Effect of Resin Cement Pre-heating on the Push-out Bond Strength of Fiber Post to Root Canal Dentin

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Abstract

Background and aims. Various factors influence the interfacial bond between the fiber posts and root canal dentin. The aim of the present study was to evaluate the effect of pre-warming of resin cement on the push-out bond strength of fiber posts to various segments of root canal dentin.

Materials and methods. In this in vitro study, 40 single-rooted human premolars were decoronated and underwent root canal treatment along with post space preparation. The samples were randomly divided into two groups: In group 1, Panavia F 2.0 cement was used at room temperature; in group 2, the same cement was warmed to 55–60°C before mixing. After fiber posts were placed and cemented in the root canals, 3 dentin/post sections (coronal, middle and apical) with a thickness of 3 mm were prepared. A universal testing machine was used to measure push-out bond strength in MPa. Data was analyzed using two-factor ANOVA and a post hoc Tukey test at α=0.05.

Results. The mean value of push-out bond strength was high at room temperature, and the differences in the means of push-out bond strength values between the resin cement temperatures and between different root segments in each temperature were significant (P<0.05).

Conclusion. Pre-warming of Panavia F 2.0 resin cement up to 55–60°C reduced push-out bond strength to root canal dentin. In addition, in each temperature group bond strengths decreased from coronal to apical segments.

Key words: Push-out bond strength, fiber post, resin cement, pre-warming, laboratory research.

Introduction

Fiber posts were introduced as an alternative to metallic post-and-cores for the restoration of endodontically treated teeth.1 Posts with high elasticity and strength are appropriate for such treatments because there is a low risk of displacement and fracture of these posts; fiber-reinforced posts can achieve these requirements in addition to providing good aesthetic results.2 Since the modulus of elasticity of
these posts is close to that of dentin, it is expected that risk of vertical fractures of the root will decrease with the use of these posts.13 Conventionally, resin cements are used for cementation of fiber posts.4

Although vertical root fracture is the most important and a decrease in post retention is the most common reason for the failure of endodontically treated teeth,5 another reason for treatment failure in these teeth is the contamination of the root canal through leakage of oral fluids and microorganisms due to inadequate seal and marginal adaptation.6 Cementation of a post into the prepared root canal is very important because the cemented post should provide a proper seal along the root canal walls with adequate retention,5 which is achieved by increased flowability and deeper penetration of cement into the post space dentin.7

It has recently been shown that pre-warming of composite resin decreases its viscosity and film thickness; it also increases composite resin flowability and improves its adaptation with the cavity walls.8,9 An increase in temperature improves polymerization kinetics of composite resin in addition to decreasing its viscosity and increasing the degree of conversion10 because the motility of free radicals increases under the direct influence of heat on one hand and under the indirect influence of a decrease in viscosity on the other.11 An increase in degree of conversion directly influences mechanical properties such as surface roughness, flexural modulus, fracture resistance, shear strength and resistance to abrasion. These characteristics may be clinically important for luting agents, too.12 However, dental composites undergo shrinkage during polymerization.13 When the degree of conversion of resin monomers increases it is possible that shrinkage and stresses will increase as a result.13

Considering the importance of interfacial bond between the resin cement and the root canal dentin, the present study was undertaken to evaluate the effect of pre-warming of Panavia F 2.0 resin cement on push-out bond strength of fiber posts at different segments of root canal. The null hypothesis was that the push-out bond strength of Panavia cement at room temperature is not different from that warmed up to 55–60°C.

**Materials and Methods**

Forty human single-rooted mandibular premolars, extracted for orthodontic reasons, were stored in 0.5% chloramine T solution for the purpose of the present study. The teeth were gathered following informed consent, approved by the Deputy Dean of Research at Tabriz Faculty of Dentistry. The working length and root canal morphology were determined radiographically. Teeth with any calcifications or obstructions inside the root canals or with working length exceeding 14 mm were excluded from the study. The teeth were decoronated 1 mm coronal to CEJ using a diamond saw (Isomet, Buchler, Lake Bluff, USA) in a low-speed straight handpiece (Kavo, Germany) under continuous water spray. The root canals were filed manually to the full working length using the step-back technique and #15 to #40 K-files (MANI, Tochigi, Japan) with a master apical file of #30; and flared using #2 to #4 Gates-Glidden drills (MANI). After each instrumentation step, the canals were irrigated with normal saline solution. The canals were dried with paper points (PT Dent, USA) and obturated with gutta-percha and AH26 sealer (De Trey, Zurich, Switzerland) using lateral condensation technique.

