction standardizing root length in 21 mm, and the crowns were discarded.

The roots were fixed at the tip a paralelometer (Bio Art, São Carlos, SP, Brazil) by the aid of a godiva stick by the center of PVC connection embedded with chemically activated acrylic resin until complete polymerization of the resin. The roots received endodontic treatment standardizing the length of 21 mm at all. It was used Kerr files (Dentsply Maillefer, Switzerland) until number 60 and concurrent irrigation with 1% sodium hypochlorite.

The specimens were randomly divided into 3 groups (n = 20) and after 24 h of desobturation with the drill guide (post no 3. Exacto/Angelus, Londrina, PR, Brazil) as follows: Group 1: Removal procedure with 2/3 of the length = 14 mm Group 2: Removal procedure with ½ of the length = 10.5 mm and Group 3: Removal procedure with ¼ of the length = 5.25 mm.

Results:

The mean values ± standard deviation in Newtons (N) were: Group 1 = 120.5 (±42.8) A, Group 2 = 103.1 (±31.2) AB, Group 3 = 41.2 (±22.4) C, P < 0.005.

Conclusion:

The preparation of ½ of remaining root appears to be a viable alternative when 2/3 of the preparation of the remaining root is not possible, but more results are needed for clinical validation.

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Abstract:

Background: The aim of this study was to evaluate, by means of pull-out test, the bond strength of fiberglass posts when cemented with different lengths in endodontically treated teeth.

Materials and Methods: Sixty single-rooted bovine roots were cut in the cementoenamel junction with 21 mm length. They were endodontically treated and randomly divided into three groups (n = 20). Group 1 - Preparation of 2/3 of the remaining roots; Group 2 - Preparation of ½ of the remaining roots and Group 3 - Preparation of ¼ of remaining roots. For all groups it was used posts n = 3 (Exacto, Angelus, Brazil), and cemented with self-etching resin cement (RelyXU200). After cementing posts, the samples were thermocycled (10.000 cycles/5°C and 55°C). The pull-out test was performed on a universal testing machine (EMIC - DL500) and the values obtained were statistically analyzed by analysis of variance (one-factor ANOVA) and multiple comparison test of Tukey, with level of significance of 5%.

Conclusion: The preparation of ½ of remaining root appears to be a viable alternative when 2/3 of the preparation of the remaining root is not possible, but more results are needed for clinical validation.

Key Words: Bond strength, fiber post, pull-out test, resin cements
After the division of the groups the posts were disinfected with 70% alcohol and ducts cleaned with sodium hypochlorite 1%, saline solution and dried with absorbent paper cones (Tanari Industrial Manaus, Brazil). The cement used was RelyX U200 (3M ESPE - USA) which was dispensed on a block of paper, spatulate and inserted into the canal with the aid of a Centrix syringe with needle tips according to manufacturer’s instructions. The posts were inserted the excess od resin cement was removed with an explorer probe and light curing for 40 s (Optilight LD MAX - Gnatus).

The specimens were subjected to thermocycling (10,000 cycles/30 s/3 s/5°C and 55°C) (Nova Etica, Model 521-E, Ethics Scientific Equipment S/A, São Paulo - SP, Brazil). The number of cycles corresponded to 12 months aging.22

After thermocycling it was made loops on the end of the device for Pull-out test. It was made a hole with a 2200 diamond bur (KG Sorensen) at high speed and thoroughly it inserted stainless steel wire coated for nylon. Then, a reinforcement of chemically activated resin was positioned at the end of the device to minimize possible disruption effect of tensioning before the pull-out test.

The pull-out test was carried out on a universal testing machine (EMIC - DL500) at a speed of 0.5 mm/s until the total traction of the fiberglass post, and the results were statistically evaluated.

Two pins Group 2 and two pins Group 3 come loose after thermocycling, and some posts broke during the test. Finally, for statistical analysis, these samples were discarded, and the final number of samples for each group was: Group 1: n = 13, Group 2: n = 17 and Group 3: n = 17.

