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An in vitro comparative study to evaluate Pull-out bond strength of a fibre-reinforced composite post system luted with two different self-adhesive resin cements

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Abstract: *This study aimed at evaluating the effects of aExcite DSC bonding agent and two self-adhesive resin cements Panavia F 2.0, Variolink II on the pull-out bond strengths of FRC posts to root canal dentine, and to compare the effects of different cementation thicknesses.*
Materials and methods: *20 extracted human single canals were selected and root filled. Incisors were embedded in acrylic resin. Trans-lutedfibre posts were luted into root canal using two different types of cements. Root canals of all teeth were prepared with Gates Glidden drill #3. In group 1 post luted with Panavia F 2.0and group 2 with Variolink II. Pull-out evaluation done using a universal testing machine. Specimens were sectioned transversally into slices at coronal, middle and apical regions of the root canal. All specimens will be analyzed by stereomicroscope.Post surface areas covered with cement were measured.*
Results:*Panavia F 2.0 revealed the significantly highest pull-out bond strengths in both groups ($p< 0.05$), while variolink II exhibited the significantly lowest pull-out bond strengths in group 2 ($p < 0.05$).*
Conclusions: *The different resin cements influenced the pull-out bond strengths, whereas the cement thickness itself was not responsible for any differences.*
Keywords: *fiber post, cement thickness, pull out strength, self etch adhesives*

I. Introduction

The restoration of severely compromised tooth is often performed by using intracanal posts [1]. Endodontically treated teeth, with a large amount of coronal structure grossly destructed, frequently require the placement of a post inside the root canal, to retain a core for definitive restoration.

Depending on the clinical factors, the choice may be a metal or an esthetic post and core restoration. Clinical studies have reported success rates in the range of 95 to 99% for teeth restored with fiber-reinforced posts, without occurrence of root fracture during the study periods.

The main reasons hindering the clinical long-term success of post-retained restorations are loss of retention [2, 3] and root fracture [4]. Post retention can be increased by using an adhesive luting technique, involving the use of dentin adhesives and resin based luting agents [5, 6], whose reliability was reported to be material dependant [6].

Root fractures can be decreased by using fiber posts [7, 8], which have a modulus of elasticity similar to dentin and subsequently they allow for a more uniform distribution of loads along root dentin compared to metal posts [9]. At present, the restoration of non-vital teeth by means of composite resin combined with fiber posts represents a most reliable treatment option [10]. Numerous factors affecting the post-root dentin strength were assessed, such as the pretreatment of root dentin [11, 12], the influence of different root canal regions [13, 14], the type of resin cement and adhesive [15, 16], the adhesive application modes [17], the translucency of the fiber post [17–19], the filler content of the cement [20, 21], the cement thickness [22–24] and the fiber post surface treatments [25, 26].

Many laboratory studies investigated to evaluate the influence of different resin cement thicknesses on the bond strength of fiber posts [22–24], but there is no study in the literature on the ideal thickness of resin cement to improve post retention. Push-out studies illustrated that the cement thickness did not significantly affect the bond strength of the fiber posts to the root dentin [22, 23]. However, a negative correlation between the thickness of the cement layer and the post-root dentin strength was also reported [4]. The aim of this study was to evaluate the post-root dentin push-out strength of posts luted in canals with two different resin cements.

II. Materials And Methods

In this in vitro study, 20 human maxillary central incisors with 15 mm length (from 1 mm above the cemento-enamel junction to the apex), extracted for periodontal reasons, were selected.The specimens were free of cracks, carious lesions, fractures, and resorption, with fully developed apices and without previous endodontic treatments, posts, or crowns.They were cleaned off of soft tissues and calculus, and placed in 2.5% sodium hypochlorite for two hours, for surface disinfection. The coronal part of each tooth was removed 1 mm above the cemento-enamel junction with diamond disks (Ref.070, D and Z, Berlin, Germany)mounted on a dental lathe machine (KaVo Polishing Unit. EWL 80, Leutkrich, Germany) at low speed, under constant water irrigation, to achieve a uniform length of 15 mm.The canal working length was established 1 mm short of the apical foramen. The step-back technique was used for canal instrumentation.