Post space was prepared 24 hours after completion of endodontic procedures. The root canals were prepared up to 10 mm using #2 and #3 Peeso reamers (MANI) and the special drills provided by the manufacturer for MATCHPOST #1/4 (RTD, St Igreve, France). MATCHPOST is a radiopaque translucent fiber post. Its diameter is 1.42 mm in the coronal part and 0.77 mm in the apical end. It is 19 mm in length with the first 15 mm parallel and a homogeneous taper at its 4-mm end. The roots were placed in a mold of condensation silicone impression material with a putty consistency (Speedex, Coltene, Switzerland) and divided into two groups.

The posts were cleaned with 70% ethanol, based on manufacturer’s instructions and dried with a compressed air current. In group 1, Panavia F 2.0 resin cement was used at room temperature based on manufacturer’s instructions: at first, an equal amount of ED-Prime II was mixed on a mixing dish for 20 seconds and was placed on the clean surface of the fiber post and the root canal using a microbrush. After 60 seconds, an equal amount of the two syringes of the cement, which had been mixed for 20 seconds on a glass slab, was placed within the canal and the fiber post was seated in place using finger pressure. The resin cement was light-cured for 20 seconds using a light-curing unit (Astralis 7, Ivoclar, Vivadent, Liechtenstein) at a light intensity of 750 mW/cm². The light-curing tip was placed at the canal orifice.

The light intensity of the light-curing unit was measured and controlled during the curing process using a light meter (Coltene, Whaledent, Switzerland).

In group 2 the procedural steps were similar to
Resin Cement Preheating and Fiber Post Bond Strength Data was analyzed using two-way ANOVA and post hoc Tukey test at significance level of \( \alpha = 0.05 \).

Results

Table 1 presents means and standard deviations of push-out bond strength values in the study groups. Based on the results, the mean value of push-out bond strength at room temperature was higher than that at 55–60°C (5.5±0.22 vs. 4.65±0.22). This difference was significant according to the results of two-way ANOVA (\( P = 0.01 \)). In addition, there were significant differences in the means of push-out bond strength values between the different root segments (\( P < 0.001 \)). However, the interactive effect of the two variables (temperature and different root segments) was not significant (\( P = 0.79 \)). Two-by-two comparisons of different root segments at room temperature and 50–60°C, separately, with the use of a post hoc Tukey test revealed significant differences between the coronal, middle and apical thirds of the root at room temperature: coronal and middle third (\( P < 0.001 \)); middle and apical third (\( P = 0.01 \)); coronal and apical third (\( P < 0.001 \)) (Figure 1). At 55–60°C, the differences between the coronal and middle thirds and between the coronal and apical thirds were significant (\( P < 0.001 \); however, there were no significant differences between the middle and apical thirds (\( P = 0.14 \)) (Figure 1).

Discussion

Retention of a fiber post within the root canal depends not only on the bond strength between the post and the luting agent but also on the bond strength between the luting agent and the post space dentin.\(^ {14} \) Scanning electron microscopy studies have shown a proper bond between the matrix of the posts and resin luting agent;\(^ {15} \) however, debonding along dentin–resin luting agent interface has been identified as the most frequently encountered mode of failure.\(^ {16} \) The bond strength at post–cement and cement–dentin interfaces is influenced by various factors, including the reaction between dentin and the luting agent, polymerization rate and stresses resulting from polymerization shrinkage of the resin luting agent, presence of the remnants of endodontic sealer.