The results were analyzed using analysis of variance (one-factor ANOVA) test and Multiple Comparison Test of Tukey at a significance level of 5%.

Results
The results are described in Table 1.

Using Tukey’s test, it was compared the averages on Group 1 and Group 2, and there was no difference statistically significant between them. Comparing Groups 1 and 3, there was the difference statistically significant (P < 0.01) as well as in the comparison between Groups 2 and 3, which also was statistically significant (P < 0.01).

Discussion
The bond strength of adhesive systems and resin cements to root dentin have been studied by several authors in recent years.10-12,18,23,24 However, the methodology, the preparation of the substrate, the materials used, among other factors show very different values.25 Few studies, however, evaluate the influence of the length of cementing on the bond strength of fiber posts.15,16,25-27

For many years, the standard assigned an optimum length for a retainer intraradical is 2/3 of root length or greater than or equal to the size of the crown.19,21 However, some teeth are contraindicated for this pattern due to the anatomy, diameter, and root remnant. PINZETTA28 analyzed 67 panoramic radiographs containing premolars restored with intracanal posts totaling 96 teeth, which were observed proportion post intraradical/root length. It was found that 96.9% of the length of the post was lower than 2/3 of the length of the root and only 3.1% of the samples had a length equal to or greater than 2/3. The results of their study suggested the high rate of teeth contraindicated for this technique.

BRAGA29 studied in 2006 bond strength of fiberglass and metal posts with different lengths; 60 samples were divided into three groups according to the length (I = 6 mm, 8 mm, II and III – 10 mm). Each group was divided into two subgroups based on material posts (metal and fiber). All posts were cemented with Panavia. Results showed that with post 10 mm long had higher tensile strength, regardless of the material of the post, and that post with 8 mm in length are similar to posts with 10 mm and clinical circumstances, where there are variations of roots (short or curved), posts with 8 mm may be a viable alternative.

The length of intraradical post is questionable, especially for short root remaining teeth or curved. SEN, 2004, obtained results by in vitro study that cements reinforced resin can compensate for the reduced length of the post since it combines adhesion to frictional retention.8

There are several studies are using bovine teeth instead of human’s on researches about Bond strength of fiberglass posts.16,30-33

It was used fiberglass post n = 3 Exacto (Angelus, Londrina, PR, Brazil). It was chosen because it has a diameter compatible to bovine roots, and it has an appropriate format to flow the cement. Reducing hydrostatic pressure during seating of the post and avoid an increase of stresses in the root canal, which may lead to fracture of the root.34-35 It was used, in this study, the centrix syringe for insertion of the resin cement, following the manufacturer’s instructions. There is good evidence in the literature for this method, as described by Michida evaluating the influence of methods of inserting resin cement on the bond

Table 1: Mean values±standard deviation for bond strength (Newtons) for each experimental group.

|       | Group 1 | Group 2 | Group 3 |
|-------|---------|---------|---------|
| mean  | 120.5 (+62.8) A | 103.1 (+31.2) AB | 41.2 (+22.4) C |