Obturation was performed using AH26 (Dentsply Caulk, Milford, Germany) and gutta-percha, with the vertical condensation method. After completion of endodontic treatment, the coronal root canal openings were filled with a provisional restorative material (GC Caviton; GC Dental Products Corp., Tokyo, Japan)and the teeth were stored in 100% humidity for one week at 37°C, to allow the sealer to set.

After one week, the gutta-percha was removed from the coronal aspect of each root with a Gates Glidden drill #3 (Dentsply-Maillefer, Ballaigues, Switzerland)leaving 4 mm gutta-percha in the apices, to preserve the apical seal. The post spaces were prepared to a depth of 10 mm with the appropriate drills (Fibio, Anthogyr, Sallanches, France). A new drill was used for every five specimens. Post size 3 was tried, to ensure that the posts would reach the bottom of the post space. All posts were marked at a distance of 10 mm from the apical end, and were cut to that size with diamond disks.

The shortened posts were cleaned with 70% ethanol for 60 seconds, rinsed with distilled water, and air dried. Before the cementation procedures, the post surfaces did not undergo any pretreatment. The prepared roots were randomly divided into two groups of 10 specimens each for cementation procedures

In group 1, the posts were luted with Panavia F 2.0 (Kuraray Medical, Inc., Okayama, Japan) after conditioning the dentin with ED-Primer for 60 seconds, using a microbrush. The post space was gently air-dried and the excess primer was removed with paper points .

In group 2, Variolink II (IvoclarVivadent, Schaan, Liechtenstein) was used as the luting agent. The canals were etched using 35% phosphoric acid (Ultra-Etch, Ultradent, South Jordan, UT, USA) for 15 seconds and rinsed with distilled water. Excess water was removed from the post spaces with a gentle stream of air and paper points.

The Excite DSC (IvoclarVivadent), dual-polymerizing, single-bottle bonding agent was applied for 10 seconds with a microbrush coated with chemical initiators and the excess bonding agent was removed with paper points and gently air-dried.The bonding agent was polymerized with a halogen light unit, with 500-mW/cm2 intensity (Coltolux 50, Coltene, Altstatten, Switzerland), for 20 seconds, with the tip of the light unit directly in contact with the canal orifice.

For cementation of fiber posts, equal amounts of luting pastes (Panavia F 2.0 and Variolink II) were mixed and applied onto the surface of the posts and into the root canals with a Lentulo spiral instrument (DentsplyMaillefer). The posts were inserted into the canal, to a full depth, by using gentle finger pressure, and the excess was immediately removed with a disposable brush.

For Panavia F 2.0 the remaining cement around the post was protected with oxygen-inhibiting gel (Oxyguard II, Kuraray). For Variolink II, after the initial chemical polymerization, light curing was performed for 60 seconds in such a way that the tip of the light unit was directly in contact with the coronal end of the posts. The light output was monitored to ensure accurate light intensity before each exposure by using the light meter (Coltolux, Coltene).

After the cementation procedures, all specimens were stored in sterile saline in a light-proof box for one week at 37°C. Next, each root was sectioned perpendicular to the long axis with a diamond disk at low speed under constant distilled water cooling to create 3 mm-thick slices. In this manner; from each root, three post/dentin sections (coronal, middle, and apical) were obtained.

Due to the tapered design of the fiber posts, post diameters were measured on each surface of the post/dentin sections, using digital calipers (Electronic digital caliper, Minova Co, Japan), with 0.01 mm accuracy.

The push-out test was performed by using the universal testing machine (TLCLO, Dartec Ltd., Stourbridge,England) at a crosshead speed of 1 mm/ minute,using a pin (diameter, 1.0 mm) on the center of the apical aspect of the post surface in an apical-coronalwalls. The peak force (N) required to extrude the post from the root slice was recorded. To express the bond strength in MPa, the load at failure (N) was divided by the area of the bonded interface, which was calculated with the formula.

The collected data were analyzed using two-way analysis of variance (ANOVA) and Post Hoc Schaffer tests at $P<0.05$ levels of significance.