Table 1. Means ± standard deviations (SD) of bond strength values in the study groups

| Temperature | Region | Mean   | SD    | Std. error | Minimum | Maximum |
|-------------|--------|--------|-------|------------|---------|---------|
| Room        | Coronal| 7.84 (a)| 1.73  | 0.38       | 4.24    | 11.51   |
|             | Middle | 5.14 (b)| 1.57  | 0.35       | 1.71    | 7.74    |
|             | Apical | 3.51 (c)| 1.88  | 0.42       | 0.78    | 7.18    |
| 55–60°C     | Coronal| 7.00 (a)| 2.15  | 0.48       | 3.37    | 11.65   |
|             | Middle | 4.02 (b)| 1.75  | 0.39       | 0.56    | 7.21    |
|             | Apical | 2.93 (b)| 1.45  | 0.32       | 0.88    | 5.72    |
or gutta-percha, configuration of the root canal, and differences in density and orientation of dentinal tubules in different root segments. Regarding the ever-increasing use of fiber posts and the importance of establishing a proper bond between the fiber post and root canal dentin for the success of treatment, evaluation of bond strength at post–cement and cement–dentin interfaces is of utmost significance. Bond strength might be evaluated by various techniques. The push-out bond strength test is an appropriate test to evaluate the bond strength between endodontic posts and intra-canal dentin. In the push-out technique, failure occurs along the post–cement and cement–dentin interfaces, which is similar to clinical situations. Bond strength might be evaluated by various techniques. The push-out bond strength test is an appropriate test to evaluate the bond strength between endodontic posts and intra-canal dentin. In the push-out technique, failure occurs along the post–cement and cement–dentin interfaces, which is similar to clinical situations. According to Goracci et al, it appears the push-out test is more reliable than microtensile technique. Therefore, in the present study, the effect of pre-heating of resin cement before mixing on push-out bond strength of fiber post to intracanal dentin was evaluated. Based on the results, the bond strength of fiber post to intracanal dentin significantly decreased when the resin cement was pre-warmed. Pre-warming technique for restorative composite resins has been recommended due to its positive effects on decreasing viscosity, improving flow, decreasing film thickness and increasing monomer conversion rate of composite resins in addition to its clinical advantages of facilitating material placement and its adaptation with cavity walls. Cantoro et al evaluated the effect of minor temperature changes in resin cements and based on the results recommended that resin cements stored in refrigerator should be warmed at least to room temperature before use. Of course, it should be pointed out that various cements with different adhesion strategies exhibit different behaviors when they are pre-warmed. Although the effect of temperature on the degree of conversion and the flowability of resin composites cannot be denied, it seems that the temperature of cement drops during mixing and dispensing processes. Therefore, an increase in the degree of conversion and polymerization shrinkage of pre-heated resin will be lower than what we have expected. Dimethacrylate-based composite resins are polymerized through a free radical polymerization reaction. The amount of polymerization in composite resins is expressed by degree of conversion which is defined as the percentage of conversion of C=C monomer bonds to C-C polymer bonds. Degree of conversion influences the mechanical and physical properties of the polymer. Surface roughness, flexural strength, flexural modulus, fracture resistance, diametral tensile strength and abrasion resistance increase with an increase in degree of conversion. Recent studies have shown that curing of composite resins at higher temperatures results in higher conversion rates. Composite resins undergo shrinkage during polymerization procedures; in addition to physical and mechanical properties, the amount of shrinkage and shrinkage strain of composite resins change proportional to degree of conversion. In other words, polymerization shrinkage and the resultant stresses increase with an increase in conversion rate.

When polymerization shrinkage is limited by adhesion to cavity walls, in addition to substrate compliance, another factor which should be considered for the release of polymerization stresses is configuration factor (C-factor), which is defined as the ratio of bonded surface to unbonded surface of the composite resin. C-factor and polymerization shrinkage stress are inversely related. The root canal has a high C-factor. Since the thermal expansion coefficient of composite resins is 6–8 times greater than that of surrounding tooth structures, it appears when the resin cement is pre-heated up to 55–60°C, high C-factor of the root canal neutralizes the increase in flowability and marginal adaptation and the decrease in film thickness, producing an unfavorable condition for bonding of the fiber post to the root canal dentin; therefore, a decrease in push-out bond strength was observed. However, Cantoro et al reported high bond strength values when Panavia F 2.0 cement was pre-warmed. Of course, it should be pointed out that in this study the resin cement was bonded to the smooth dentin surface and the effect of
C-factor was not significant.