Different letters mean statistically different, P<0.0001
The adhesive resin cements eliminate the pre-treatment of dental substrate, which is the stage of completion of washing and conditioning the enamel and dentin prior to cementation, preventing the breakdown of collagen fibers and loss of permeability to adhesives monomers. By being self-etching adhesive and have reduced working time and supposedly safety because a simpler process with fewer steps while running, fewer errors occur. These cements have in their composition the acid that demineralizes enamel and dentin, and hydrophilic monomer infiltrating these structures resulting in a strong union. In this study, it was used the self-adhesive cement RelyX U200, among the various materials available in the market because it is a relatively new material and the object of further research. The self-adhesive cement RelyX U100, its predecessor, has a high value of bond strength compared to other materials available for cementation of fiberglass. Amaral compared the bond strength of the cement to conventional resin cement after undergoing mechanical cycling and proved the superior of this cement in the adhesion of fiber glass post. The choice of self-adhesive and self-etching cement was based on results of Soares, in 2012, that evaluated the effect of cementing agent and design of fiber-glass post on the bond strength at different lengths in the root. They concluded that the retention of fiberglass posts remained unchanged by the surface roughness of the posts, but it was influenced by the type of resin cement, and the cement self-adhesive RelyX Unicem was significantly tougher. BERGOLI, 2012 found in the self-adhesive cement RelyXU100 a good alternative for cementation of fiberglass, a new material and the object of further research. The ISO TR 11405 (1994) and ISO TS 11405 (2003) indicate an appropriate test as an artificial aging compound in water for 500 cycles between 5°C and 55°C. In turn LELOUP, in a study reviewing data published between 1992 and 1996, concluded that thermal cycling has no significant effect on bond strength, suggesting that this number of cycles was probably too low foraging to be obtained. Nevertheless several studies have demonstrated the negative effect of thermal cycling on Bond strength after a large number of cycles such as 15,000-30,000 cycles. Gale and Darvell, evaluated laboratory methods to simulate the temperature changes that occur in the oral cavity and the best method of aging on research samples. They concluded that thermal cycling, although they did not find evidence in the literature that could interfere in the results of the research should be conducted to have proven its clinical relevance. They also concluded that the number of cycles corresponding to 12 months of aging is 10,000. In order to simulate the temperature variations experienced by the tooth in the oral cavity and the aging of the samples it was performed the thermocycling in this study where the specimens were submitted to 10,000 cycles of 30 s in each bath, with an interval of 3 seconds in temperatures of 5°C and 55°C, corresponding, according to this author to aging for 12 months.

The initial number of samples was 20 specimens in each group (Group 1: n = 20; Group 2: n = 20, and Group 3: n = 20). During thermocycling two samples of Group 2 loosened and 3 samples of Group 3. DE MUNCK, 2005, suggest that normally, even in short periods of water storage, the specimens show a decrease in bond strength. This decrease in bond strength may be caused by the degradation of the components of the adhesive interface, caused by the hydrolysis process. In Group 1, 7 samples were lost by breaking the post or the disruption of strap made to carry out the tensile test before full traction of post pin.

The evaluation of this study, unlike most in the literature, is based on a single variable: The length of the post. The pull-out test was chosen, because the results in shear force are comparable to clinically foundings, although few studies are reporting this methodology. This method better distributes stress, and it is considered able accurately to measure the bond strength between the post and root dentin. The pull-out test is more suitable than the push-out when the objective is to measure the holding force of the post along the duct and the type of craze. Innella et al., Ferrari and Mannocci, highlighted the bond strength significantly higher in the cervical region, a fact that occurs for two reasons: reduction of dentinal tubules in mm² in the apical direction, and difficulty of the technique due to the accumulation of fragments at the walls of apical third. This could be an explanatory factor for the equality of results between Groups 1 (14 mm) and Group 2 (10.5 mm).

Another relevant factor is the density and distribution of dentinal tubules, which decreases significantly from coronal region toward the apical region of the root canal, and is related to the bond strength. In studies reporting evaluation of bond strength by cutting the cervical, middle and apical, through the push-out test, show that the apical adherence is critical due to the remnants of gutta-percha in the root canal wall, difficult access, difficulty of cleaning beyond narrowing of the diameter, however, the results obtained in this study with Group 3 (5.25 mm) showed lower values compared with the other groups.
The significant difference between Groups 1 and 2 (14 mm and 10.5 mm in removal procedure, respectively) compared to Group 3 (5.25 mm removal procedure) corroborate the findings by Macedo et al. that evaluated the influence of the length cement retention of fiberglass and concluded that improvement in retention post occurred with increasing length of cementation.

Macedo et al. assessed the effects of length of fiber cement and glass retention after subjected to artificial aging. It was tested bovine incisors endodontically treated that had fiberglass posts cemented with 5 mm or 10 mm of length. These posts were cemented with RelyX ARC and RelyX Unicem with others. The samples were subjected to aging by thermal cycling and/or mechanical cycling and then be pulled by pull out test. The control group did not undergo cycles for aging. They concluded that independent of aging protocol, greater depth (10 mm) showed higher bond strength than the samples of 5 mm, except for RelyX Unicem without thermocycling. And the effect of artificial aging on the tensile strength depends on the type of material used in cementing and depth.