III. Results

The mean push-out bond strength values (MPa) of the test groups in different root canal regions are shown in Table 2.

Table 1 &2-Descriptive statistics of push-out bond strength values (MPa) of two groups in different root canal regions

Cement	Root canal region	Mean	Standard deviation	95% confidence interval	
				Lower bound	Upper bound
Panavia F	Coronal	17.12	5.37	14.789	19.451
	Middle	12.87	3.31	10.539	15.201
	Apical	7.78	2.60	5.447	10.109
Variolink II	Coronal	16.20	3.49	13.869	18.531
	Middle	12.60	4.06	10.269	14.931
	Apical	8.68	2.39	6.349	11.011

Cement	Root canal region	Mean	Standard deviation	Position on Chart
Panavia F	Coronal	17.12	5.37	A1
	Middle	12.87	3.31	A2
	Apical	7.78	2.6	A3
Variolink II	Coronal	16.2	3.49	B1
	Middle	12.6	4.06	B2
	Apical	8.68	2.39	B3

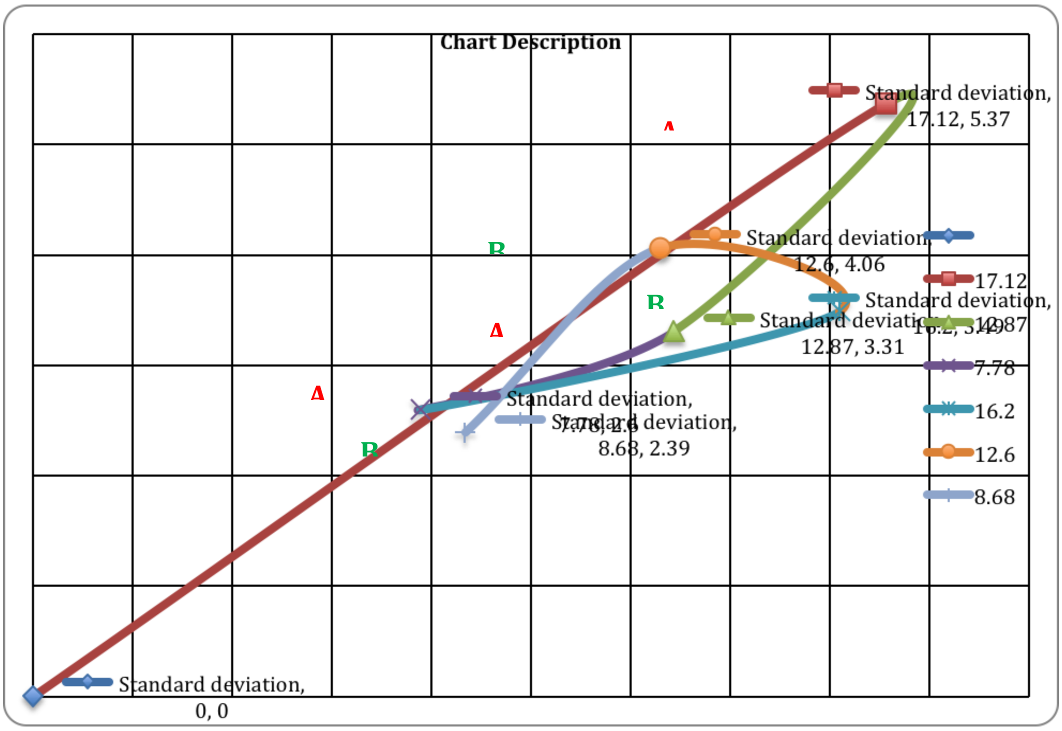

Fig – 1 Mean value and standard deviation values for group 1 and Group 2

The two-way ANOVA showed no significant differences between the mean push-out bond strength values recorded for two experimental groups (two types of cement systems) and there was no interaction between the type of resin cement system and different root canal regions ($P=0.920$ and $P=0.731$, respectively) [Table 3].