Another finding of the present study was the higher mean of push-out bond strength of fiber post in the coronal third compared to the middle and apical thirds, with the lowest bond strength in the apical third of the root canal. Although Bitter demonstrated that the apical bond strength of Panavia F cement was higher;31 and in a study carried out by Oskoee et al.,14 it was shown that the self-etch technique did not result in a significant difference in the push-out bond strength in different root segments, the results of the present study in relation to the effect of various root segments on bond strength are consistent with the results of previous studies.15,32,33 Based on SEM studies, adhesive bonding to the root canal dentin was mainly attributed to the formation of resin tags.34 The density of dentinal tubules and the number and length of resin tags significantly decrease in the cervico-apical direction.14 On the other hand, problems related to manipulation and access to narrow and terminal parts of the apical region of root canal and the probable presence of the smear layer or gutta-percha remnants55 might interfere with thorough penetration of the adhesive and resin cement into the dentinal tubules, compromising the bond strength in the apical regions of the root canal.

Finally, it should be pointed out that despite the importance of in vitro studies, it is difficult to extend the results to clinical situations. In addition, considering the varieties and different functions of resin cements and the importance of their other properties, it is suggested that the effect of pre-warming of cements on their physical and mechanical properties and also their shelf life be evaluated in situations as similar to oral cavity conditions as possible. Besides, precise evaluation of cement–dentin interface in the above-mentioned conditions might furnish useful data.

Conclusion

Under the limitations of the present study it can be concluded that pre-warming of Panavia F 2.0 resin cement up to 55–60°C significantly decreases the bond strength of cement to root canal dentin. Also in each temperature group bond strengths decreased from coronal to apical segments.

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References

1. Asmussen E, Peutzfeldt A, Heitmann T. Stiffness, elastic limit, and strength of newer types of endodontic posts. J Dent 1999;27:275-8. doi:10.1016/s0300-5712(98)00066-9
2. Gwinnett AJ. Altered tissue contribution to interfacial bond strength with acid conditioned dentin. Am J Dent 1994;7:243-6.
3. Sirimai S, Riis DN, Morgano SM. An in vitro study of the fracture resistance and the incidence of vertical root fracture of pulpless teeth restored with six post-and-coresystems. J Prosthet Dent 1999;81:262-9. doi:10.1016/s0022-3913(99)70267-2
4. Zicari F, Couthino E, De Munck J, Poitevin A, Scotti R, Naert I, Van Meerbeek B. Bonding effectiveness and sealing ability of fiber-post bonding. Dent Mater 2008;24:967-77. doi:10.1016/j.dental.2007.11.011
5. Goodacre CJ, Spolnik KJ. The prostodontic management of endodontically treated teeth: a literature review. Part I. Success and failure data, treatment concepts. J Prosthodont 1994;3:243-50. doi:10.1111/j.1532-849x.1994.tb00162.x
6. Bachicha WS, DiFiore PM, Miller DA, Lautenschlager EP, Pashley DH. Microleakage of endodontically treated teeth restored with posts. J Endod 1998;24:703-8. doi:10.1016/s0099-2399(98)80117-x
7. Cantoro A, Goracci C, Papacchini F, Mazzitelli C, Fadda GM, Ferrari M. Effect of pre-cure temperature on the bonding potential of self-etch and self-adhesive resin cements. Dent Mater 2008;24:577-83. doi:10.1016/j.dental.2007.06.012
8. Blalock JS, Holmes RG, Rueggeberg FA. Effect of temperature on unpolymerized composite resin film thickness. J Prosthet Dent 2006;96:424-32. doi:10.1016/j.prosdent.2006.09.022
9. Daronech M, Rueggeberg FA, Moss L, de Goes MF. Clinically relevant issues related to preheating composites. J Esthet Restor Dent 2006;18:340-50; discussion 51. doi:10.1111/j.1708-8240.2006.00046.x
10. Daronech M, Rueggeberg FA, de Goes MF, Giudici R. Polymerization kinetics of pre-heated composite. J Dent Res 2006;85:38-43. doi:10.1177/1544059106008500106
11. Daronech M, Rueggeberg FA, de Goes MF. Monomer conversion of pre-heated composite. J Dent Res 2005;84:663-7. doi:10.1177/154405910508400716
12. Deb S, Di Silvio L, Mackler HE, Millar BJ. Pre-warming of dental composites. Dent Mater 2011;27:e51-9. doi:10.1016/j.dental.2010.11.009
13. Labella R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. Dent Mater 1999;15:128-37. doi:10.1016/s0109-5641(99)00022-6
14. Oskoee PA, Navimipour EJ, Oskoee SS, Bahari M, Pournaghiazar F. Effect of different adhesion strategies on bonding potential of self-etch and self-adhesive resin cements. Int J Prosthodont 2003;16:593-6.