Due to the scarcity literature on the subject, it is suggested that further studies be conducted on different methodologies on the cementation of posts and removal procedure of root canal.

Conclusion
The preparation of the remaining root ½ appears to be a viable alternative when 2/3 of the preparation of the remaining root is not possible, but more results are needed for clinical validation.

Clinical significance
The results of this study can influence the clinical procedures in cementation of fiberglass posts because the bond strength values of posts cemented with ½ length were similar to those cemented with 2/3 of the length. It may suggest a more conservative cementation technique and it can allow the cementation of posts when the root canal is curved.

References
1. Schwartz RS, Robbins JW. Post placement and restoration of endodontically treated teeth: A literature review. J Endod 2004;30(5):289-301.
2. Malfferrari S, Monaco C, Scotti R. Clinical evaluation of teeth restored with quartz fiber-reinforced epoxy resin posts. Int J Prosthodont 2003;16(1):39-44.
3. Ferreira JC, Pires PT, Azevedo AF, Oliveira SA, Melo PR, Silva MJ. Influence of solvents and composition of etch-and-rinse and self-etch adhesive systems on the nanoleakage within the hybrid layer. J Contemp Dent Pract 2013;14(4):691-9.
4. Alsamadani KH, Abdaziz el-SM, Gad el-S. Influence of different restorative techniques on the strength of endodontically treated weakened roots. Int J Dent 2012;2012:343712.
5. Balbosh A, Kern M. Effect of surface treatment on retention of glass-fiber endodontic posts. J Prosthet Dent 2006;95(3):218-23.
6. Soares CJ, Valdivia AD, da Silva GR, Santana FR, Menezes Mde S. Longitudinal clinical evaluation of post systems: A literature review. Braz Dent J 2012;23(2):135-740.
7. Holmes DC, Diaz-Arnold AM, Leary JM. Influence of post dimension on stress distribution in dentin. J Prosthet Dent 1996;75(2):140-7.
8. Sen D, Poyrazoglu E, Tuncelli B. The retentive effects of pre-fabricated posts by luting cements. J Oral Rehabil 2004;31(6):585-9.
9. Ferrari M, Cagidiaco MC, Goracci C, Vichi A, Mason PN, Radovic I, et al. Long-term prospective study of the clinical performance of fiber posts. Am J Dent 2007;20(5):287-91.
10. Amaral M, Santini MF, Wanderscher V, Amaral R, Valandro LF. An in vitro comparison of different cementation strategies on the pull-out strength of a glass fiber post. Oper Dent 2009;34(4):443-51.
11. Bouillaguet S, Gysi P, Wataha JC, Ciucchi B, Cattani M, Godin C, et al. Bond strength of composite to dentin using conventional, one-step, and self-etching adhesive systems. J Dent 2001;29(1):55-61.
12. Darr AH, Jacobsen PH. Conversion of dual cure luting cements. J Oral Rehabil 1995;22(1):43-7.
13. Farrokh A, Mohsen M, Soheil S, Nazanin B. Shear bond strength of three self-adhesive resin cements to dentin. Indian J Dent Res 2012;23(2):221-5.
14. Hitz T, Stawarzyk B, Fischer J, Hämmerle CH, Sailer I. Are self-adhesive resin cements a valid alternative to conventional resin cements? A laboratory study of the long-term bond strength. Dent Mater 2012;28(11):1183-90.
15. Macedo VC, Faria e Silva AL, Martins LR. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J Endod 2010;36(9):1543-6.
16. Macedo VC, Souza NA, Faria e Silva AL, Cotes C, da Silva C, Martinelli M, et al. Pullout bond strength of fiber posts luted to different depths and submitted to artificial aging. Oper Dent 2013;38(4):E1-6.
17. Radovic I, Mazzitelli C, Chielli N, Ferrari M. Evaluation of the adhesion of fiber posts cemented using different adhesive approaches. Eur J Oral Sci 2008;116(6):557-63.
18. Valandro LF, Filho OD, Valera MC, de Araujo MA. The effect of adhesive systems on the pullout strength of a fiberglass-reinforced composite post system in bovine teeth. J Adhes Dent 2005;7(4):331-6.
19. Morgano SM, Milot P. Clinical success of cast metal posts and cores. J Prosthet Dent 1993;70(1):11-6.
20. Pegoraro LF. Prótese Fixa, São Paulo: Artes Médicas; 1998. p. 313.
21. Standlee JP, Caputo AA, Hanson EC. Retention of endodontic dowels: Effects of cement, dowel length, diameter, and design. J Prosthet Dent 1978;39(4):400-5.
22. Gale MS, Darvell BW. Thermal cycling procedures for laboratory testing of dental restorations. J Dent 1999;27(2):89-99.