Table 3- Two-way ANOVA

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected model	720.607	5	144.121	10.664	0.000
Intercept	9437.103	1	9437.103	698.297	0.000
Type of resin cement	0.138	1	0.138	0.010	0.920
Root canal regions	711.943	2	355.971	26.340	0.000
Resin cement * Root regions	8.526	2	4.263	0.315	0.731
Error	729.781	54	13.514	-	-
Total	10887.490	60	-	-	-
Corrected total	1450.388	59	-	-	-

Significant differences were observed among the bond strength values of the root dentin regions ($P<0.001$). The lowest bond strength values were obtained in the apical regions. The Post Hoc Scheffe test revealed that in both resin cement systems, there were significant differences between the coronal and apical regions.

IV. Discussion

Many experimental tests were described for theevaluation of the bond strength between root dentin andposts, such as the pull-out test, the micro-tensile test and thepush-out test. The pulling out of the whole post fromrestored roots necessitates high loads and results in testing largeadhesive interfaces, where the stress distribution is highlynon-uniform [27].For assessment of retention of adhesively cemented posts, push-out and pull-out tests have been conventionally used [28,29,4].Until now, attempts to include micro tensile techniques to compensate for the limitations of conventional shear and tensile bond strength tests have failed, mostly due to problems like untimely failures [4].With the present experimental set-up, the pull-out test design was chosen for evaluating the retention of fibre-glass posts luted with self- adhesive resin cements. The clinical significance of this test is based on the fact that debonding is the most usual failure mode of FRC posts,[30]and that axial loading is considered predominant with clinical restorations. [31]

A stereomicroscope was employed for the evaluation of the failure modes. Because of the post surface convexity, the marginal areas of every post's hemisphere were captured twice. However, as these limitations were the equal for all posts, possible statistical inaccuraciesshould have ruled out, and measurements should have been comparable.

In this study, it was revealed that the factor 'resin cement' significantly affected the pull-out bond strengths of the used posts. However, the factor 'cement thickness' had no influence on the respective pull-out bond strengths. Hence, the null hypothesis tested in the present study had to be partially rejected. NaOCl is a halogenated compound with a low surface tension, and is usually used in endodontics to dissolve organic tissues. When interpreting the results it should be emphasized that NaOCl has been reported to compromise bond strengths of the adhesive systems to (root canal) dentine [32]. In the present study, the observed bond strength values did not diminish to a non-acceptable clinical level.

When considering the factor 'resin cement', the significantly highest pull-out bond strengths were observed for Group 1, while in group 2 showed the significantly lowest mean bond strengths. These results are in agreement with several previous studies, reporting differences among bond strength values of cemented posts luted with different resin cements [33,34].

With regard to post retention, it has been stated that the dislocation resistance of posts luted with resins or glass ionomer cements continues from the following parameters: (a) micromechanical interlocking, (b) chemical bonding, and (c) sliding friction [35].Consequently, any factor influencing the above mentioned parameters could have influenced the pull- out bond strength performance of the FRC posts used in the present study.

At a first look, polymerization stress could have donated to the significantly different pull-out bond strengths observed with the current experiments. Polymerization stress of resin composites is the result of their volumetric shrinkage, viscoelastic behavior, and restrictions imposed on composite shrinkage [36].Because in the present experiment root canal anatomy and tooth substrate could be considered as strongly comparable in all subgroups, resin cements' volumetric shrinkage and/or viscoelastic behavior might have been different. These properties depend on differences among materials' compositions as well as on the degree of conversion (DC), and on the reaction kinetics [36-38].

Moreover, in comparison to light-initiated polymerization, the self-initiated reaction results in low polymerization shrinkage and DCs, due to its slower reaction rate [39]and its reduced amount of free radicals [36]However, all resin cements included in the present study were light activated. Thus, differences in volume fraction, type, [37]size and shape [40]of fillers, as well as in proportion, molecular weight [41]and functionality [42]of matrix monomers could have contributed to low polymerization stresses in the Panavia F (group 1), or to high polymerization stresses in the Variolink II (group 2).

Moreover, according to the manufacturers, the adhesion properties of the examined cements rely on the self-adhesion capability of phosphoric acid methacrylate monomers composing their matrix. Hence, differences in acidic group monomers and their concentrations could lead to different etching patterns, to a differing wetting ability, and to differences regarding chemical adhesion to dentine [43].In contrast, however, several studies have already shown low demineralization effects of self-adhesive cements with dentine [34].This mainly was attributed to the chemical interaction of acidic monomers with hydroxyapatite, since only sporadic hybridization of dentine could be detected [44].