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17. Ogata M, Nakajima M, Sano H, Tagami J. Effect of dentin primer application on regional bond strength to cervical wedge-shaped cavity walls. Oper Dent 1999;24:81-8.
18. Perdigao J, Geraldeli S, Lee IK. Push-out bond strengths of tooth-colored posts bonded with different adhesive systems. Am J Dent 2004;17:422-6. doi:10.1016/s0084-3717(08)70034-5
19. Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC, Tay F, Ferrari M. The adhesion between fiber posts and root canal walls: comparison between microtensile and push-out bond strength measurements. Eur J Oral Sci 2004;112:353-61. doi:10.1111/j.1600-0722.2004.00146.x
20. Cantoro A, Goracci C, Carvalho CA, Coniglio I, Ferrari M. Bonding potential of self-adhesive luting agents used at different temperatures to lute composite onlays. J Dent 2009;37:454-61. doi:10.1016/j.jdent.2009.02.006
21. Weinmann W, Thalacker C, Guggenberger R. Siloranes in dental composites. Dent Mater 2005;21:68-74. doi:10.1016/j.dental.2004.10.007
22. Watts D. Kinetic mechanism of visible-light-cured resins and resin-composites. Trans Acad Dent Mater 1992;5:80-112.
23. Lovell LG, Berchtold KA, Elliott JE, Lu H, Bowman CN. Understanding the kinetics and network formation of dimethacrylate dental resins. Polym Adv Technol 2001;12:335-45. doi:10.1002/pat.115
24. Lobauer U, Zinelis S, Rahiotis C, Petschelt A, Eliaides G. The effect of resin composite pre-heating on monomer conversion and polymerization shrinkage. Dent Mater 2009;25:514-9. doi:10.1016/j.dental.2008.10.006
25. Atai M, Watts DC. A new kinetic model for the photopolymerization shrinkage-strain of dental composites and resin-monomers. Dent Mater 2006;22:785-91. doi:10.1016/j.dental.2006.02.009
26. Silikas N, Eliaides G, Watts DC. Light intensity effects on resin-composite degree of conversion and shrinkage strain. Dent Mater 2000;16:292-6. doi:10.1016/s0109-5641(00)00020-8
27. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. J Dent Res 1987;66:1636-9. doi:10.1177/00220345870660110601
28. Miguel A, de la Macorra JC. A predictive formula of the contraction stress in restorative and luting materials attending to free and adhered surfaces, volume and deformation. Dent Mater 2001;17:241-6. doi:10.1016/s0109-5641(00)00077-4
29. Tay FR, Loushine RJ, Lambrechts P, Weller RN, Pashley DH. Geometric factors affecting dentin bonding in root canals: a theoretical modeling approach. J Endod 2005;31:584-9. doi:10.1097/01.don.0000168891.23486.de
30. Sidhu SK, Carrick TE, McCabe JF. Temperature mediated coefficient of dimensional change of dental tooth-colored restorative materials. Dent Mater 2004;20:435-40. doi:10.1016/j.dental.2003.02.001
31. Bitter K, Meyer-Lueckel H, Priehn K, Kanjuparambil JP, Neumann K, Kielbassa AM. Effects of luting agent and thermocycling on bond strengths to root canal dentine. Int Endod J 2006;39:809-18. doi:10.1111/j.1365-2591.2006.01155.x
32. Goracci C, Sadek FT, Fabianelli A, Tay FR, Ferrari M. Evaluation of the adhesion of fiber posts to intraradicular dentin. Oper Dent 2005;30:627-35.
33. Kalkan M, Usumez A, Ozturk AN, Belli S, Eskitascioglu G. Bond strength between root dentin and three glass-fiber post systems. J Prosthett Dent 2006;96:41-6. doi:10.1016/j.prosdent.2006.05.005
34. Ferrari M, Grandini S, Simonetti M, Monticelli F, Goracci C. Influence of a microbrush on bonding fiber post into root canals under clinical conditions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;94:627-31. doi:10.1067/moe.2002.129184
35. Serafino C, Gallina G, Cumbo E, Ferrari M. Surface debris of canal walls after post space preparation in endodontically treated teeth: a scanning electron microscopic study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:381-7. doi:10.1016/j.tripleo.2003.10.004