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23. Goracci C, Sadek FT, Fabianelli A, Tay FR, Ferrari M. Evaluation of the adhesion of fiber posts to intraradicular dentin. Oper Dent 2005;30(5):627-35.

24. Radovic I, Monticelli F, Goracci C, Vulicevic ZR, Ferrari M. Self-adhesive resin cements: A literature review. J Adhes Dent 2008;10(4):251-8.

25. Chuang SF, Yaman P, Herrero A, Dennison JB, Chang CH. Influence of post material and length on endodontically treated incisors: an in vitro and finite element study. J Prostheth Dent 2010;104(6):379-88.

26. Ferrari M, Sorrentino R, Zarone F, Apicella D, Aversa R, Apicella A. Non-linear viscoelastic finite element analysis of the effect of the length of glass fiber posts on the biomechanical behaviour of directly restored incisors and surrounding alveolar bone. Dent Mater J 2008;27(4):485-98.

27. Schiavetti R, García-Godoy F, Toledano M, Mazzitelli C, Barlattani A, Ferrari M, et al. Comparison of fracture resistance of bonded glass fiber posts at different lengths. Am J Dent 2010;23:227-30.

28. Pinzetta L, Tetsuo IR, Paulo FP. Radiographic evaluation of the ratio of length intraradicular in relation to root length in support teeth unit fixed partial dentures and composite. Rev Gaúcha Odontol 2006;54(4):302-7.

29. Braga RR, Cesar PF, Gonzaga CC. Mechanical properties of resin cements with different activation modes. J Oral Rehabil 2002;29(3):257-62.

30. Imfeld T. Comparison of the mechanical effects of a toothbrush and standard abrasive on human and bovine dentine in vitro. J Clin Dent 2001;12(4):92-6.

31. Nakamichi I, Iwaku M, Fusayama T. Bovine teeth as possible substitutes in the adhesion test. J Dent Res 1983;62(10):1076-81.

32. Schilke R, Lisson JA, Bauss O, Geurtsen W. Comparison of the number and diameter of dentinal tubules in human and bovine dentine by scanning electron microscopic investigation. Arch Oral Biol 2000;45(5):355-61.

33. Wrbas KT, Altenburger MJ, Schirrmeister JF, Bitter K, Kielbassa AM. Effect of adhesive resin cements and post surface silanization on the bond strengths of adhesively inserted fiber posts. J Endod 2007;33(7):840-3.

34. Anusavice KJ. Phillip’s Science of Dental Materials, 11th ed. New Delhi: Harcourt; 2005.

35. Fernandes AS, Dessai GS. Factors affecting the fracture resistance of post-core reconstructed teeth: A review. Int J Prosthodont 2001;14:355-63.

36. Michida SM, Souza RO, Bottino MA, Valandro LF. Cementation of fiber post: Influence of the cement insertion techniques on the bond strength of the fiber post-root dentin and the quality of the cement layer. Minerva Stomatol 2010;59(11-12):633-6.