Furthermore, resin cements' compatibility with post surfaces could contribute to a better post retention [34].According to the assumption that products of the same manufacturer should exhibit chemical affinity, the problem of incompatibility could be reduced in Group 1, thus possibly contributing to higher pull-out bond strengths.

When regarding the factor 'cement thickness', the significantly lower pull-out bond strength performance of Group 2 (when applied in a thick layer) is consistent with the results of other studies, which have reported lower push-out [4]and pull- out [28]bond strength values after increasing the cement thickness. According to the present study, it may be assumed that either the polymerization shrinkage or the stiffness of Group 2 was higher with thick cementation layers, and this might have reduced the post retention [45].

Indeed, the adhesive failure mode at the cement-post interface was an expected result. It is well known that the polymer matrix of the commercially available FRC posts is highly cross-linked. As a result, no active monomers of the adhesive luting agent will remain [46]to enable any chemical bonds. Therefore, no chemical post pre-treatment (which might promote a better bonding of cements to FRC posts) was performed [47].

Taking into explanation that the direction of the polymerization contraction depends on the bonding quality and the cavity geometry, [48]and, further considering that only the post space (geometry) changed, it seems that due to an increase of the polymerization shrinkage, cement detachment mainly occurred from root canal dentine walls of the post spaces. However, pull-out bond strengths did not reduce, and, hence, it might be speculated that the contribution of sliding friction to post retention [17, 49]has compensated for shrinkage increase and/or low adhesive properties.

The hypothesis that there are no differences between the bond strengths in different post space regions has been rejected. In the case of the first hypothesis, our result was in agreement with some previous studies. Noirrit et al. stated that the hybrid layer and resin tags that resulted from both bonding systems (self-etch and total-etch) were nearly the same, although the conditioning of the canal walls was different.

Micro morphological investigations demonstrated that etching the dentin with phosphoric acid (PH≈2) (as used in the 'etch-and-rinse' systems) completely dissolved the smear layer and exposed the tubule apertures, collagen fibrils, and inter-fibrillar spaces, while the use of self-etch bonding systems had a variable effect on the smear layer. They noted that the hybrid layer appeared thinner with the 'self-etch' system, than with the 'etch-and-rinse' system. They concluded that demineralization by phosphoric acid led to a deeper penetration of the adhesive than did a self-etch system, which could not completely penetrate the smear layer.

Some researchers have stated that a system with a self-etching primer and light-polymerized bonding agent provided significantly higher bond strength to root canal dentin than the self-etching bonding agents and the strength of this bond was not dependent on the hybrid layer thickness.

In contrast, some authors stated that simplified self-etch and self-adhesive resin cements, such as Panavia 21, exhibited an etching potential insufficient (even with a PH of ≈ 2.0) to dissolve the thick smear layers generated in the post-space preparation, with slow-speed drills. They stated that this fact give way to the high shrinkage stress in the thin cement layer and the resultant opening of interfacial gaps might account for the relatively low push-out strength recorded for ED Primer/Panavia 21 as compared to the results obtained with the use of the total-etch system, Excite DSC/Variolink II. However, they suggestd the use of self-adhesive resin cements for intra-canal posts, because of their simple luting procedure.

In the case of the second hypothesis, my result was in agreement with the previous studies that reported higher bond strength for coronal dentin than values for the middle and apical sections of the root.It might be speculated that the reduced thickness of the luting material results in a lower polymerization shrinkage and a subsequently lower polymerization stress, thus not impairing the bond strength [50].

Goracci et al.[18] observed a higher bond strength in the coronal sections for Excite/Variolink II, but similar values for RelyXUnicem.It has been shown that tubule density is greater in the coronal and middle thirds than in the apical region of the root canal, and the diameter of the tubules decreases in the apical direction.

The difference in the number of tubules may clarify why the strongest adhesion is achieved in the most coronal regions. In the presence of a greater number of tubules per mm2 a stronger bond will be expected, because the adhesion may be improved by the penetration of the resin into the tubules.

In addition, it is shown that dentin hybridization is not consistent in the apical region of the root canal dentin and the lateral branches of the resin tags are not monitored in the apical part of the interface postadhesive system. Some methodological factors might have contributed to the discrepancies in bond strength values, such as, enhanced accessibility of the coronal portion of the root canal, which made it easier to etch and apply the adhesive agents.

At last, a decrease of light energy during transmission would lessen polymerization of the bonding agent at the medium and apical regions. Some other studies found no significant differences in the bond strengths among the different regions of the bonded posts to root canal dentin. In this study, the method of pushing out fiber posts was not evaluated. The specimens were prepared without coronal tooth structure. It was suggested that the amount of remaining coronal tooth structure played a chief role in the longevity of the restoration of endodontically treated teeth.

V. Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn:

1. There was no significant difference between the push-out bond strengths of glass fiber reinforced composite posts for self-etching and conventional resin cement
2. The coronal region of the root dentin showed a significantly higher bond strength of the glass fiber reinforced composite post than the apical region.

References

[1]. Peroz I, Blankenstein F, Lange KP, Naumann M (2005) Restoring endodontically treated teeth with posts and cores—a review. Quintessence Int 36:737–746

[2]. Hatzikyriakos AH, Reisis GI, Tsingos N (1992) A 3-year postoperative clinical evaluation of posts and cores beneath existing crowns. J Prosthet Dent 67:454–458

[3]. Torbjörner A, Karlsson S, Odman PA (1995) Survival rate and failure characteristics for two post designs. J Prosthet Dent 73:439–444

[4]. Kremeier K, Fasen L, Klaiber B, Hofmann N (2008) Influence of endodontic post type (glass fiber, quartz fiber or gold) and luting material on push-out bond strength to dentin in vitro. Dent Mater 24:660–666

[5]. Balbosh A, Ludwig K, Kern M (2005) Comparison of titanium dowel retention using four different luting agents. J Prosthet Dent 94:227–233

[6]. Naumann M, Sterzenbach G, Rosentritt M, Beuer F, Frankenberger R (2008) Is adhesive cementation of endodontic posts necessary? J Endod 34:1006–1010

[7]. Sorrentino R, Monticelli F, Goracci C, Zarone F, Tay FR, García-Godoy F, Ferrari M (2007) Effect of post-retained composite restorations and amount of coronal residual structure on the fracture resistance of endodontically-treated teeth. Am J Dent 20:269–274

[8]. Salameh Z, Sorrentino R, Ounsi HF, Goracci C, Tashkandi E, Tay FR, Ferrari M (2007) Effect of different all-ceramic crown system on fracture resistance and failure pattern of endodontically treated maxillary premolars restored with and without glass fiber posts. J Endod 33:848–851

[9]. Duret B, Duret F, Reynaud M (1996) Long-life physical property preservation and postendodontic rehabilitation with the Composipost. CompendContinEduc Dent Suppl 20:S50–56

[10]. Dietschi D, Duc O, Krejci I, Sadan A (2008) Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, part II (evaluation of fatigue behavior, interfaces, and in vivo studies). Quintessence Int 39:117–129

[11]. Coniglio I, Magni E, Goracci C, Radovic I, Carvalho CA, Grandini S, Ferrari M (2008) Post space cleaning using a new nickel titanium endodontic drill combined with different cleaning regimens. J Endod 34:83–86

[12]. Ohlmann B, Fickenscher F, Dreyhaupt J, Rammelsberg P, Gabbert O, Schmitter M (2008) The effect of two luting agents, pretreatment of the post, and pretreatment of the canal dentin on the retention of fiber-reinforced composite posts. J Dent 36:87–92

[13]. Zhang L, Magni E, Radovic I, Wang YJ, Chen JH, Ferrari M (2008) Effect of curing modes of dual-curing luting systems and root regions on retention of translucent fiber posts in root canals. J Adhes Dent 10:219–226

[14]. Wang VJ, Chen YM, Yip KH, Smales RJ, Meng QF, Chen L (2008) Effect of two fiber post types and two luting cement systems on regional post retention using the push-out test. Dent Mater 24:372–377