37. Nakabayashi N, Pashley DH. Hybridization of Dental Hard Tissues, Tokyo: Quintessence Publishing Company; 1998.

38. Souza TR, Leão Filho JC, Beatrice LC. Self-adhesive resin cements: Efficiencies and controversies. Dent Mag Online 2011;10(21):20-5.

39. Bergoli CD, Amaral M, Boaro LC, Braga RR, Valandro LF. Fiber post cementation strategies: Effect of mechanical cycling on push-out bond strength and cement polymerization stress. J Adhes Dent 2012;14(5):471-8.

40. Leloup G, D’Hoore W, Botuer D, Degrange M, Vrenen J. Meta-analytical review of factors involved in dentin adherence. J Dent Res 2001;80(7):1605-14.

41. Inoue S, Koshiro K, Yoshida Y, De Munck J, Nagakane K, Suzuki K, et al. Hydrolytic stability of self-etch adhesives bonded to dentin. J Dent Res 2005;84(12):1160-4.

42. Miyazaki M, Sato M, Onose H, Moore BK. Influence of thermal cycling on dentin bond strength of two-step bonding systems. Am J Dent 1998;11(3):118-22.

43. Yang B, Adelung R, Ludwig K, Bössmann K, Pashley DH, Kern M. Effect of structural change of carbon fibrils on the durability of dentin bonding. Biomaterials 2005;26(24):5021-31.

44. De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: Methods and results. J Dent Res 2005;84(2):118-32.

45. Mitchell CA, Orr JF, Connor KN, Magill JP, Maguire GR. Comparative study of four glass ionomer luting cements during post-pull out tests. Dent Mater 1994;10(2):88-91.

46. Teixeira EC, Teixeira FB, Piasick JR, Thompson JY. An in vitro assessment of prefabricated fiber post systems. J Am Dent Assoc 2006;137(7):1006-12.

47. De Santis R, Prisco D, Apicella A, Ambrosio L, Rengo S, Nicolais L. Carbon fiber post adhesion to resin luting cement in the restoration of endodontically treated teeth. J Mater Sci Mater Med 2000;11(4):201-6.

48. Ebert J, Leyer A, Günther O, Lohbauer U, Petschelt A, Frankenberger R, et al. Bond strength of adhesive cements to root canal dentin tested with a novel pull-out approach. J Endod 2011;37(11):1558-61.

49. Nagase DY, Takemoto S, Hattori M, Yoshinari M, Kawada E, Oda Y. Influence of fabrication techniques on retention force of fiber-reinforced composite posts. Dent Mater J 2005;24(2):280-5.

50. Innella R, Autieri G, Ceruti P, Gassino G. Relation between length of fiber post and its mechanical retention. J Mater Sci Mater Med 2000;11(4):201-6.

51. Ferrandi AS, Dessai GS. Factors affecting the fracture resistance of post-core reconstructed teeth: A review. Int J Prosthodont 2001;14:355-63.

52. Calixto LR, Bandéca MC, Clavijo V, Andrade MF, Vaz LG, Angelis F, Trubiani O, et al. Bond strength of three types of adhesive cements in the restoration of endodontically treated teeth. Oper Dent 2012;37(1):80-6.

53. D’Arcangelo C, Zazzeroni S, D’Amario M, Vadini M, De Angelis F, Trubiani O, et al. Bond strengths of three types of fiber-reinforced post systems in various regions of root canals. Int Endod J 2008;41(4):322-8.
on fiber post retention to root canal. J Appl Oral Sci 2009;17(6):600-4.

55. Leme AA, Coutinho M, Insaurralde AF, Scaffa PM, da Silva LM. The influence of time and cement type on push-out bond strength of fiber posts to root dentin. Oper Dent 2011;36(6):643-8.

56. Mallmann A, Jacques LB, Valandro LF, Mathias P, Muench A. Microtensile bond strength of light- and self-cured adhesive systems to intraradicular dentin using a translucent fiber post. Oper Dent 2005;30(4):500-6.