[15]. Radovic I, Monticelli F, Goracci C, Vulicevic ZR, Ferrari M (2008) Self-adhesive resin cements: a literature review. J Adhes Dent 10:251–258

[16]. Zicari F, Couthino E, De Munck J, Poitevin A, Scotti R, Naert I, Van Meerbeek B (2008) Bonding effectiveness and sealing ability of fiber-post bonding. Dent Mater 24:967–977

[17]. Faria e Silva AL, Casselli DS, Ambrosano GM, Martins LR (2007) Effect of the adhesive application mode and fiber post translucency on the push-out bond strength to dentin. J Endod 33:1078–1081

[18]. Goracci C, Corciolani G, Vichi A, Ferrari M (2008) Light-transmitting ability of marketed fiber posts. J Dent Res 87:1122–1126

[19]. dos Santos Alves Morgan LF, Peixoto RT, de Castro Albuquerque R, Santos Corrêa MF, de Abreu Poletto LT, Pinotti MB (2008) Light transmission through a translucent fiber post. J Endod 34:299–302

[20]. Carvalho CA, Monticelli F, Cantoro A, Breschi L, Ferrari M (2009) Push-out bond strength of fiber posts luted with unfilled resin cement. J Adhes Dent 11:65–70

[21]. Ferrari M, Carvalho CA, Goracci C, Antoniolli F, Mazzoni A, Mazzotti G, Cadenaro M, Breschi L (2009) Influence of luting material filler content on post cementation. J Dent Res 88:951–956

[22]. Perez BE, Barbosa SH, Melo RM, Zamboni SC, Ozcan M, Valandro LF, Bottino MA (2006) Does the thickness of the resin cement affect the bond strength of a fiber post to the root dentin? Int J Prosthodont 19:606–609

[23]. Hagge MS, Wong RD, Lindemuth JS (2002) Effect of dowel space preparation and composite cement thickness on retention of a prefabricated dowel. J Prosthodont 11:19–24

[24]. D'Arcangelo C, Cinelli M, De Angelis F, D'Amario M (2007) The effect of resin cement film thickness on the pullout strength of a fiber-reinforced post system. J Prosthet Dent 98:193–198
[25]. Monticelli F, Osorio R, Sadek FT, Radovic I, Toledano M, Ferrari M (2008) Surface treatments for improving bond strength to prefabricated fiber posts: a literature review. Oper Dent 33:346–355
[26]. Radovic I, Monticelli F, Goracci C, Cury AH, Coniglio I, Vulicevic ZR, Garcia-Godoy F, Ferrari M (2007) The effect of sandblasting on adhesion of a dual-cured resin composite to methacrylic fiber posts: microtensile bond strength and SEM evaluation. J Dent 35:496–502
[27]. Van Noort R, Noroozi S, Howard IC, Cardew G (1989) A critique of bond strength measurements. J Dent 17:61–67
[28]. Schmage P, Pfeiffer P, Pinto E, Platzer U, Nergiz I. Influence of oversized dowel space preparation on the bond strengths of FRC posts. Operative Dentistry 2009;34:93–101.
[29]. Wrbas KT, Altenburger MJ, Schirrmeister JF, Bitter K, Kielbassa AM. Effect of adhesive resin cements and post surfacesilanization on the bond strengths of adhesively inserted fiber posts. Journal of Endodontics 2007;33:840–3.
[30]. Bitter K, Neumann K, Kielbassa AM. Effects of pretreatment and thermocycling on bond strength of resin core materials to various fiber-reinforced composite posts. Journal of Adhesive Dentistry 2008;10:481–9.
[31]. Bateman GJ, Lloyd CH, Chadwick RG, Saunders WP. Retention of quartz-fibre endodontic posts with a self-adhesive dual cure resin cement. European Journal of Prosthodontics and Restorative Dentistry 2005;13:33–7.
[32]. Farina AP, Cecchin D, Barbizam JV, Carlini-Junior B. Influence of endodontic irrigants on bond strength of a self-etching adhesive. Australian Endodontic Journal 2011;37:26–30.
[33]. Sahafi A, Peutzfeldt A, Asmussen E, Gotfredsen K. Retention and failure morphology of prefabricated posts. International Journal of Prosthodontics 2004;17:307–12.
[34]. deDurao Mauricio PJ, Gonzalez-Lopez S, Aguilar-Mendoza JA, Felix S, Gonzalez-Rodriguez MP. Comparison of regional bond strength in root thirds among fiber-reinforced posts luted with different cements. Journal of Biomedical Materials Research Part B Applied Biomaterials 2007;83:364–72.
[35]. Ohlmann B, Fickenscher F, Dreyhaupt J, Rammelsberg P, Gabbert O, Schmitter M. The effect of two luting agents, pretreatment of the post, and pretreatment of the canal dentin on the retention of fiber-reinforced composite posts. Journal of Dentistry 2008;36:87–92.
[36]. Braga RR, Ballester RY, Ferracane JL. Factors involved in the development of polymerization shrinkage stress in resin-composites: a systematic review. Dental Materials 2005;21:962–70.
[37]. Ellakwa A, Cho N, Lee IB. The effect of resin matrix composition on the polymerization shrinkage and rheological properties of experimental dental composites. Dental Materials 2007;23:1229–35.
[38]. Braga RR, Ferracane JL. Contraction stress related to degree of conversion and reaction kinetics. Journal of Dental Research 2002;81:114–8.
[39]. Huber L, Cattani-Lorente M, Shaw L, Krejci I, Bouillaguet S. Push-out bond strengths of endodontic posts bonded with different resin-based luting cements. American Journal of Dentistry 2007;20:167–72.
[40]. Berger SB, Palialol AR, Cavalli V, Giannini M. Characterization of water sorption, solubility and filler particles of light-cured composite resins. Brazilian Dental Journal 2009;20:314–8.
[41]. Hervas-Garcia A, Martinez-Lozano MA, Cabanes-Vila J, Barjau-Escribano A, Fos-Galve P. Composite resins. A review of the materials and clinical indications. Medicina Oral Patologı´a Oral y Cirugı´aBucal 2006;11:E215–20.
[42]. Amirouche-Korichi A, Mouzali M, Watts DC. Effects of monomer ratios and highly radiopaque fillers on degree of conversion and shrinkage-strain of dental resin composites. Dental Materials 2009;25:1411–8.
[43]. Van Landuyt KL, Snauwaert J, De Munck J, Peumans M, Yoshida Y, Poitevin A, et al. Systematic review of the chemical composition of contemporary dental adhesives. Biomaterials 2007;28:3757–85.
[44]. Bitter K, Paris S, Pfuertner C, Neumann K, Kielbassa AM. Morphological and bond strength evaluation of different resin cements to root dentin. European Journal of Oral Sciences 2009;117:326–33.
[45]. Pilo R, Cardash HS, Levin E, Assif D. Effect of core stiffness on the in vitro fracture of crowned, endodontically treated teeth. Journal of Prosthetic Dentistry 2002;88:302–6.
[46]. Bitter K, Noetzel J, Neumann K, Kielbassa AM. Effect of silanization on bond strengths of fiber posts to various resin cements. Quintessence International 2007;38:121–8.
[47]. Monticelli F, Ferrari M, Toledano M. Cement system and surface treatment selection for fiber post luting. Medicina Oral Patologı´a Oral y Cirugı´aBucal 2008;13:E214–21.
[48]. Chiang YC, Rosch P, Dabanoglu A, Lin CP, Hickel R, Kunzelmann KH. Polymerization composite shrinkage evaluation with 3D deformation analysis from microCT images. Dental Materials 2010;26:223–31.
[49]. Goracci C, Fabianelli A, Sadek FT, Papacchini F, Tay FR, Ferrari M. The contribution of friction to the dislocation resistance of bonded fiber posts. Journal of Endodontics 2005;31:608–12.
[50]. Alster D, Feilzer AJ, de Gee AJ, Davidson CL (1997) Polymerization contraction stress in thin resin composite layers as a function of layer thickness. Dent Mater 13:146–150.